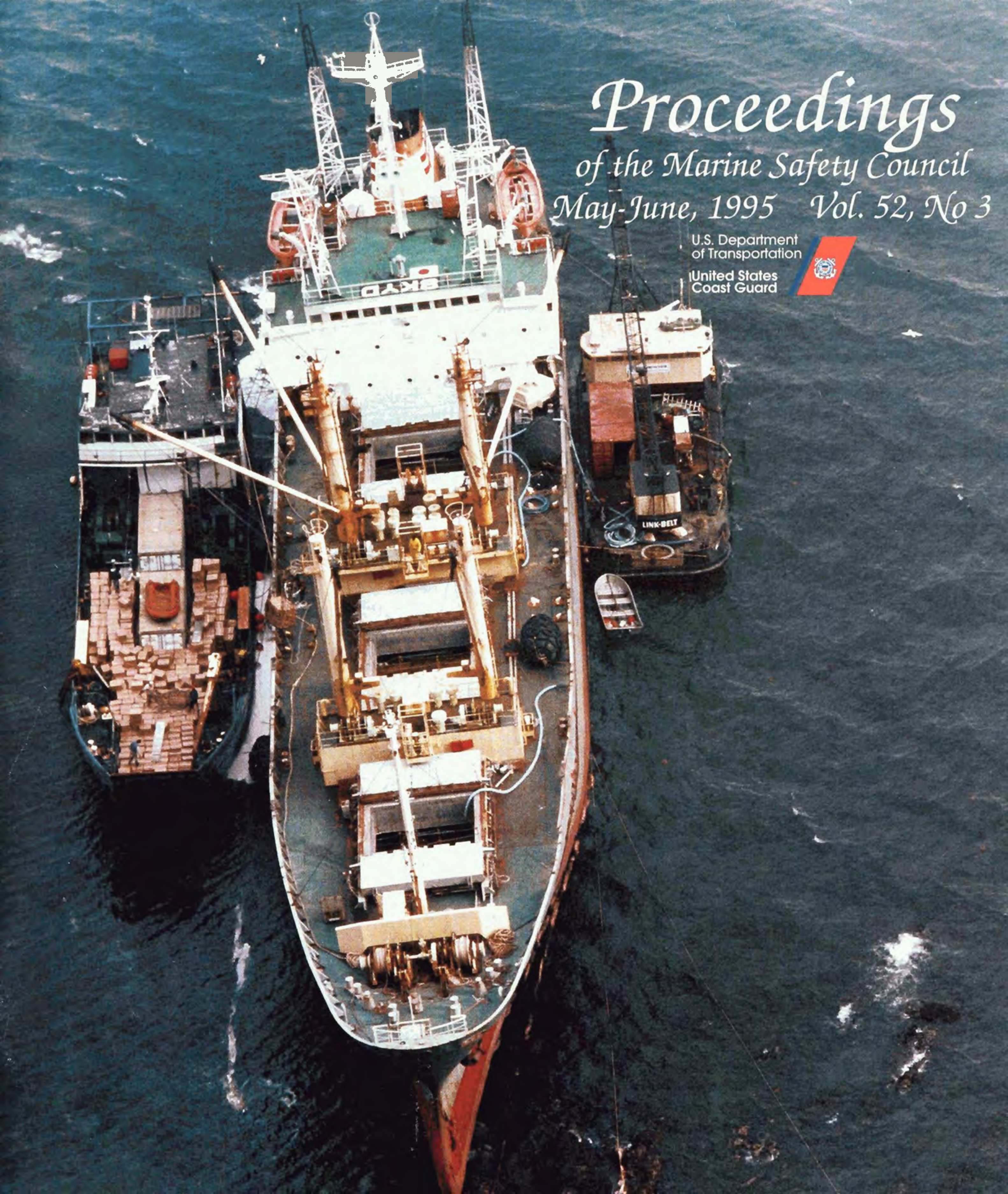
Proceedings

of the Marine Safety Council

May-June, 1995 Vol. 52, No 3

U.S. Department
of Transportation

United States
Coast Guard



Proceedings is published bimonthly by the Coast Guard's Office of Marine Safety, Security and Environmental Protection, in the interest of safety at sea under the auspices of the Marine Safety Council. The Secretary of the Office of Transportation has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this agency. Special permission for republication, either in whole or in part, except for copyrighted material, is not required, provided credit is given to Proceedings. The views expressed are those of the authors and do not represent official Coast Guard policy. All requests for subscriptions and changes of address must be in writing, addressed to: Editor, Proceedings Magazine, U.S. Coast Guard (G-MP-4), 2100 Second Street, S.W., Washington, D.C. 20593-0001; (202) 267-1408. Please include mailing label when changing an address.

DIST (SDL No. 133)
A: ac(2); ebfghijklmnopqrsuv(1).
B: nr(50); cefgipw(10); bklqshj(5); xdmou(2);vyz(1).
C: n(4); adek(3); blo(2); cfgijmpqrtuvwxyz(1).
D: ds(5); abcefghijklmnopqrtuvwyz(1).
E: kn(2). F: abcdehjkloqst(1).
List TCG-06.

Proceedings

of the Marine Safety Council

May-June, 1995 *Vol. 52, No 3*

Special human element issue

Accidents like this need not happen.

Prevention through people

By RADM James C. Card

Prevention through people is a new initiative for the Office of Marine Safety, Security and Environmental Protection. In the November-December issue of Proceedings, we stated that the human element was not being adequately addressed as a causal factor in marine casualties. In this issue, we will take a penetrating, comprehensive look at the role of human error in maritime accidents.

Other solutions

The maritime community has historically spent the majority of available resources addressing design requirements and technical "fixes" to eliminate the "human element." These initiatives have eliminated most of the material failures and systems' problems.

However, analysis indicates that up to 80 percent of all marine casualties are caused by people. Consequently, it is necessary to refocus our efforts to address the human element and the root causes of casualties with adequate resources.

In examining the human element in maritime operations, we must be careful not to limit our sights to judgment, experience and training alone. We must also look closely at behavior, fatigue, awareness, maintenance, management, operating standards, procedures and controls.

There is a growing awareness that the human element must be looked at from a broad perspective, and that each aspect must be carefully and fully considered if casualty rates are to decline.

Continued on page 2

"We welcome your ideas and suggestions."

Continued from page 1

Joint effort

Prevention through people is "our" initiative to adequately address the role of human error. This must be a joint government, industry, mariner and classification society effort focusing on the prevention of marine casualties through "people's" collective efforts. For many in the Coast Guard, this will require a cultural change as we develop new roles and methods for managing maritime risk in a systematic and coordinated manner.

Task force

We have formed a Coast Guard task force to evaluate maritime functions and examine how human error and human element problems result in the loss of life, injury and pollution. This task force is correlating maritime industry, mariner and government field personnel input; reviewing casualty data and National Transportation Safety Board reports; and examining a breadth of human factor and risk assessment literature to identify the high risk, high growth and technology-driven maritime functions where human error and human element problems dominate. The efforts of this task force should serve as a starting point.

Joint work groups can then analyze the highest risk maritime functions and develop cost-effective prevention measures to eliminate or control the human element problems identified. Commensurate with this effort, we will assess the effectiveness of our current maritime safety and waterways management activities. Resources dedicated to activities identified as minimally effective will be redirected to the prevention through people initiative.

Issue focus

In this spirit of open dialogue, we are dedicating this special issue of *Proceedings* to the human element. We have a wide variety of articles from academia, industry and various government agencies which address alertness, the impact of technology, systems approaches, international programs and management practices as root causes of failures. We also focus on Coast Guard efforts to reduce maritime accidents though human error considerations.

Feedback

As you read these articles and consider human error and the human element in maritime casualties, try to determine how we can concentrate efforts in your operation/industry to improve the human or people side of the maritime safety equation.

This could include learning how to use people as preventive agents defining, isolating and determining root causes of casualties; developing effective prevention measures; and modifying human behavior, abilities, expectations, values and work loads to prevent maritime losses.

We welcome and need your ideas and suggestions. It is this type of dialogue and partnering that we seek as we move beyond technical solutions and join in the prevention through people effort to reduce loss of life, injuries and pollution.

RADM James C. Card is the chief of the Office of Marine Safety, Security and Environmental Protection.
Telephone: (202) 267-2200.

The offshore drilling platform Piper Alpha (right) is shown prior to the accident adjacent to another platform.

Men, ships and the sea

By: Professor Robert Bea

Approximately 80 percent of marine casualties have root causes in human and organizational elements. The vast majority of these accidents occur during system operations. If substantial improvements are to be made in marine safety, challenges concerning human and organizational elements in design, construction and operation of systems must be addressed, at least as well as we have learned to treat technical aspects.

Piper Alpha

At 11 p.m., July 6, 1988, the night shift had just taken over operations on the *Piper Alpha* offshore drilling platform in the northern North Sea. Installed in the mid-1970s, this massive island of steel supported drilling and production equipment, housed up to 250 people. The platform was originally designed to handle 250,000 barrels per day, and upgraded for 350,000 barrels per day. Significant equipment and piping had been added to accommodate the additional production.

Earlier that day, gas being produced from two adjacent platforms and sent via pipeline to *Piper Alpha* placed the latter on a code red status (maximum production). One of the two condensate (liquids produced from the gas) injection pumps failed, and the spare pump was turned on. This pump could not inject fluids into the pipeline because it had been taken out of service. It had been blind-flanged (sealed with a closure plate) for the day crew to repair an emergency relief valve. A gas leak occurred and ignited with a deafening explosion in the gas compression module.

The crew working on the pump and the production superintendent were killed instantly. The nearby control room was devastated, and the emergency and power systems knocked out. There was no power to activate emergency shut-in controls.

Unprotected fuel storage above the gas compression module was ignited, and thick, dense, toxic smoke engulfed quarters where surviving crew members were being mustered for evacuation in life boats. They were overcome by smoke and died. The order to evacuate never came. Crew members who were saved did not muster in the quarters. They jumped off platform decks into the water some 100 feet below where they were picked up by stand-by boats.

Water could not be pumped through the fire deluge system (like a building fire sprinkler system), because the pumps were on manual control. This precaution had been taken to protect divers under the platform from being sucked into the intake. The fire-fighting pumps and deluge system could not be activated due to the loss of the production control room. Because of the intensity of the heat and explosions, and confusion in the command system, a fire-fighting barge moored adjacent to the platform withdrew without attempting to control the fire.

Pipes near the first explosion and blaze softened from the intense heat, oil leaked, and more fires developed in the adjacent oil separation module almost an hour after the initial explosion.

Continued on page 4

Continued from page 3

High pressure risers bringing in gas from adjacent platforms ruptured, resulting in a blinding explosion. Emergency shut-in valves intended to prevent gas from flowing out of the pipelines were near the explosion and were destroyed. Now an estimated 900,000 cubic meters of gas from nearby platforms compressed into import and export pipelines, was dumped into the fire. The *Piper Alpha* platform was totally destroyed along with 167 lives. It was a $4 billion catastrophe.

Alexander Kielland

Often large production platforms do not have sufficient space for quarters, and flotels (floating hotels) must be moored nearby. In one such case, the flotel *Alexander Kielland* was placed in dry dock for maintenance before going offshore in the Norwegian sector of the North Sea.

While the flotel was in dry dock, a hydrophone (water depth measurer) was welded on an underwater brace. Engineering personal were not consulted regarding the placement of the device. A large crack in the brace was made during the welding process which inspectors failed to notice. It was certain that the brace was cracked in dry dock, because the crack had the same paint on it as applied to the unit there.

After the *Alexander Kielland* was moored adjacent to a platform, the brace snapped in poor weather on March 27, 1980. This triggered a series of other structural failures, and the flotel began to list and sink. Life boats could not be lowered due to the extreme 35° list of the platform. Those that were dropped struck the hull, were holed and sunk.

Only one of 212 people on the flotal donned a survival suit properly. In the dark, panic and confusion reigned inside the *Alexander Kielland*. Those who jumped were numbed by cold water and their improperly donned survival suits filled up. Many drowned.

Twenty minutes after the brace snapped, the *Alexander Kielland* turned completely upside down. This casualty resulted in the deaths of 123 people.

Ocean Ranger

On the night of February 15, 1982, the floating offshore drilling unit *Ocean Ranger* was operating in about 260 feet of water about 166 miles east of St. John's, Newfoundland, Canada. Heavy seas produced waves up to 40 feet high and winds were gusting up to 90 knots. Drilling operations were suspended.

About 7 p.m., spray from a large wave broke a portlight in the ballast control room, causing an electrical malfunction. The storm caused a 10- to 15-degree list and liquids were accidentally transferred in the ballast tanks by the malfunctioning control system.

The master and crew of the *Ocean Ranger* apparently did not understand the operation of the complex ballast control system and were unable to manually correct the listing. The operations manual did not provide adequate guidance, and the drilling unit slowly continued to turn over.

Although the *Ocean Ranger*'s upper hull was watertight, there were large openings to the chain lockers in each corner column. The lockers store chain to moor the system. As the unit continued to list, the chain lockers were filled by the waves and the *Ocean Ranger* capsized and began to sink.

At 1 a.m. the next morning, emergency rescue aircraft and boats were dispatched to the scene. However, due to the severe storm, the aircraft could do little except direct the rescue boats to the site. The crewmen donned life jackets, but there were no exposure suits for protection against the cold 31° F water. Those aboard the *Ocean Ranger* who escaped into the water were quickly immobilized and died from hypothermia before they could be picked up by standby boats.

The one life boat that could be launched capsized alongside a rescue boat when water entered a hole in the bow and everyone moved to one side. The stand-by vessels did not have adequate equipment to recover survivors under the adverse weather conditions.

Nine hours after the portlight was broken, the *Ocean Ranger* sank to the bottom of the North Atlantic. All 84 crew members perished.

Very similar accounts of unexpected and undesirable interactions of people and systems were in the background of other major marine accidents involving the *Torry Canyon, Amoco Cadiz, Exxon Valdez, Braer, Herald of Free Enterprise* and *Estonia.*

Common theme

As these sad incidents testify, the majority of high consequence, low probability marine accidents have a common theme:

a chain of important errors made by people in critical situations involving complex technical and organizational systems.

The errors go beyond the individuals directly involved in the incidents. In the majority of these accidents, there are organizations providing "cultures" that invite excessive risk taking, demand superhuman performance or develop complacency resulting in reactive safety management. Excessive cost-cutting measures and a focus on short-term results are often symptomatic of such cultures. The industry, government and public encourage such cultures to develop and persist.

Those of us involved in marine safety have begun to realize that, in most cases, we have been working on 20 percent of the problem. About 80 percent of major marine accidents have root causes based on human and organizational elements. About 80 percent of these elements surface in unexpected, undesirable ways during marine operations.

Similar observations can be made about major accidents involving a wide variety of complex non-marine systems, including buildings, bridges, dams, nuclear power plants, airplanes, trains and automobiles. People are the primary problem, not systems. We can learn much from experiences involving non-marine systems.

Problems

We have been designing some marine systems that cannot be constructed and operated as intended, so field modifications and shortcuts must be enacted. Design engineers rarely hear about these problems.

People are transferred so rapidly and, in some cases, retire so early that there is a loss of corporate memory of these mistakes. Sometimes, the systems cannot be inspected and maintained reliably, so unexpected early signs of decay (corrosion, fatigue cracking) begin to show up. Complexity in procedures, systems, facilities and organizations invite human and organizational errors resulting in major casualties.

It is when we do not properly recognize hazards and put safeguards in place, that the risks manage us. In ignoring the human and organizational elements, we ignore a major part of the risk. When we surrender vigilance to complacency, we cause accidents waiting to happen. When we engineer overly complex systems, and place them in the hands of improperly trained, motivated and certified people, we ask for trouble.

Continued on page 6

A gigantic explosion destroys the Piper Alpha.

Flotel like the Alexander Kielland is linked up to drilling platform.

The floating offshore drilling unit Ocean Ranger after it capsized.

Continued from page 5

Answers

For the past six years, a series of research projects at the University of California at Berkeley have attempted to develop some practical answers to this very perplexing question. These projects have been sponsored by a variety of agencies including the Coast Guard, Minerals Management Service, classification societies, including the American Bureau of Shipping, and marine industry constructors, owners and operators.

The research clearly indicates that we must start engineering human and organizational elements of marine systems, just like the structures and facilities. We need to expect errors, minimize the chances that they will occur and the effects when they do occur.

We must supply clear operating manuals for complex systems, and train, test and verify that things are going properly. There must be early warning systems to detect when potentially catastrophic chain events start, and then activate emergency shut-downs to prevent or minimize the effects of accidents.

The dual strategies of accident prevention (proactive identification and safety measures) and mitigation (reactive interruption of dangerous escalating events) need to be fully considered. It is generally very difficult to improve the performance of people and organizations so that errors are reduced. Such improvements tend to degrade rapidly. Our research indicates that, if given sufficient warning and time, people are much more likely to recover from potentially dangerous situations, than not make the mistakes that cause them.

Accidents

In the past, much safety work was directed at preventing "normal" accidents — ones we can anticipate and adopt measures to prevent and mitigate the effects. It may be true that "an ounce of prevention is worth a ton of cure," but prevention can only go so far. More work should be directed at learning how to manage catastrophic "abnormal" accidents.

The admission that there can be abnormal accidents representing unrecognized and perhaps unknowable combinations of situations is a major step in the right direction. Our research clearly indicates that very different measures are required to successfully manage abnormal accidents. This is particularly true when stress is high (perhaps due to noise, motion and threat of harm), and the situation is rapidly unfolding.

Personnel

There are some highly qualified, devoted people attempting to improve marine safety. However, there are also inadequately trained, poorly motivated people in these jobs, frequently working without adequate resources. This is a work function that costs money, and, if it succeeds, does not clearly show a reduction in costs. In other words, the costs of accidents that don't happen don't show up on balance sheets.

In most cases, properly qualified and experienced safety personnel have not been involved in the early design and construction phases of marine systems. They often are presented with an extremely complex system and hazardous situation, and told to manage it without halting production (like changing the oil in a car going 60-miles-an-hour). Perhaps it is not surprising that many people faced with marine safety system management problems focus on technical fixes, while largely ignoring people fixes.

Recognition of the roles of human and organizational elements in the safety of marine systems must address the level of the individual: selection, training, testing, motivating and verifying to a degree commensurate with the job to be performed and the needs for safety. People must be trained to manage crisis situations in the systems they operate.

Reducing complexity of tasks, improving personnel selection procedures, providing for self and external checking, planning and scheduling to decrease time pressures and fatigue effects, and supplying positive incentives for high quality performance can help reduce accidents caused by human and organizational elements. Our research demonstrates that high quality crews involved in design, construction, operation and maintenance of marine systems are far more important than the quality of the systems themselves.

Organization

A very critical aspect of improving safety of marine systems concerns organizational aspects. Our research reveals that dominant contributing or underlying causes of most high consequence accidents relate to organizations that influence the life-cycle of particular marine systems. The same can be said for compounding causes that allow accidents to reach catastrophic proportions.

We need to understand the heritages of corporate cultures, their powers and limitations, flaws, incentives and abilities to respond positively in quickly escalating, potentially catastrophic situations.

We need to recognize the extreme importance of effective communications, including data collecting, archiving, retrieval, analysis and dissemination; in particular, the potentials for information filtering (things are better than they are rumored) need to be recognized.

We need to develop organizations to maintain constant situation awareness, promote decision making by those who have the most information, and provide robust organizational structures so that defects and deficiencies will not be allowed to degrade safety.

An equitable system of positive incentives must be provided to encourage safe marine systems.

Conclusion

Those who go to sea in ships must be truly proactive, first at accident prevention and second at mitigation. We must honestly recognize the potential blindness produced by our pride, our enduring trait of wishful thinking (optimism), our limitations (fatigue, boredom, confusion, ignorance), and our reckless ways.

The human and organizational elements of our systems must be engineered, built, tested and revised just as the physical elements are. And each must compliment the other.

We should design our systems to be more forgiving and tolerant of defects and flaws -- people -- and more damage-tolerant (fail-safe). We must understand that imperfection is more the rule than perfection. Marine systems must be designed so that they are simpler and more adaptable to what people can and will do.

Professor Robert Bea is a member of the Department of Naval Architecture and Offshore Engineering, and the Department of Civil Engineering, University of California at Berkeley, 212 McLaughlin Hall, Berkeley, California 94720-1712.

Telephone: (510) 642-0967.

Nine switches of alertness

And you have to be alert to operate these switches on a control panel of the steamboat Mississippi Queen.
Photograph by YN3 Joseph Relle.

By CAPT Jerry Aspland

Twenty-five years ago, I heard the quote, *"85 percent of all maritime accidents are caused by human error."* One month ago, I heard the quote, ***"85 percent of all maritime accidents are caused by human error."***

Is this coincidence or the result of the marine community's failure to address a most complex system: **human behavior**. I have to assume that it is the latter, and, until the community faces the issue in a positive, constructive manner, the quote will remain valid 25 years from now.

Alertness

During the past eight years, the staff of Arco Marine, Inc., a major tanker operator, has spent considerable time and resources addressing the area of human behavior. We came to the conclusion that one element of behavior has more impact on human error than any other. This is "alertness."

Alertness can be defined as the optimal activated state of the brain when the fog of fatigue has lifted, the brain hums and purrs, and innovative solutions to old problems pop into mind. It is a state in which individuals can make conscious decisions about what to pay attention to in their environments, and what to exclude. It is alertness that keeps us out of trouble at sea and in port during cargo operations.

The difference between alertness and other causes of human actions is that it dramatically changes with time and may differ from moment to moment.

In 1993, a topic of discussion at a seminar at the Massachusetts Maritime Academy covered the 24-hour work day, its implications and how it affects "alertness." At the conclusion of the seminar, a technological organization was commissioned to prepare two manuals: *"The Nine Switches of Alertness: A Manual for Crisis Management Teams"* and *"The Nine Switches of Alertness: A Manual for Operating and Engineering Personnel."*

Nine Switches

The nine key internal and external factors (switches) which trigger an individual's alertness are:

#1 Sense of danger, interest or opportunity

Many seafarers have stood watch on a very boring night with nothing to do but stare out the window or at the control room gauges, when all of a sudden, they realize they are staring into danger — the heart pounds, and skin turns cold and clammy. Alertness is triggered!

To overcome this switch, we must stay active in our work, and interact with other personnel to enhance alertness.

#2 Muscular activity

We all know what happens when we sit in a chair for long periods of time. Our alertness wans.

Physical activity, such as walking or stretching will stimulate alertness. Even chewing gum can help.

#3 Time of day

We all have our natural traditional pattern of daytime wakefulness and nighttime sleep. This natural pattern gets us in trouble when faced with a 24-hour work period. Many people have experienced drowsiness in late afternoon or early morning. During these periods, our alertness suffers.

Allow 30 minutes to wake up before starting your duties. Monitor work-sleep patterns to get enough sleep. Allow time to adjust to time zone differences. Take short 10- or 15-minute naps. These help maintain alertness when the time of day is the drowsiness culprit.

#4 Sleep bank balance

Everyone has a sleep bank. Deposits are made by recuperative sleep. Sustained wakefulness makes withdrawals. When the sleep bank is low - especially after 24 hours of wakefulness, the need for recuperative sleep has a dampening effect on alertness.

A good night's sleep or strategically placed naps can replenish a sleep bank. It is very dangerous for anyone to be awake for more than 24 hours.

#5 Ingested nutrients and chemicals

Alertness can be altered by chemicals and food, even though many people disagree.

Avoid drugs to combat sleep. Coffee is only a temporary aid to alertness. Be careful what and when you eat.

#6 Light

Light has a dramatic effect on alertness. Retail businesses use light to speed up or slow down purchasing activities. You must have 1000 candlepower or more to combat drowsyness.

Increase light sources during port operations to improve alertness.

#7 Temperature

Have you ever noticed how a flight crew controls the temperature on an airplane, especially at night. Take-off and landing are relatively cool when you need to be alert. During the flight, however, the temperature is raised to help you sleep.

Keep cool air circulating in operating spaces to avoid the loss of alertness.

#8 Sound

Sound works the same way as light and temperature. It can either invigorate or put you to sleep. Background noise in the engineroom or cargo control room can be very soothing and decrease alertness.

Turn on a radio to lively music to stay alert.

#9 Aroma

Aromas also work two ways concerning alertness.

Strong smells, like air fresheners, can keep you alert.

Conclusion

These nine switches to alertness can serve as a basis for change in the design of onboard work areas, sleep patterns and watch standing routines. They perform a major role in alertness.

The lack of alertness may contribute to human error more than any other factor. If this is so, the nine switches to human alertness should be addressed immediately.

CAPT Jerry Aspland recently retired as president of Arco Marine, Inc., 300 Oceangate, Long Beach, California 90801-5617.

Telephone: (310) 590-4407.

Minding

"Minding the Helm"

By Dr. Martha Grabowski

Since the early days of navigation, vessels entering or leaving port, or sailing over other hazardous waters, have been guided by pilots with a thorough knowledge of local currents, tides, rocks, shoals and weather conditions. The skill and care of the pilot was vitally important for the safety of lives, vessels and cargo, and to protect ports and the marine environment.

Today, as in the past, vessels normally are required by port states to engage independent pilots.

Responsibilities

Piloting demands more skills than simply guiding a vessel through a waterway. It requires a diverse mix of navigation and ship-handling skills.

Pilots are expert advisors to vessel navigators, determining when and where to turn, as well as when and how to execute necessary maneuvers. Pilots play an important role in traffic management: coordinating, queuing, and maintaining the correct horizontal separation between vessels.

Pilots also have to know how to manage different types of ships with varying degrees of maneuverability. Considerable skill is needed to compensate for variations in vessel behavior, even between sister ships, which may vary in their maneuverability according to their equipment and cargoes. Pilots must know how to anticipate and respond to varying intensities of vessel reactions, particularly with regard to the effects of shallow waters and small under-keel clearances.

Although the safe navigation of a vessel is the ultimate responsibility of the captain, it depends increasingly on the attentiveness and skills of a pilot.

Thus, in simple terms, navigation decisions as the vessel nears or operates in a port rely on the expert knowledge and skill of the pilot. In the absence of an independent marine pilot, a ship's officer would perform the same functions, but, in most cases, would not be as familiar with local operating conditions. Automated systems are being developed, ostensibly to supplement, rather than supplant marine pilots.

"Minding the Helm"

In October 1994, the Marine Board of the National Research Council released a report entitled, *"Minding the Helm: Marine Navigation and Piloting."* It was produced over a four-year period by a committee of 14, including two pilots and seven ship's masters. The committee was asked to address issues, such as the:

- changing character of vessel traffic, such as vessel types and sizes, traffic density, and port configuration and operation;
- evolving state of vessel navigation and piloting practices due to technical advances;
- shifting roles of vessel masters, officers, bridge complements, marine pilots and shore-based traffic safety personnel;
- effects of technical advances on training, licensing and performance, as well as on navigation and piloting administration; and
- government's role in oversight and operation of navigation and piloting systems.

The report describes the large-scale marine navigation and piloting system, which includes navigation and piloting tasks, technology, human elements and organizations with cultures and structures. These subsystems exist and interact within an operating environment supported by vessel and waterway systems, and characterized by substantial risk and changes. The report suggests that problems that can lead to failures can arise in any one subsystem or in combinations. Therefore, navigation and piloting is addressed as a system, rather than as a series of independent subsystems.

More importantly, the report suggests that understanding how the system works may have more to do with the relationships between the subsystems than in understanding the subsystems themselves. For instance, the relationships between the people, technology and tasks in the marine navigation and piloting system may provide clearer understandings of how it works and how best to prevent problems.

The difficulty with such large-scale systems is that examining these relationships is not easy. Neither is recognizing that a "fix" in one part of the system may, in fact, cause problems and even malfunctions in other parts of the system. Effective planning, operation, management, administration, research and error prevention requires a system-level approach.

the helm

Human error

What do these elements have to do with people? Although the report concludes that the system is safe, it emphasizes that it could be safer. Several recommendations for enhancing safety focus on people and human factors.

Because human error is a major cause of marine accidents, industry and regulators must focus on areas influenced largely by human actions. The report suggests that human performance can be enhanced by improving professional development, organizational piloting structures for decision making and technology.

The safety of the system depends on effective human performance. Navigation and ship handling skills, and judgment and decision-making abilities of vessel pilots are fundamental and critical. The individual piloting a vessel is expected to function effectively under all operating conditions and contingencies, and to be prepared for any emergency.

Traditionally, such expertise is developed and maintained through formal instruction and training, observation, tutelage, and trial and error. However, the report notes, piloting insight gained by experience is informally shared among masters, mates, pilots and operators. The nature of marine operations keeps these individuals dispersed throughout the system and relatively isolated from their colleagues. Furthermore, there are few formal avenues for sharing information and lessons learned from operational experience.

In addition, despite the strong tradition of pilot organizations training junior pilots, standards for entry-level education, training and continuing professional development for pilots tend to be informal, although some state organizations have well-developed curricula. Periodic refresher training has been increasing, particularly for ship handling in special conditions. The number of pilot associations with continuing professional development programs for members has increased considerably in recent years.

Although there is some informal monitoring of pilot performance by colleagues, the report states that there is no systematic recertification or professional monitoring program for pilots to detect or prevent substandard performance. Deficiencies in knowledge and skills, or personal problems that adversely affect performance, are often identified only after a casualty.

Official oversight of practical skill development is lacking in federal marine licensing programs for masters, mates and pilots. Such professional development needs to be improved, and each individual's navigation and piloting knowledge and skills need to be periodically refreshed, upgraded and confirmed.

Recommendations

The report recommends strong improvements by federal and state authorities in the following areas:

- ability to determine and correct systemic problems underlying human causal factors in accidents;
- organizational structures for decision-making, including vessel traffic services and other technological aids;
- quality, integrity and consistency of pilot development programs and marine licensing;
- accountability of pilotage systems and pilots; and
- introduction and use of navigational technologies.

One way to achieve these improvements is with a model piloting system, ideally promoted by industry rather than government. Such a system would focus on developing formal professional standards and accreditation programs for pilotage services, as well as pilot qualifications and performance.

Summary

People in general and pilots in particular are the linchpins in the marine navigation and piloting system. The report stresses the importance of people in assuring the safety and effectiveness of the system, and suggests measures which may change the training, licensing, certification, recertification and governance of those assigned with safety responsibilities. Such measures can help make the whole system safer.

Dr. Martha Grabowski is a professor at LeMoyne College, Syracuse, New York 13214, and at Rensselaer Polytechnic Institute, Troy, New York 12180-3590.

Telephone: (315) 445-4427 or (518) 276-2954.

Why use risk-based technology?

By Mr. Robert A. Landman

Historically, a casualty has been the impetus for regulatory action, often without regard to the cause. While this "fly-fix-fly" approach frequently satisfies immediate concerns, the regulated industry is often saddled with excessive costs to prevent an accident that is unlikely to occur again.

Similarly, regulations are too often developed to address the "worst case" scenario, ignoring the potentially "most likely" incident. This approach will also most likely result in high priced compliance.

With today's economy and environment, it is imperative that regulatory agencies responsible for high consequence operations, such as marine transportation, move beyond the traditional approaches.

New direction

The direction which should be taken features new state-of-the-art risk-based technologies (hardware or system safety methods), which consider the role played by the human element. As such, these technologies address the contribution of the human element as both a risk contributor and a "risk mitigating" factor in overall system operation.

Once the human role is understood and documented, regulations relevant to the system, including its management, can be drafted. They will consider the human element as well as traditional hardware issues.

Traditional approach

The process for developing risk-based regulations differs greatly from the traditional regulatory process. The latter often approach safety with prescriptive requirements specifically geared for individual components, such as a type of piping or valve.

Traditional regulations rarely consider the interrelationships between components, and do not adequately address risks and mitigating factors of the operating environment or the human element.

Risk techniques

There are many risk techniques available. Only a few are widely known. The most familiar are useful in random hardware and small-scale subsystem designs. However, they do not address the human role.

There are more advanced analysis methods suited for human factor considerations, such as preliminary hazard analysis, and the hazard and operability study. These studies rely on a systems engineering approach which addresses not only equipment functions, but the relationships between components and the effects of the total operating environment on the system.

When this approach is used as a basis for regulatory development, regulations can address safety issues in a holistic context, which has many advantages. It produces base-line safety criteria, which allows for the articulation of true safety concerns and their mitigating factors, which include equipment or human actions that reduce the likelihood of failure.

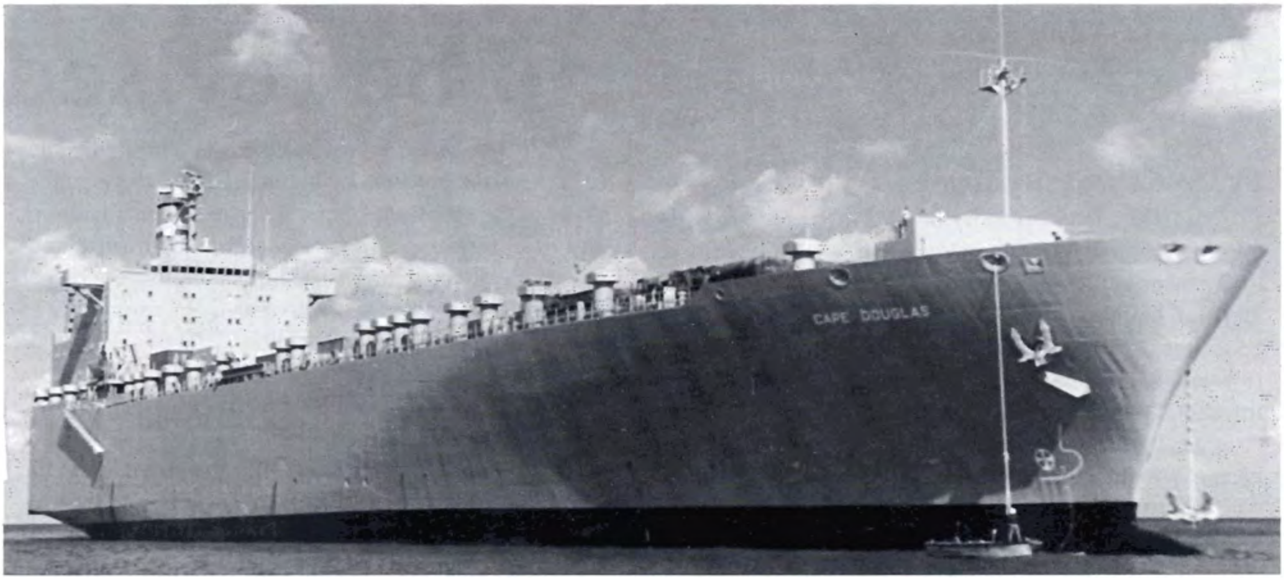
Risk-based requirements on system safety also offer easier, less costly means of compliance.

Risk analysis

To consider the human role in the system, an appropriate risk analysis must be performed to answer three questions:

1) What can go wrong?
2) What is the likelihood?
3) What are the consequences or damages?

Active risk-management programs are typically extensions of lessons learned from formal risk analysis. Risk management identifies decisions affecting the likelihood of events.



MARAD Ro/Ro vessel.

Practice

The Coast Guard's Marine Safety Evaluation Program team recently put into practice risk-based technologies, including weighing the human contribution in the system while evaluating alternative compliance requests. The alternative compliance issues concerned the adequacy of installed hazardous location lighting systems on board the Maritime Administration's (MARAD) Cape H and Cape W class Ro/Ro vessels.

Because of the high cost of light replacements, MARAD wanted to leave the exisiting fixtures in place. However, the installed lighting did not comply with existing hazardous location requirements. It was agreed that the best approach was a risk analysis study.

In evaluating the lighting system's acceptability, a preliminary hazard analysis was conducted to determine safety criteria. This not only took into account the equipment installed, but its operating environment, which addresses the crew's overall safety contributions.

The analysis of the lighting system demonstrated that if various actions were taken by the crew, such as monitoring and recording explosive gas levels, and improving maintenance operations, the fixtures could remain in place. The use of a preliminary hazard analysis provided an alternative means of regulatory compliance and cost savings of over $7 million.

The understanding of the human role dictated the modification of existing procedures and the development of new ones, such as improved procedures for watchstanding, and cargo handling and maintenance. The use of the human role as a mitigating factor was a key reason that the alternative compliance request was granted. (The results of this analysis will be included in the next revision of title 46 CFR, subchapter J.)

Conclusion

The marine industry has been identified at international forums as "high consequence operations." Other industries, such as chemical processing and nuclear power generation, have successfully operated with regulations based on risk technologies. Managers in these industries have integrated risk management practices into their procedures and operations. These practices are based on human element considerations.

To effectively regulate the increasingly complex systems developing in marine industries without imposing heavy monetary burdens, the Coast Guard must give more consideration to risk analyses for system evaluation.

Only when the complete risk analysis is satisfactorily performed, can the true contribution of the human element be understood and appreciated . . . and be articulated into regulations.

Mr. Robert A. Landman is the chief of the Electrical Section, Engineering Branch, Marine Technical and Hazardous Materials Division .
Telephone: (202) 267-2206.

Seafarer standards to be revised

By Mr. Christopher Young

The highest priority on the work program of the International Maritime Organization (IMO) today is the revision of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW). A primary reason for this revision is the concern that the predominant cause of maritime casualties is human error.

It is generally agreed that the human element has not adequately been addressed in developing standards and guidelines. To reduce casualties and pollution incidents, this must change.

In early 1993, the IMO Subcommittee of Training and Watchkeeping started preparing a draft text of proposed amendments to the convention. Upon completion, it was submitted to the IMO Maritime Safety Committee which approved a draft text for circulation to parties to the convention at a conference beginning in late June 1995.

Training

The STCW stipulates the minimum knowledge and experience requirements for certifying candidates. Proposed revisions reflect a concern that knowledge alone is insufficient to serve as the standard of competence. Candidates must be able to apply their knowledge properly to actual operating conditions.

Three additional elements are considered necessary :

1) identification of skills associated with the function to be performed,

2) demonstration of essential skills, and

3) quality assurance system to ensure that training and assessment programs are meeting objectives.

Within the context of skills-based training strategies and competence assessments, the proposed revision also addresses purposes of seagoing service, the use of record books, performance standards for simulators, and qualifications of instructors and assessors.

Language problems

No simple solution has emerged for the increasing problem of the inability of multinational crews to communicate in a common language. A suggestion by the United States that the IMO should formally endorse the established trend toward using English as the working language for maritime communication has not received universal support.

The proposed revisions make a limited attempt to address the problem by including English language skills in the standards of competence for certification and by introducing a requirement for ship owners and operators to ensure that "the ship's complement can effectively coordinate their activities in an emergency situation and in performing functions vital to safety or the prevention or mitigation of pollution." It is understood that the term, "coordinate their activities," denotes communication among crew members.

The proposal is similar to the provision in the International Safety Management (ISM) Code (resolution A.741{18}) that a company "should ensure that the ship's personnel are able to communicate effectively in the execution of their duties related to the safety management system." A proposal is under review to make this provision mandatory so that both IMO instruments are compatible.

Shipboard procedures

One test of crew competency is the ability to follow operational procedures properly. This is reflected in recent amendments to other IMO conventions relating to operational control. Revisions to STCW are intended to be compatible with these amendments in stressing the need for crew members to be familiar with procedures.

The draft text of the proposed amendments includes a requirement for operating companies to ensure that "seafarers on being assigned to any of its ships are familiarized with their specific duties and with all ship arrangements, installations, equipment, procedures and ship characteristics that are relevant to their routine or emergency duties." As with communication skills, this principle is reflected in the ISM Code, and will be reviewed to ensure compatibility with International Convention for Safety of Life at Sea (SOLAS) provisions.

Basic safety training

To ensure that the STCW Convention covers seafarers who are not required to be certificated, a regulation is included in the draft which would require all seafarers to "receive basic safety training or instruction." All individuals employed or engaged on a seagoing ship would be required to receive familiarization training in personal survival techniques or instruction on what to do in certain conditions.

Those assigned to pollution prevention duties would have more advanced basic training in matters such as fire fighting and elementary first aid.

Fatigue prevention

The current STCW Convention includes this provision on fatigue: "The watch system shall be such that the efficiency of watchkeeping officers and watchkeeping ratings is not impaired by fatigue. Duties shall be so organized that the first watch at the commencement of a voyage and the subsequent relieving watches are sufficiently rested and otherwise fit for duty."

The proposed revision to expands on this with a new regulation: "Each administration shall, for the purpose of preventing fatigue, establish and enforce work hour limits and/or rest periods and/or limits in periods of responsibility for watchkeeping personnel."

The United States proposed that specific work hour limits should be prepared as guidance for implementing this new regulation. As a starting point, the United States suggested a text based on the Oil Pollution Act of 1990 (OPA 90) limits, plus a continuous period of rest, as follows:

> **".1 Individuals assigned to watchkeeping duties as officer in charge of a navigational watch, look-out, helmsman, engineer officer in charge of a manned engineroom, or a member of an engineering watch should not be permitted to work more than (15) hours in any 24-hour period, and no more than (36) hours in any 72-hour period, except in an emergency or drill.**
>
> **".2 These individuals should also be provided with a continuous period of off-duty rest of at least (six) hours in any 24-hour period, during which no work should be assigned, except in an emergency or drill."**

A modified version of this principle is included in the proposed revisions to STCW. It stipulates that except in an emergency, a drill, or other overriding operational condition, an individual who is assigned duty as an officer in charge of a navigational watch, a lookout or a helmsman shall be permitted at least ten hours of rest in 24-hour period. This may be divided into no more than two periods, one of which shall be at least six hours long. A minimum of 70 hours of rest are provided each week.

Manning

Although the STCW Convention is not technically considered a "manning instrument," the United States has indicated that guidance is needed "for ensuring factors which affect crew performance are fully taken into account in a ship's safe manning document.

"These factors include (a) the rate of turnover in the crew; (b) the need for adequate time for new crew members to become familiar with complex shipboard arrangements, and other opportunities for onboard training; (c) workload associated with operational requirements and maintenance of vital systems, as well as general ships maintenance duties; (d) difficulties in communication among crew members who do not share a common language; and (e) the need to have properly supervised teams to respond to emergencies while other operational and navigational requirements continue to be met."

Such guidance is more likely to be developed in the context of the SOLAS Convention, which requires ships to be issued a safe manning document. However, as a fundamental human element issue, the concern for manning implications has influenced the course of IMO deliberations on STCW many times.

Casualty analysis

From the beginning of the effort to revise STCW, concern has been expressed about the lack of reliable casualty data to indicate where a critical chain of events might have been broken by having better trained, more competent seafarers involved in the operation. In other words, it is rarely clear in cases where human error has been the contributory cause of an accident, that the error might be prevented in the future by making improvements in the STCW Convention.

The need for careful human element analysis is essential if lessons are to be learned from casualties involving human behavior and performance limitations.

An underlying purpose of STCW revisions is to ensure that lessons learned from casualty analysis can be reflected more quickly in improved standards of competence.

Mr. Christopher Young is a staff member of the Vessel Manning Branch, Merchant Vessel Personnel Division.

Telephone: (202) 267-0229.

"How many mariners?"

By Dr. Anita M. Rothblum

"How many people does it take to change a light bulb?" is a joke with many punch lines. In this case, it doesn't really matter what the answer is, as long as it is funny. But the question, *"how many mariners does it take to sail a particular vessel safely?"* also has dozens of answers. Unfortunately, if answered incorrectly, there can be deadly serious consequences.

In the 1960s, merchant vessels commonly sailed with crews of 40 or more. Things changed radically over the past 30 years, as increasing automation and economic pressures launched a trend toward smaller and smaller crew sizes. We have reached a point where shipping companies request crew complements smaller than those mandated by regulations.

At the same time, casualty statistics demonstrate that human error contributes to the vast majority - from 60 to 80 percent - of marine casualties. Some of these errors are the result of overworked crews.

The economic desire to decrease the number of crew members aboard ships is confronted by the fear that this might escalate maritime accidents. Thus it becomes increasingly important that we find the right answer to the question, *"how many mariners?"*

Safety factors

Safe, efficient vessel operation depends on many factors. Anecdotal evidence abounds. Mariners rattle off dozens of sea stories about near misses due to, for example, a shipmate being overly tired from duties or watch schedules.

Unfortunately, there is little quantitative evidence tying specific operational factors to mariner performance and ship safety. The Coast Guard's Research and Development Center (R&DC) is trying to identify the operational variables that contribute most to performance and safety. Some factors under study are:

- **Watch schedules.** There are several different schedules used commonly today, and research is showing that they are not compatible with the basic human need for a relatively long period of uninterrupted sleep (typically about eight hours).

Times have changed! *And these are just the berth deck cooks aboard the USS Powhatan in the 1870s.*

- **Crew size.** Streamlining crews places heavier demands on each member, risking overtaxing mental and physical capabilities, and increasing fatigue.

- **Voyage duration.** The longer the voyage, the more likely cumulative sleep deprivation and chronic fatigue (and, perhaps, chronic boredom) will impair a mariner's ability to perform.

- **Frequency of port calls.** Port calls are often marked by a frenzy of shipboard activity which can continue non-stop for hours. The resulting acute fatigue can affect the safety of both the cargo activities and subsequent departure.

- **Environment.** Humans do not operate as effectively on ships bandied about in rough seas or when subjected to strong, frigid winds.

Industry partnership

Commercial shippers want to understand the factors that influence safe, efficient vessel operations. The 13 United States-flag shipping companies invited to participate in a Coast Guard R&DC study responded enthusiastically, creating the partnership necessary for a thorough, scientific investigation.

Photograph is courtesy of the U. S. Naval Historical Center.

An R&DC research team will ride commercial ships to discuss crew perceptions of the effects of different operational factors and to collect quantitative data during the voyages. The data will probably include types of activities performed during on- and off-duty hours, sleep duration and quality during the voyage, physical or stress-related complaints, and scores on performance tests sensitive to changes in human adaptation to the work environment. A series of "research rides" on various vessels will show how different shipboard environments relate to safe, efficient operation.

Shipboard model

Establishing links between operational variables and crew performance partially answers the question, *"how many mariners?"* because it helps to explain the interrelationships of these factors in normal operations. However, we can't stop here. We need a way to predict *"how many mariners"* for any given ship in any operational environment.

The solution is to develop a model of shipboard operations, which is currently under way. This model contains tasks performed on any given vessel type, and determines how these activities affect the number and type of crew needed to sail a particular vessel safely.

The links discovered between operational factors and crew performance will be used to influence crew size requirements. For example, if it is discovered that frequent port calls are excessively tiring for crew members, additional crew might be required for such voyages. On the other hand, if land-based cargo crews are used, those on ship may be able to perform their duties with fewer members.

The model is based on the types of activities or tasks commonly performed during voyages. Based on the National Research Council's 1990 book, *"Crew Size and Maritime Safety,"* a list of these tasks has been developed and a database is being compiled to contain the average duration of each task, how frequently performed and typical crew assignments for different vessel types.

By giving the model data on a particular voyage (including port call schedule), a particular vessel (type and equipment) and a proposed crew complement, the voyage is simulated by scheduling shipboard activities and by assigning crew members to each. The model also determines whether the proposed crew complement is capable of carrying out all the shipboard duties within union and OPA 90 work hour rules.

Another, more valuable benefit of the shipboard model will be its ability to help us compare the effects of different operations on crew size. By inserting emergencies, such as a fire or severe storm, into the simulated voyage, the abilities of different crew sizes to respond to emergencies can be compared. Thus, an appreciation is gained of some of the safety trade-offs which may be made with smaller crews.

The model will allow a redefinition of crew structures. By comparing alternative structures (for example, looking at dual deck/engine certification, or perhaps a completely novel combination), it can be predicted whether they can be used to reduce manning without risking ship safety.

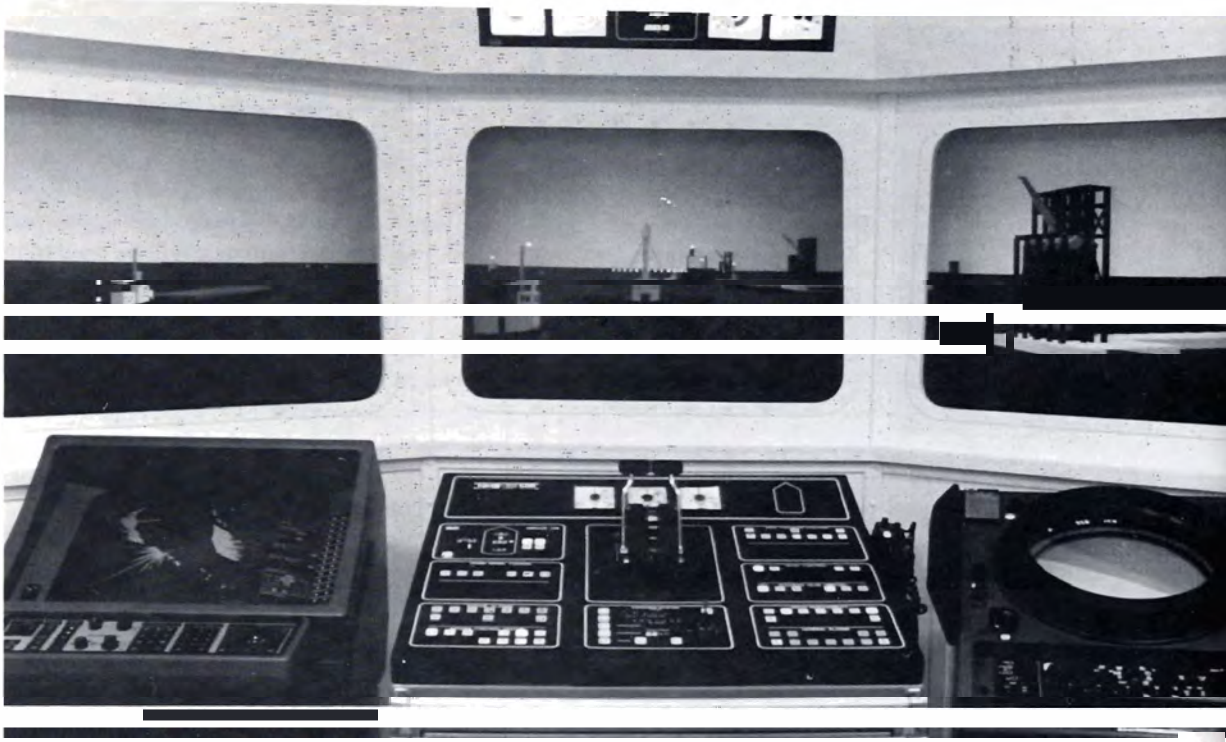
"How many mariners?"

This research should shed much-needed light on the *"how many mariners?"* problem. Careful, thorough investigation will identify safety-related operational factors and quantify their effects on the performance of shipboard activities.

Through such projects, a truly rational basis can be achieved for estimating *"how many mariners"* are required for safe, efficient vessel operation.

Dr. Anita M. Rothblum is the human factors project manager at the Coast Guard Research and Development Center, 1082 Shennecossett Road, Groton, CT 06340-6096.

Telephone: (203) 441-2847.



A simulator is a good training tool, but it takes more to run a ship.

Coast Guard probes human factors

By Dr. Marc B. Mandler

Humans are fallible. We get tired. We forget. We lose alertness. We make mistakes. In demanding occupations like the merchant marine, it is these typical human traits that often contribute to accidents. Government and industry try to correct these fallibilities through education and regulation.

The Coast Guard prescribes work hours for some crews. We set training and qualification requirements. We mandate that certain equipment be carried on vessels. We inspect vessels. We focus a great deal of attention and resources on accident prevention by reducing human error, yet statistics continue to show that human error is still at the root of most accidents.

Reducing human error in the maritime industry is not simple, though it is a reachable goal. Through appropriate, systematic study of the marine system, it is possible to nibble away at factors that contribute to human error.

The Coast Guard Research and Development Center (R&DC) has undertaken a long-term, multifaceted research program to understand the role of the human in the marine system, and to identify and develop countermeasures to minimize or control factors that contribute to human error.

Systems perspective

The function of the marine system is to move people, goods and services over the water as safely and efficiently as possible. The system is a complex set of interrelated elements including technology, environment, organization and human. Problems can be rooted in any one element or a combination of elements.

Because the elements interact, it is often difficult to change one without affecting others. For example, a desire to reduce crew fatigue levels might prompt a rule that crews work fewer hours in a 24-hour period. This might necessitate crew additions, which would increase operating costs. This increase might reduce the emphasis on preventive maintenance, increasing the probability of a mishap. It is conceivable, then, that a change motivated by the desire to improve one element of the system could have negative consequences on the system as a whole.

Research program

In 1992, a planning effort began to define human factors-related problems in the maritime community. The effort resulted in a long-term research plan to address five major areas:

(1) manning, qualifications and licensing;
(2) automated systems' design;
(3) safety procedures and data;
(4) communications; and
(5) organizational factors.

The R&DC is conducting projects in the first three areas.

The research is being carried out by four R&DC scientists in coordination with professionals from both government and the marine industry.

Automated bridge systems and electronic navigational aids demand new knowledge and skills.

Manning, qualifications and licensing

Safe vessel operation relies on the ability of the crew to perform shipboard operations. This ability depends on the number and qualifications of the crew members, as well as their physical and psychological conditions. Variables such as fatigue, drugs, temperature, and noise can greatly affect performance. The R&DC is conducting four projects in this area.

Automation qualifications

Automation is becoming more prevalent on commercial vessels, and when it is introduced, the mariner's tasks change. Certain manual tasks may not longer be necessary and are often replaced by new duties related to the operation of automated equipment. In some cases, tasks formerly performed by two or more mariners are now combined for a single crew member. New knowledge and skills required to operate a vessel need to be reflected in the qualifications and licensing/certification requirements of the crew members.

The R&DC has developed methods to assess how a given automated system changes tasks, and the knowledge and skills of the crew. These methods are being applied to various automated systems on the bridge and in the engine room. The consequences of automation on shipboard tasks, mariner skills, work-load, comprehension and Coast Guard training and qualification requirements are under study.

Continued on page 20

"Reducing human error in the maritime industry is not simple, though it is a reachable goal. . . . it is possible to nibble away at factors that contribute to human error."

Continued from page 19

Minimum crewing standards

There aren't any well-accepted methods to establish minimum safe crewing levels for commercial vessels. A multi-year research and development effort started in 1994 might help the Coast Guard and industry determine minimum crewing requirements. The method relies on a detailed breakdown of all tasks that must be performed by crews operating during different phases of a voyage. This method considers the crew numbers and qualifications needed for these tasks during the entire voyage.

An important feature of the method is that it identifies assumptions about tasks and crewing for various ship types, as well as differences between the proposed crewing of a given vessel and the "baseline" assumptions.

This method can improve communication between the Coast Guard, shipping companies and labor unions regarding rationales for different crewing complements.

Human resource management

Crew fatigue and alertness have been industry concerns for years, yet little research has been conducted on the effects of work characteristics such as watchkeeping schedules, tour lengths, port call numbers, vessel types etc. on crew performance.

The R&DC is developing at-sea data collection tools to be used on a number of ships during actual voyages for up to 60 days. Research scientists will ride the ships, interviewing crew members to collect performance data for detailed analysis to determine the relationships between mariner characteristics and crew performance.

Rules of the road tester

Licensing examinations evaluate the knowledge of mariners. There is concern, however, that pencil-and-paper tests are not adequate evaluators. The R&DC is evaluating desktop simulation methods to test knowledge of the rules of the road.

Simulation is being considered because it can present realistic at-sea scenarios to prospective mariners and record their responses. Mariners control a simulated vessel in a simulated waterway, demonstrating their abilities to detect potential threats and take corrective action. A computer records mariner actions and "grades" them according to a scheme developed by expert mariners. The interactive rules of the road tester is being evaluated at the Merchant Marine Academy at Kings Point, New York.

Automated system design

This is concerned with incorporating human factor principles in the design and use of automated systems. The distribution of information to multiple workstations and crew members, and the impact of automation on job performance are areas in which research is required.

We have recently completed one project in this area.

Vessel traffic service

The Coast Guard operates a vessel traffic service at various ports, which provides information on local hazards (i.e., dredging operations in a channel), monitors marine traffic, and relays traffic information to mariners to avoid collisions and keep traffic flowing smoothly and safety. A given traffic service unit has a few watchstanders monitoring large regions. There was concern that during peak traffic hours, that workloads at certain units may be nearing dangerously high levels.

Task and workload analyses were performed at two vessel traffic service units. The data were analyzed to determine the elements that affect watchstander workloads, and recommendations were made for equipment and job design changes to increase the effectiveness of the watchstander.

To avoid collisions, marine traffic is monitored at various ports by the Coast Guard's vessel traffic service.

Safety procedures and data

Decreasing the frequency of marine accidents depends on safety procedures and data. Safety-related data, such as on the causes of marine accidents, lead to an understanding of the root causes of safety problems and can provide guidance on eliminating the problems. Safety procedures, such as inspection methods, help ensure that specific criteria are met. The R&DC is conducting one project in this area.

Casualty investigations

The Coast Guard has been collecting ship casualty and personnel injury data for many years to analyze factors that affect marine safety. The collection of reliable human error casualty data has yet to be realized, however.

The R&DC plans to conduct a pilot study evaluating an alternative approach to data collection and analysis. An R&DC data base will focus on fatigue's contribution to marine casualties.

Concise data collection methods will be developed with field input from investigating officers. The resulting pilot study will provide a basis for redesigning human error casualty data collection and analysis methods to obtain valid reliable data.

Conclusion

A variety of research projects are funded by the Coast Guard to increase knowledge of human factor problems in the marine system and to find ways to reduce factors contributing to human error.

We need to remain aware that the human is only one element in a complex system and that a study of the interactions between the human and other elements of the marine system is required to obtain valid knowledge about human error.

Dr. Marc Mandler is chief of the Systems Analysis Branch of the Coast Guard Research and Development Center in Groton, Connecticut 06378. Telephone: (203) 441-2615.

Reducing human error on Coast Guard cutters

By CDR Walter E. Hanson

Introduction

The December 1989 grounding of the Coast Guard cutter *Mesquite* at Keweenaw Point in Lake Superior forced the service to take a hard look at "how" it did business. Hard on the rocks, the hull split open, causing uncontrolled flooding. There were only three minor personnel injuries, but the cutter was lost.

The *Mesquite* had been working on an aid that marked a shoal. The deck officer had failed to fix the ship's position before departing the area, and the commanding officer had failed to verify the ship's position and navigation plan before the course was ordered.

About 10 years before, the cutters *Cuyahoga* and *Blackthorn* had been lost. The Coast Guard then instituted controls, including periodic examinations for its deck watch officers and rigorous seamanship refresher courses for all prospective commanding officers and executive officers.

These controls, however, did not prevent the loss of the *Mesquite*. Human errors brought about by ineffective planning, lack of situational awareness, stress and poor judgments were some of the causes. One immediate solution was to introduce bridge resource management principles to Coast Guard crews.

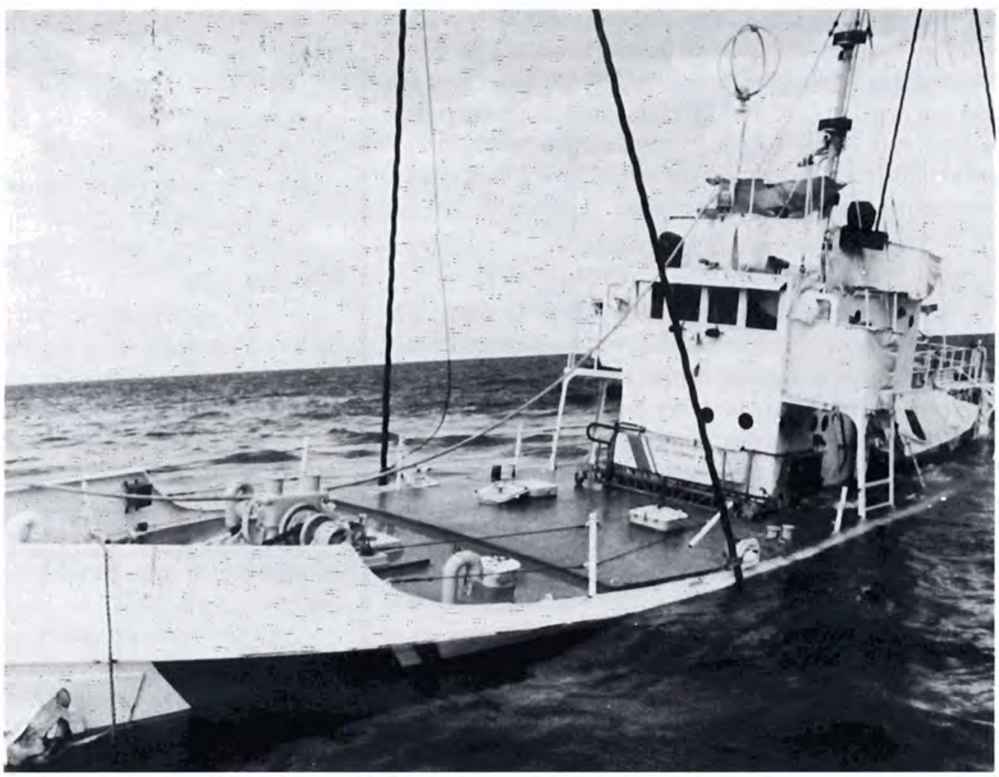
Initial phase (1991-1992)

The Coast Guard started voluntary training for cutter bridge crews. One contractor trained teams and another taught individuals: commanding officers, executive officers, navigators and deck watch officers.

Three-day bridge crew training was designed to facilitate open discussion between ranks. It included structured decision-making and risk management, methods to detect and eliminate poor judgment chains, recognition of a person's loss of situational awareness and how to regain it, methods to enhance team communication, recognition of hazardous attitudes, and how to recognize and control stress.

The five-day individual training covered mission briefing, assertive communications, maintenance of situational awareness, error recognition, decision-making, work delegation and crew performance monitoring.

The training programs had a positive impact. In the two years, 1991 and 1992, compared with 1987-1990, there was a 40 percent reduction in losses from minor navigational mishaps. (A minor mishap causes a property loss no greater than $200,000, and/or injury not resulting in death or permanent disability.)



Cuyahoga
On October 20, 1978, the cutter Cuyahoga collided with a cargo vessel in the Chesapeake Bay and sank. Eleven lives were lost. The Coast Guard bridge crew misinterpreted the other vessel's whistle and did not attempt to call over the bridge-to-bridge radio.

The bridge resource management training produced benefits, but the course delivery system was causing problems. It was too expensive to mandate attendance. Only 25 percent of the target population could be trained using commercially provided sources. Due to personnel changes, crews needed to be trained at least annually. Also the terms and methods differed to the point that a graduate from one course could not readily understand a graduate from the other. In addition, the Coast Guard was unsure if bridge resource management was the correct solution to its problems.

Problem and solutions (1993)

The Coast Guard did an in-depth analysis of its navigational mishaps from 1987 through 1992. They included collisions, groundings, capsizing, sinkings, fouled propellers and towing losses. The financial losses from these incidents totaled $9.4 million.

An analysis of reports from these accidents revealed that human error contributed to more than 60% of them. The statistics in terms of human error contributions concerning Coast Guard cutters and boats were nearly identical.

The primary causes for 68 percent of the reported mishaps were due to poor judgment; 18 percent due to inattention; six percent due to poor supervision and eight percent due to other factors, including poor communications and fatigue. (Poor judgment includes not knowing or understanding the situation, losing situational awareness; inadequate risk assessment, making a "GO" decision when a "NO-GO" decision would be more prudent; or using incorrect information in decision-making. Inattention includes: failure to monitor displays; not maintaining a good lookout; forgetting to enforce standards and procedures; inadequate oversight; or not verifying that a job is done properly.)

A chain of errors contributed to nearly all Coast Guard navigational mishaps. They often began with undetected mistakes in mission planning, which sometimes led to erroneous decisions. Deadline pressures on decision-makers often limited considerations of safer objectives or less hazardous alternatives to meet a fixed goal. Awareness of what was happening may have been temporarily lost. Some individuals may have concentrated on one hazard, failing to see another.

The error chain grew until the accident was inevitable. Experienced commanding officers and coxswains have been involved in such incidents, proving that technical skill alone cannot always prevent disaster.

The analysis determined that bridge crew behavior had to change to correct this problem. The entire crew must assume responsibility for the data and navigation processes. Crew members must be more aware of the situation and the needs of others for information, their stress levels and how they make decisions.

Crew members would be authorized to speak up in the hope that they could identify errors before they lead to mishaps. This empowerment would make cutter safety a solid team effort.

The team concept demands a top-down approach; strong advocacy by Coast Guard hierarchy and individual officers. Commanding officer attitudes must be changed to tolerate behavior that in the past could have been perceived as challenges to authority.

The concept also requires that information processes, such as decision-making, risk management and error "trapping" be standardized for full team comprehension. (Error trapping is detecting misinformation or poor judgment that could affect navigation, and having the situation resolved.)

Team coordination (1994)

Existing training programs were restructured and expanded into seven critical skill areas, titled, "team coordination."

Seven skills

1- **Leadership.** Directing and guiding the activities of other team members, stimulating individuals to work together as a team, and providing feedback on their performance.

2- **Mission analysis.** Making long-term and contingency plans; and organizing, allocating and monitoring team resources. Assessing and controlling safety risks, reporting those determined unacceptable to higher authority.

3- **Adaptability and flexibility.** Altering a course of action to meet changing situational demands, maintaining constructive behavior under pressure and working effectively with other team members.

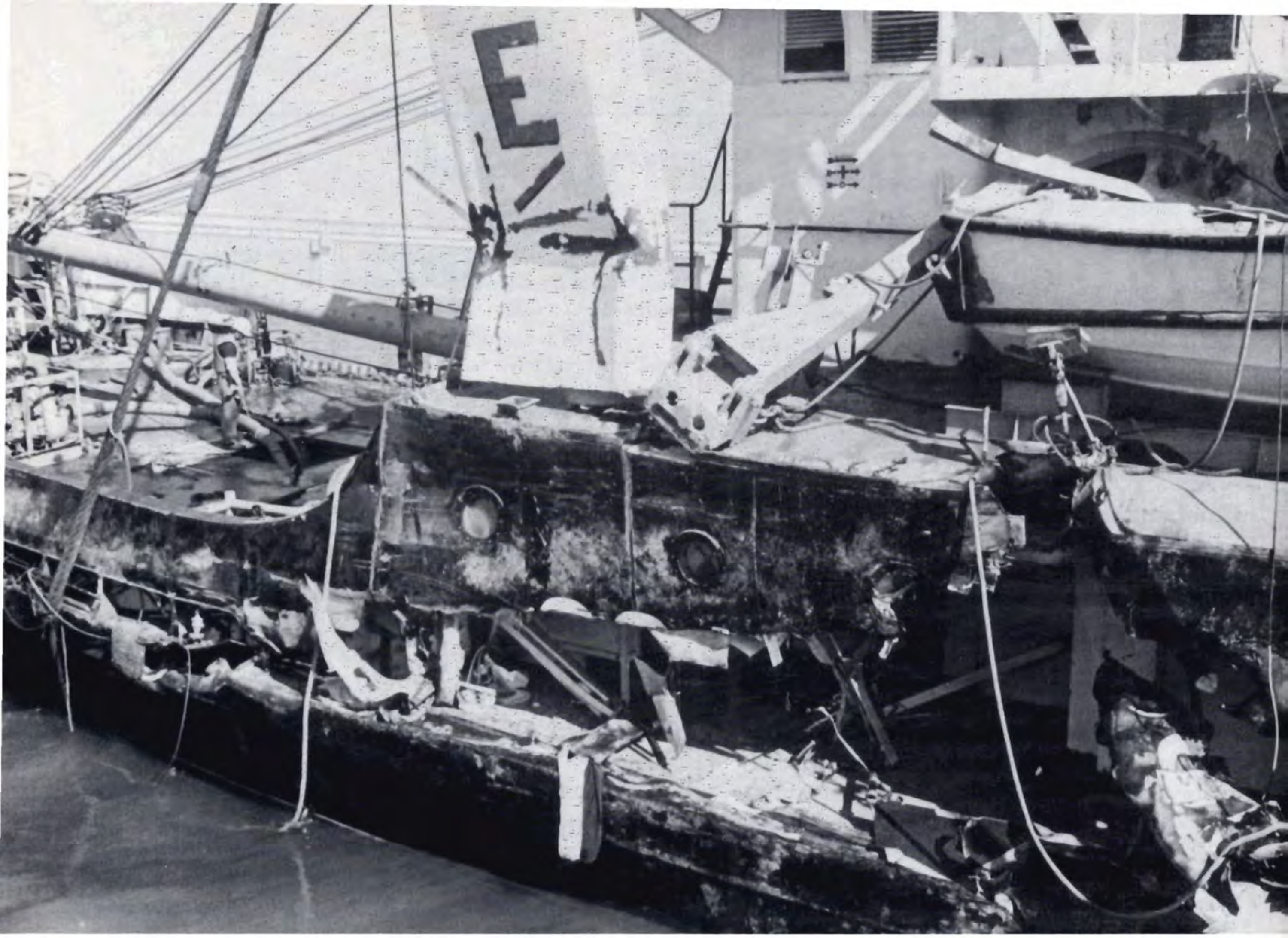
4- **Situational awareness.** Knowing at all times what is happening within the bridge crew and to the cutter.

5- **Decision making.** Applying logical and sound judgment based on available data.

6- **Communication.** Clearly and accurately sending and acknowledging information, instructions and commands, and providing useful feedback.

7- **Assertiveness.** Actively participating, stating and maintaining a position until convinced by the facts (not the authority or personality or another) that the position is wrong.

Continued on page 24



Blackthorn

At 8:30 p.m. on January 28, 1980, the cutter Blackthorn and a tank ship collided in Tampa Bay, Florida. Blackthorn capsized and sank, and 23 Coast Guard personnel drowned. The Coast Guard bridge crew failed to take adequate precautions and use all means available for safe passage. Charts were not appropriately marked. Contacts were neither reported or tracked. In addition, the deck officer had not detected the potential risks.

Continued from page 23

Crew training

To meet the team coordination needs for cutters, a multi-tiered training program has been established. It includes special courses for the command, navigator and bridge crew members. The commanding officer and executive officer receive introductory training before assuming shipboard duties. The navigator receives three days of concentrated training.

In late 1995, each cutter will receive on-the-job training packages for bridge crews. The navigator will facilitate the training.

Conclusion

The Coast Guard has developed a team approach going beyond bridge resource management to reduce navigational mishaps. The approach requires teams to be proficient in seven skill areas, including risk management.

To facilitate team performance, the Coast Guard has integrated skill training into operational schools, along with on-the-job training at each unit. Standards and requirements for team coordination skills have been incorporated into training.

Skills will be maintained through recurring facilitator training and external evaluation. The goal of this approach is to gain a fourfold increase in skill training without an increase in costs.

Performance-based training makes it easy to assess how well crews apply their skills. This, along with team coordination, will create and maintain a new safety culture within the Coast Guard than can serve as a pattern for the maritime industry.

CDR Walter E. Hanson, is chief of the Vessel Safety Branch, Safety and Environmental Health Division, Office of Health and Safety.
Telephone: (202) 267-6863

The enemy from within

By Dr. Richard B. Jones

The main assets and, at the same time, the main liabilities of any business are its people. There would be no product or service without them.

What is not clear, however, is exactly how people contribute to the safety and risk of business operations. This is a very subtle area where risks are the most difficult to identify, quantify and modify. It is also the area that has been shown to be the greatest cause of increased risk.

Documentation

An integral part of any industrial or service operation lies with the people who operate and maintain equipment or perform its vital functions.

In two independent studies performed on nuclear power down-time events in the late 1970s and early 1980s, the single largest "root cause" was human performance. Other categories included component failures, design deficiencies, external factors, manufacturing and documentation. The number of operational failures fundamentally caused by human performance was very high in each study. The actual percentages of down-time events in the human performance category was 42 percent in one study and 52 percent in the other. Subsequent studies continue to document the size of human contributions to failures.

Errors

There are two kinds of errors in human contributions to risk: active and latent.

Active errors are those resulting from almost instantly observable effects. These are the failures we see right away. Active errors are usually associated with direct, responsive operations, such as those performed by drivers, pilots and process-control operators. When an active error occurs, it is either recognized immediately by the operator or by system controls built to detect anomalies and notify the operator.

Latent errors are not immediately noticeable. Their consequences are not evident or realized for a relatively long period of time. In fact, they may not be recognized until they combine with other factors.

Reliability

Some experts believe that while technology is increasing equipment reliability, it is actually reducing the human reliability of its operation. Here's why.

Historically, machine and process operation required direct "hands-on" activity. As process designs increased in complexity and size, computer automation raised people to a higher control level, with fewer hands-on tasks. As control became more precise, local human intervention was removed, moving people to remote control rooms with computer displays. The information received by operators is now channeled through computers and displayed on color, touch-controlled video screens.

Systems have defenses against failures the designers know about. This means that most accidents are caused by failures or combinations of failures not anticipated by the designers. Thus, in order for an accident to occur, a sequence of highly unlikely events must usually take place in the right order at the right time.

Latent failures generally are major players in these events. Technology by itself cannot contain all the required checks and balances for active and latent error detection and correction. Because many accidents are the result of combinations of unexpected conditions, the technology can actually deluge operators with information they can't use, inhibiting them from obtaining the information they need to know.

Ultimately, accident prevention and control requires continuous, proactive (before accidents occur) refinement of the procedures and management practices that employees, including operating crews and supervisors, apply routinely to perform their regular duties.

Continued on page 26

Continued from page 25

Root causes

People are essentially human system components "controlled" by managerial, design, regulatory and other procedures. When a failure occurs and the root cause is attributed to "human error," the people on the scene are often not the root cause of the accident.

It is easy to assign blame this way. After all, the people involved are a highly visible part of the accident sequence. Yet, time after time, the design, managerial and regulatory procedures they must follow are among the real root cause candidates. To reduce the human contributions to risk, one must consider these real root causes in the design of procedures that manage the actions of people.

Fatigue

One should not be hasty in assuming human error due to fatigue is the root cause of accidents in and of itself. Everyone, to some extent, has felt the effects of fatigue.

The risk becomes real when people perform their duties in a state of fatigue. For example, about 30 percent of all commercial airline accidents and 80 percent of general aircraft accidents have pilot, crew, air controller or maintenance personnel fatigue as a contributing probable cause factor. It is also worth noting that industrial accidents such as Three Mile Island, Bhopal, Chernobyl, the *Exxon Valdez* and others occurred at night.

In continuous process industries, and as more activities shift to 24-hour schedules, technological advances can literally outperform the human operators. The risks associated with fatigue are growing as increasing control is placed in the hands of individual operators and competitive demands increase on human crews operating around the clock. Computerized control and automation regulate the manufacturing processes under the remote, computer-filtered control of human operators.

Fatigue is one factor in the human contribution to system risk. There are many other human-related contributors that are not as easily identified. It is known that the manner in which people operate and maintain equipment has a major effect on reliability, but it is difficult to identify the procedures and managerial practices that are at the root cause of problems.

The procedures directing the actions of the people must account for the likelihood of fatigue. Without this recognition, the root causes of failure is largely in the hands of the procedures, rather than the people using them.

Multi-causes

It is usually found that several errors together are to blame for accidents. A component failure, cognitive error or substandard human performance does not, by itself, cause a severe accident. In fact, the majority are caused by faulty procedures and management practices that direct the activities of the people on the scene.

Accidents are caused by a special sequence of events and involve routine practices. In other words, the practices that can, in part, cause, support or reinforce an accident are in operation today. Our challenge is to develop ways to actively identify and correct them.

Fallible decision-making is a part of life. People will always make mistakes. It is futile to try to eliminate all errors. The real task is to ensure that adverse effects of poor decisions can be quickly detected and proper actions taken, or that errors produce small failures. Equipment failures by themselves do not cause accidents. They are caused by a sequence of events.

Web of errors

Obviously, if plant or corporate management recognizes unsafe or high risk practices, corrections are made. Well-defined problems yield well-defined solutions.

The trouble is that accidents are caused by an interlocking web of mostly latent errors. Each alone would not be sufficient to cause the accident. The errors must occur in the right order at the right time. A pessimistic view of this is called fate.

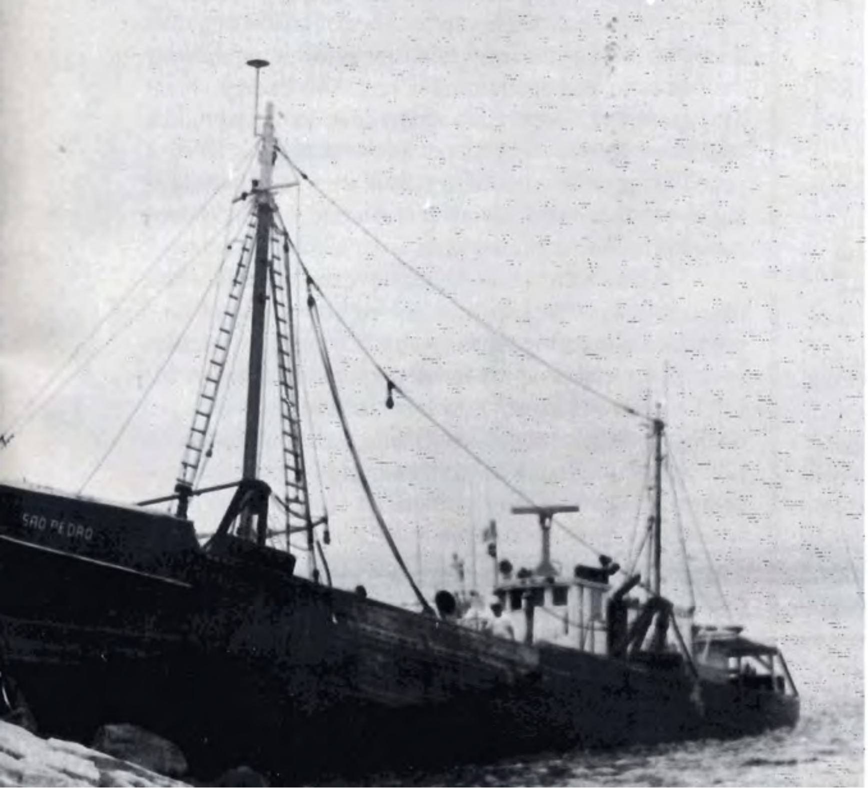
Some individuals view these events as random. It is more likely, however, that seemingly spontaneous accidents occur because of insufficient measurement to identify faulty procedures.

Measurement

The errors we are attempting to discover are subtle, latent and mostly innocuous by themselves. The fundamental objective of measurement is to identify small problems before they become big ones.

On July 14, 1972, the 97-foot fishing dragger <u>Sao Pedro</u> tipped up on the breakwater in the Cape Cod Canal. With a radar perched atop its pilot house, the <u>Sao Pedro</u> come to grief at a radar reflector at the end of the breakwater. This is very difficult to explain except in terms of human error.

Photograph by William P. Quinn, Orleans, Massachusetts.



How can a facility measure its human operational risk component and reduce it by identifying and eliminating high-risk management practices? One way to identify potential problems is to examine the times of day and days of the week when most failures occur.

Historical reference

Through the study of past failures, we can arrive at the times of day and days of the week with the highest and lowest probabilities of error. When this statistical identification is completed, management review answers the question, "Why?" Based on the answers, changes in procedures and management practices can be made, and the results measured.

Once the root causes of failures are determined, remedial steps must be planned to address deficiencies. For example, one company noticed that a higher number of accidents happened during shift changes. Improvements in communication between shifts and more efficient start-up procedures reduced the risks of human error.

Conclusion

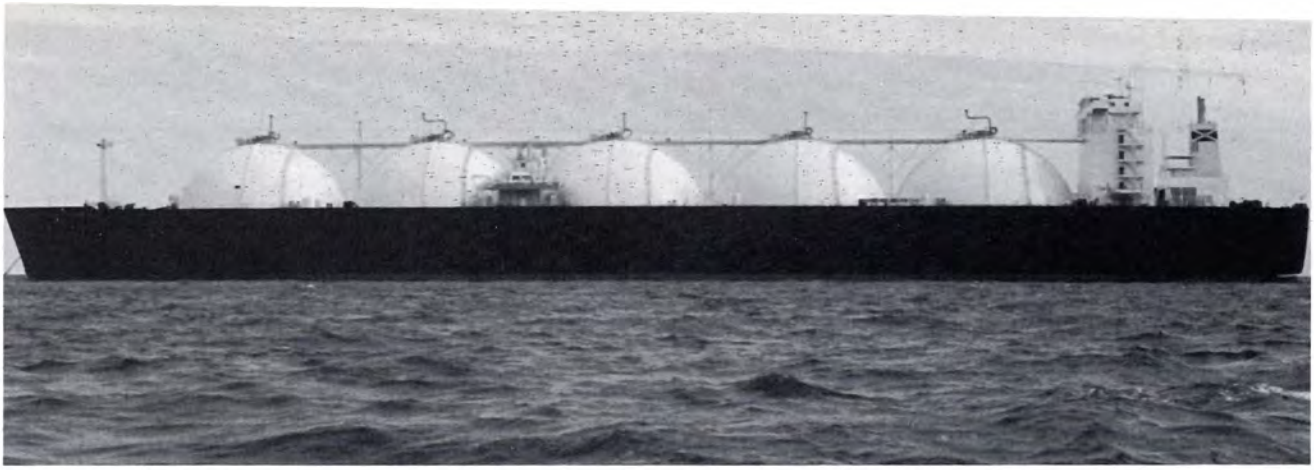
Statistics and risk analysis are decision support tools. The real identification of improvement opportunities comes from the people with the operational experience, not from the numbers.

The people component of risk assessment represents a new and exciting challenge. By managing crews' performances, insights can be obtained to help identify high risk procedures and management practices, the hidden enemy within all organizations. Reducing the human contribution to risk is a virtual gold mine of opportunity.

The material in this article is adapted from the book: __Risk-Based Management: A Reliability-Centered Approach__ issued by Gulf Publishing Company, Houston, Texas.

Dr. Richard B. Jones is director, Statistics and Risk Analysis, Hartford Steam Boiler Inspection and Insurance Company, One State Street, Hartford, Connecticut 06102-3001.

Telephone: (203) 722-5649.



This liquefied natural gas carrier is operated by the Energy Transportation Corporation.

Natural gas vessel operator looks at safety management

By Mr. Peter G. Schaedel

For the past 18 years, the Energy Transportation Corporation, operator of eight United States flag vessels in the Far East, has relied on a safety management system to ensure the safe, reliable transportation of liquefied natural gas in a cost effective manner. This system, which is a major part of an overall quality management system, recognizes that more than 65 percent of all marine casualties are directly related to human elements. Dealing with human elements is essential to achieving the company's objective of constantly reducing the number of vessel and personnel safety-related incidents.

According to a recent Coast Guard initiative, *"Prevention through people,"* the maritime industry has historically addressed vessel safety concerns through technical fixes, trying to reduce the human element as much as possible. However, no matter how much technical safety is designed into marine equipment, casualties will still occur because the human element cannot be totally eliminated.

Technology has not reached a level where vessels can be operated safely without qualified human control. As liquefied natural gas vessels are some of the most sophisticated commercial vessels in service, addressing the human element involved in marine accidents is of paramount importance.

Safety is often defined as "how we protect our employees, the environment or other resources." Quality is directly associated with understanding and satisfying your customer's requirements. In operating a liquefied natural gas vessel, safe and reliable operation is a paramount customer requirement.

Another major requirement is cost efficiency, a commercial necessity in today's competitive environment. Cost control is directly related to vessel, personnel and environmental safety.

System elements

The vessel operating philosophy and pollution prevention policy are the primary elements of the corporation's safety management system. These elements report through independent channels to top management to prevent any conflicts of interest from clouding judgment.

This structure is compatible with the intent of the International Safety Management (ISM) Code (IMO resolution A741(18). The intent of the code is for owners and operators to place safe vessel operations and pollution prevention as core elements of their operating philosophy.

Safety record

Quantifying improvements in safe vessel operation is best measured by the number of vessel incidents, including personnel lost-time injuries, equipment malfunctions and operator mistakes. The Energy Transportation Corporation reports that its vessel mishaps have decreased by 35 percent over the past five years. A major portion of the decrease was in individual lost time injuries, which declined more than 50 percent during the same period.

This record has enhanced vessel reliability and reduced costs. The accidents decreased because of improvements in safety issue approaches and a commitment to corrective action by all corporation employees.

All employees now have the tools within a quality management system to bring safety and pollution prevention issues to the attention of shoreside management. A closed loop incident reporting system starts with safety meetings held on board corporation vessels. The follow-up corrective action process involves all management levels and all departments in efforts to eliminate the root causes of incidents, and prevent them from occurring or re-occurring.

Processes

All of the corporation's quality management processes are directly related to reducing the human element factor as a root cause of vessel incidents. These processes include:

- systematic, closed loop corrective action and continuous improvement;
- documented procedures and work instructions for accomplishing tasks critical to vessel and individual safety, which can be improved or corrected by any employee;
- adoption of best practices in safety related training aids from outside the marine industry, i.e., the Dupont Take II Program described below;
- coordinated planned review of major equipment procurement;
- identification of current and potential personnel skill retainment or enhancement requirements based on any change in the company's operating environment;
- internal and external audits of individual and vessel quality-related practices;
- management review; and
- contingency planning.

1) Systematic corrective action

To allow efficient use of resources and to prevent corrective action from getting bogged down in bureaucracy, the company developed a two-level structure for its systematic corrective action system. On safety and pollution-related issues, the primary way to report incidents and near misses, and make recommendations is at safety and pollution prevention meetings held monthly onboard each of the eight company vessels. Mandatory attendance is required for all senior officers and unlicensed personnel. All crews are invited.

Discussions of personnel injuries, vessel pollution, safety-related incidents or potential incidents, near misses and recommendations take place at each meeting. Minutes are sent to the home office and reviewed by the safety manager, who responds to questions or incidents requiring corrective actions.

Addressing safety and pollution related issues that require changes in policies, procedures, or corrective action fleetwide is done through a continuous improvement process. This is a systematic mechanism for reporting and reviewing problems, prioritizing them and carrying out solutions.

2) Established procedures

Detailed guidelines or procedures are written for tasks critical to providing quality vessel operating services. Their receipt is acknowledged when distributed to ensure that all employees are aware of the latest instructions applicable to their jobs. A major portion of the instructions relates to vessel and personnel safety. All employees can enhance these procedures through the continuous improvement process. Deviations from established procedures must be reported.

Allowing employees to deviate from company policy when conditions warrant gives them the flexibility to meet quality objectives in an ever changing operating environment. Reporting deviations ensures corrective action will be taken if needed.

As an example, the failure of a mooring winch will disrupt the standard mooring arrangement. The master must deviate from the company's standard mooring practice to ensure the vessel's safety. He or she will then notify management through a continuous improvement process of the actions taken to temporarily resolve the problem. Management, in turn, will examine the situation, make any necessary documentation changes and permanently resolve the problem.

This process can be applied to many situations. Most importantly, it maintains fleet standards, keeps management informed, and ultimately achieves a safe working environment.

3) Dupont Take II Program

A series of video presentations developed by Dupont demonstrate how individuals interact safely in their work environment. Called "Take II," the videos promote active exchange of ideas among views on achieving safety on board. The films, which are shown weekly on corporation vessels, have been instrumental in reducing onboard injuries through safety awareness.

4) Equipment procurement review

A coordinated review of any new major equipment to be installed onboard operating vessels is required to examine potential safety and pollution related issues. The review also determines the training necessary to ensure safety in both the installation and operation of the new equipment.

Continued on page 30

Continued from page 29

5) Personnel skill

One of the most important tools used to eliminate the human element and reduce the technical element in marine accidents is to ensure that operating personnel are well trained, with skill levels matching performed tasks. The Energy Transportation Corporation's training program takes a multi-faceted approach to assure vessel safety and reliability. It includes:

- working with labor unions to ensure qualified personnel are recruited to work aboard liquefied natural gas vessels;
- conducting training sessions onboard;
- making courses available on safety-related topics for vessel personnel when they are ashore;
- ensuring that labor union-sponsored courses are available for general skill retention and improvement; and
- holding shoreside seminars on management issues for senior personnel, including vessel officers.

6) Internal and external audits

Internal audits are conducted on each vessel at least once a year. Adherence to company policies and procedures concerned with safety and pollution prevention is a major part of this audit. Major discrepancies uncovered are reported through the continuous improvement process, allowing for corrective action.

The Energy Transportation Corporation's main and regional offices and two randomly selected vessels are subjected to external audits annually by Lloyds Register Quality Assurance. This verifies that the company is complying with all international regulations dealing with the safe operation of ships and pollution prevention. The audit also checks that the company is complying with internal documented procedures.

7) Management review

Quarterly senior management reviews examine all aspects of the safety management system to determine whether company objectives are met. The reviews include safety- and pollution-related incidents during the previous quarter, safety- and pollution-related continuous improvement requests in the system, corrective actions to be taken, and results of previous actions.

8) Contingency planning

Contingency planning minimizes the negative aspects of safety- or pollution-related incidents through quick and efficient responses. The development of contingency plans reduces human error in responding to safety- and pollution-related incidents. They also ensure continuous training of appropriate personnel to respond to emergencies.

The corporation has defined 12 safety-and/or pollution-related incidents most likely to occur, based on historical statistics. Each vessel is required to drill responses for one of the 12 defined emergency situations every month. Examples of these situations include loss of steering in confined waters, loss of the main engine, evacuation of an injured person from a confined space, and response to an oil spill on deck during bunkering.

Employee motivation

Employee acceptance of the safety management system is crucial to its success. The Energy Transportation Corporation uses motivation to promote this acceptance and overcome elements which discourage it. Such elements include:

- well-defined management hierarchies, creating strong superior-subordinate relationships;
- traditional control over individuals, encouraging dependency and reducing freedom of choice;
- command unity reinforcing subordinate roles of workers; and
- specialization which breaks down jobs into small tasks, frequently leaving some employees with less satisfying work.

To overcome these negative elements, employees are empowered to contribute to their own safe environment and that of co-workers. This helps the employee assume an active role, giving him or her avenues for addressing concerns directly to upper management levels. This approach is supported by a management philosophy that promotes teamwork, shares information and practices positive recognition.

Rewards, such as merit salary increases, acceptance by peers and a sense of accomplishment influence workers in different ways. What may be important to one may mean less to another. However, one reward usually stands out above the rest. This is employee recognition by approving and implementing their suggestions, which creates a feeling of individual importance at all levels.

Cost efficiency

To compete in the global marketplace, cost efficiency is essential. Costs involved in major casualties are substantial. Costs for individual accidents, such as lost time, are also substantial. In the Energy Transportation Corporation's case, the average cost for lost-time accidents is about $15,000. (A lost-time accident causes injury requiring an employee to be repatriated off the ship.)

It has been estimated that hidden costs, including lost productivity and shoreside resources expended are between two and three times the direct costs. This is a substantial drain on a company's ability to compete.

This liquefied natural gas carrier relies on a safety management system for reliable cost efficiency.

Critical time

The move by the international maritime community to embrace quality management comes at a critical time. Freight profit margins are extremely low with substandard operators still prevalent and exerting stiff competitive pressures in the marketplace.

The intent of the ISM Code, mandatory for all tank vessels by July 1, 1998, is to level the playing field by holding all vessel operating companies to the same minimum standard. This will reduce the number of safety- and pollution-related incidents.

This goal, however, will only be reached if compliance with the code is market driven. The driver will be port states requiring strict compliance with the code to enter their ports. If compliance is not driven by the market, reputable operators will be forced to cut corners to compete with marginal ones.

To this date, no major port state has announced its policy in this regard. With some 40,000 commercial vessels worldwide requiring a comprehensive survey by 1998, and then annually, the announcements had better come soon if maritime safety- and pollution-related incidents are to decrease.

Mr. Peter G. Schaedel is vice president for corporate quality, Energy Transportation Corporation, 1185 Avenue of the Americas, New York City, New York 10036.

Telephone: (212) 642-9800.

Ready . . . Aim . . . Put out the *FIRE*

By Mr. Al Kirchner

Maritime casualties from fire command headline attention worldwide. In recent years, the International Maritime Organization (IMO) has taken a number of formal actions concerning fire protection.

IMO resolution A.647(16) adopted in 1989 reflects the belief that safety performance can improve markedly if ship owners and operators paid more attention to training and fire prevention practices, fire fighting and fire-protection system maintenance.

Since 1989, interest in these performance improvements has intensified . In 1990, IMO issued MSC Circular 544, "*Fire Drills and On-Board Training*," which includes draft regulations with minimum standards in the annex. This circular serves as a starting point for a future amendment to the International Convention on Safety of Life at Sea (SOLAS). A report by the General Accounting Office in March 1993 on cruise ship safety stressed the need for this course of action.

Based on findings and recommendations of both the National Transportation Safety Board and the General Accounting Office, the Coast Guard submitted a position paper in July 1994 to the IMO seeking to improve operational readiness in shipboard fire protection.

The Coast Guard paper proposed a number of human performance and technical initiatives through amendments and guidelines to SOLAS. In particular, aim was taken at improving general fire prevention awareness among crew members; establishing more effective inspection, testing, maintenance and operational programs for installed fire detection and suppression systems aboard ship; and, finally, setting realistic performance standards for fire-fighting parties.

In developing these proposals, careful attention was paid to ensure that they did not increase crew size, to hold costs to a minimum, and to link each requirement to actual losses or an established engineering requirement. The Coast Guard relied heavily on the expertise of industry and the maritime fire-training community in developing the proposals.

IMO should issue performance standards for industry training and evaluation in all three areas of concern: l) fire prevention; 2) operational readiness of fire suppression systems; and 3) fire fighting.

Objective

The Coast Guard's current goal is to promote performance-based solutions which are flexible enough for industry to follow and also sufficiently scientifically grounded to be justified as an IMO requirement. A SOLAS amendment must avoid a "how to" approach and provide a "how well" benchmark for performance.

Successful models

The shore-based, structural fire protection community has many successful systems founded on well understood concepts and demonstrated approaches to achieve defined levels of safety. These include fire-risk assessments, fire-growth understanding, water requirements in proportion to fire intensity, and the impact of automatic fire suppression system

Collectively, these approaches offer an ideal, non-controversial and easily understood starting point. With rather simple adaptation into maritime applications, useful and measurable fire-safety performance standards can be developed.

A fire interrupted the Prinsendam's cruise to Alaska and the Orient in the fall of 1980. When fire-fighting efforts failed, passengers and crew took to the lifeboats. All 500 people on board were saved. Here the seven-year old cruise ship drifts in the Gulf of Alaska.

Fire prevention

Fire prevention measures range from personal fire safety activities to system operational procedures. The former should be a basic core requirement for all ship personnel.

The next level requirement should involve fire prevention measures directly related to individual crew member work stations and, again, apply to all ship personnel.

Finally, the third level would be technical fire-prevention procedures and operational directions for major ship systems and subsystems. These would be applicable only to appropriate supervisors and officers.

Readiness

Operational readiness of fire-suppression systems also have a range of complexity and require different levels of responsibility.

All individuals must master core skills related to their assignments and environments. These include sounding the alarm, recognizing and reacting to an alarm, "first-aid" fire fighting, activation of fixed systems in their work and living spaces, deactivating these spaces and recognizing when systems are not functioning properly.

The next level of competence is more technical and would require certain crew members to perform preventive and corrective maintenance and testing of onboard fire suppression systems.

Finally, ship's officers would be required to demonstrate knowledge of basic operation and capability of each system in their areas of responsibility.

Continued on page 34

Continued from page 33

READINESS

Operational readiness demands that manual fire-fighting forces intervene with the right amount of water before flashover occurs. This is a two-pronged approach.

First, intervention before flashover is an understandable and measurable goal. It is a realistic fire-party performance requirement.

Second, the proper amount of water for the attack means matching the water quenching and cooling capacities with the expected rate of heat release from the fuel load in the fire area.

10 minute drill

This time chart is based on the 10 minutes from ignition to flashover.

Minutes	Event or action
0	Ignition.
+1	Detection (automatic or human).
+2	Report and alarm. Shutdown, isolation and de-energizing measures.
+3	Fire party at muster station. Fire officer's on-scene assessment.
+5	Fire party sets up initial attack at staging area
+8	Fire party begins attack.
+10*	First progress report from fire party officer.
+12	Additional fire parties put hose lines in service. Relief crews and back-up hoselines on standby. Spare air cylinders and medical supplies delivered to staging area. Second progress report.

(* Point at which flashover would have occurred without intervention.)

This check list permits the crew to drill, evaluate and correct deficiencies without supervision.

Fire party standards

While no one would question the need to improve the effectiveness of fire party operations, there is bound to be trade-offs and debates on strategies, operational concepts, performance and requirements. Some arguments can be resolved by looking at shore-based fire protection for models and answers.

The difficult questions concern the unique maritime industry practice of using crews as fire fighters to battle tough outbreaks. The key issues involved are establishing acceptable performance levels and how to achieve them.

A goal of this effort is to develop performance measures for placing the right number of hose lines needed in time to prevent fire flashovers in a particular type of space. (Flashover is the point where the fire gets out of control.)

Based on the time it takes to reach flashover, a series of timed tasks would be performed that could be easily evaluated for deficiencies. Any such weaknesses could be corrected by additional training and drills.

The proposed approach would be designed around four simple procedures for fire-fighting parties: advance the hose line, extend the hose line, withdraw the hose line and search for victims. All fire party leaders and senior officers will need to know the rudiments of an incident command system.

Conclusion

Achieving total operational readiness in fire protection through prevention, system preparation and proficiency will require the cooperation of industry and the fire protection community.

There is also an opportunity to develop a single, comprehensive fire protection guide to eliminate the need to gather and assimilate the information from disparate sources. Such a "one-stop" document would eliminate confusing duplication and resolve conflicts, thereby enhancing fire-safety efforts all over the world.

Mr. Al Kirchner is a fire protection engineer, Ship Design Branch, Marine Technical and Hazardous Material Division.

Telephone: (202) 267-2997.

Learn from mistakes

Human factors in three casualties

By LT Shelley Atkinson

One way to prevent the same type casualty from happening over and over again is to thoroughly investigate and analyze root causes of actual mishaps, and apply the findings in a concrete manner to improve marine safety. It has been estimated that up to 80 percent of all marine casualties have human-related causes. Following is a review of three recent casualties, pointing out the human factors involved and recommending ways to prevent similar occurrences.

Atticos
The bulk carrier sustained only minimal damage to its bulbous bow.

Galveston and *Atticos*

On March 24, 1993, at nearly 3 o'clock in the morning, the United States offshore supply vessel *Galveston* and the Panamanian bulk carrier *Atticos* collided in the Lower Mississippi River near Venice, Louisiana. The *Galveston* quickly sank, resulting in the loss of three lives, while the *Atticos* sustained only minimal damage to its bulbous bow.

The human factors evident are:

- **Failure to maintain a proper lookout visually and by radar.**
  The master on the *Galveston* apparently was distracted from his duties by navigation light problems. He was searching for the light switches on a panel on his left at knee level, while the radar was located on his right at waist level, for three to four minutes before the collision. Unfortunately, he did not survive to explain his actions.

- **Insufficient time to adapt to the dark.**
  The *Galveston* had been conducting cargo transfer operations at a brightly-lit facility, got underway and collided three to four minutes later. It takes about 30 minutes for the eyes to adapt to low lighting and 20 percent more time for smokers. It has also been demonstrated that what a smoker sees is 50 percent darker than a nonsmoker. The short period of time between departure from the facility and the collision, and the fact that the master smoked, supports this human factor.

- **Failure to establish a proper passing agreement.**
  The pilot of the *Atticos* reported that he called the *Galveston* and asked for a one whistle pass. Receiving no response, the *Atticos* called again and the *Galveston* replied, "One." The *Atticos* pilot believed that the passing agreement had been understood since the *Galveston* was showing its port sidelight. This was interpreted as an indication that the *Galveston* was changing course to starboard to accomplish a one-whistle meeting. However, the *Galveston* had not changed course. It was continuing downriver. The port sidelight probably became visible to the *Atticos* pilot as a result of being turned on.

  Then, after a pause and in a heightened tone of voice, the *Atticos* pilot said, "I need you to go starboard." The *Galveston* instead had turned to port and the two vessels collided.

  The *Atticos* pilot should have been more prudent and verified the passing agreement after the *Galveston* did not initially respond, and then responded too briefly.

In response to recommendations based on this casualty, the Coast Guard is working with the International Maritime Organization (IMO) to develop a reference manual of maritime terminology, including standard phraseology for bridge-to-bridge communication.

Continued on page 36

Continued from page 35

Morris J. Berman

On January 7, 1994, at 2:30 a.m., the tank barge *Morris J. Berman* was being towed by the tug *Emily S*, when it broke free and grounded at Punta Escambron, Puerto Rico, 11 nautical miles from the tug. The barge discharged approximately 798,000 gallons of #6 fuel oil. The tow line had parted earlier and was replaced with an emergency tow wire, which also parted, causing the barge to break free.

The human factors evident are:

- **Poor judgment and failure to prepare a proper towing system.**
  A change to 33 CFR 155.230 published in December 1993, required emergency tow wires to be rigged and ready for use on all offshore oil barges by June 20, 1994. The tow wires must also have the same towing characteristics. The tow wire used following the first failure did not have the same characteristics as the original wire. Although the requirement did not have to be followed until June, it would have been good practice to comply as soon as possible. Also the emergency tow wire was not attached with a bridle, which is used for directional stabilization of the tow.

  Lack of lubrication and poor maintenance practices by the crew and operating company led to a severely deteriorated wire that failed prematurely due to abrasion and corrosion.

  Before the vessel left port, the senior operator had requested that a new tow wire be installed due to the poor condition of the existing one. This could not be done right away, and the operator decided that he could complete the voyage with the existing tow wire, although he did not personally check on its condition.

  An operating company representative did not want to delay delivery of the fuel by waiting for the new wire, because of penalties that would be imposed by the receiving facility if the cargo was not delivered at a certain temperature. The barge could not heat the cargo and the representative felt that delay would cause it to cool. The facility, however, estimated that the cargo temperature could be maintained for several hours to several days.

  Failure to maintain an adequate catenary (the curve assumed by a flexible inextensible cord of uniform density and cross section hanging freely from two fixed points) in the tow wire caused it to whip, resulting in extreme wear on the eye.

- **Failure to maintain a proper watch.**
  During the earlier parting of the tow rope, the operator on the watch reported that he felt the tug surge forward. It is probable that the operator of the tug was asleep during his midnight to 6 a.m. watch, since he did not become aware of the loss of the barge until the men on the barge contacted him on the radio at 4 a.m. It was determined that, in all likelihood, the tow line parted at 2:30 a.m.

In response to recommendations proposed concerning this casualty, the Coast Guard will revise the Navigation Vessel Inspection Circular (NVIC) 5-92 to include information on approved wire lubricants and clarify 46 CFR 155.230 concerning the weight of emergency tow wires.

The Coast Guard will also update tests given to license applicants. A regulatory development project initiated before the casualty will provide minimum safety and operational standards for towing systems, as well as guidelines on inspection of towing equipment.

orris J

Noordam and *Mount Ymitos*

On November 6, 1993, around 8 p.m., the passenger ship *Noordam* and the loaded bulk carrier *Mount Ymitos* collided two miles south of Southeast Pass in the Gulf of Mexico. Both vessels were damaged, but there were no serious personnel injuries or pollution.

The human factors in evidence are:

Failure of officers on the *Noordam* to maintain vigilant watch.
The chief officer on the *Noordam* did not detect the presence of the *Mount Ymitos* visually or on radar until the vessels were less than a mile apart.

Before the watch change at 8:30 p.m. on the *Noordam*, the new watch checked the radars but saw no approaching vessels. The departing watch officers also did not detect any vessels. The radar was not being used for collision avoidance or observation of moving targets.

Preoccupation of *Noordam* bridge crew with arrival activities.
Although there were nine people on the bridge at the time of the collision, no one saw the *Mount Ymitos* visually or on radar.

The bridge crew was preoccupied with required paperwork and other activities concerning the vessel's arrival in New Orleans.

The number of people on the bridge may have increased the complacency level and lowered the attentiveness of the watchstanders in keeping a dedicated visual and radar watch.

Failure to communicate.
The pilot on the *Mount Ymitos* entered the approaching vessel into the automatic radar plotting aid, but the master and third officer were unaware of this and inadvertently removed the entry.

Radio calls were made, however, the heavy accent of the master on the *Mount Ymitos* may have caused the bridge watchstanders on the *Noordam* to fail to recognize the master's radio calls as being directed at a passenger vessel.

In response to recommendations made following this casualty, the commandant said New Orleans is one of two lead ports for installation of a state-of-the-market vessel traffic system (VTS) 2000. This VTS is expected to be operational in 1998-1999.

In its current efforts to revise the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, the IMO will consider requiring officers to be trained in bridge resource management and other subjects that would be useful in preventing the situations uncovered in this casualty.

Mount Ymitos (above) and Noordam (below) are shown after colliding in the Gulf of Mexico.

Improvements

The Coast Guard initiated an improved comprehensive data-collection system for human factors information. An integrated plan for human factors research has also been developed. Research areas are: manning, qualifications and licensing; automation design; safety procedures and data; communications and organizational practices. The goal is to establish a technical basis for developing technologies and regulations.

The correct response to casualties is to study the mistakes that caused them and try to prevent them from ever happening again.

LT Shelley Atkinson is a casualty review analyst with the Casualty Review Branch of the Marine Investigation Division.

Telephone: (202) 267-1418.

Crystal Harmony cruises through the Panama Canal.

Human factors in passenger ship safety

By Mr. Rajiv Khandpur

Complex system

Today's passenger cruise liner is a large complex system, which includes both people and equipment. Typically, an ocean-going cruise ship carries about 2,000 people — about 1,300 passengers and 700 crew. The passengers are all ages and come from diverse backgrounds with various levels of ability.

Cruise companies are no longer in the transportation business, but in the entertainment industry. Though, typically, there is one crew member for every two passengers, most of the crew are not professional seafarers (traditional deck and engine crews). The majority of the crew is entertainment staff — hotel personnel, caterers and performers. Of the 700 crew members, less than 100 would be professional seafarers.

To further compound the mix of people aboard ship, the crews are from different parts of the world. One ship could carry as many as ten different nationalities, speaking as many languages.

Industry growth

In the past decade, the cruise industry has grown tremendously. The annual number of passengers vacationing on cruise ships has doubled in 10 years, from two million in 1983 to four million in 1993. This trend is expected to continue into the next century.

At any given time, approximately 120,000 people embark on passenger ships operating out of United States ports. (About 63 percent of cruise ship traffic worldwide operates in United States waters.)

Organization

The Coast Guard has a mandate to ensure the safety of passengers and crews sailing out of United States ports. The responsibility for accomplishing the tasks to fulfill this mandate actually are shared by other organizations. They include the flag and port states, classification societies, ship owners and operators. Organizations, such as the International Maritime Organization (IMO) and associations, such as the International Council of Cruise Lines (ICCL) help facilitate the tasks involved.

Ultimately, however, it is the individual ship owning company that decides the level of safety which provides the best balance between being competitive and profitable, and maintaining good will. Poor decisions and bad management by the company can translate into unsafe practices at the operational level.

Port-state control

Generally, the Coast Guard can only monitor passenger cruise ships under its authority as a port state. (See the special *Proceedings* issue on port-state control, March-April 1995.) This is because all but two ships operating out of United States ports fly foreign flags. Of the world fleet of 256 passenger cruise ships, only one percent is flagged in the United States.

Consequently, even though the Coast Guard has a very active port-state control program, it is only oversight, and relies heavily on the flag states and classification societies to do their share.

Human factors

Managing such an enormous, complex system of equipment, machinery and people aboard ship, which operates under a much larger, more complicated system of ports and waterways, presents massive human factor problems.

How does one define this big, mushy, amorphous thing called "human factors?" How does one give it shape or substance? Even the human factors community is divided on the answers.

Some see it as a design issue, such as the man-machine connection, and believe that most issues can be resolved at the design stage. Others define it as a training and procedures issue, taking the simplistic view that human beings can be trained for any eventuality. Still others see it as a manning or documentation, or an ergonomic/habitability issue.

Actually, it really is a combination of all these and more — a particular way of thinking, a mindset. No matter how it is defined, the fact is that the subject of human factors is associated with errors caused by people, how and why these errors occur, and how they might be prevented or, at the very least, how their consequences can be minimized.

In the past, great attention was paid to active failures, i.e., the causes of human error immediately preceding a mishap. However, it is now widely recognized that a human error or failure might occur because of a latent flaw in the "system," which could be triggered by local and sometimes relatively minor events.

For example, investigation of the immense *Exxon Valdez* oil spill in Prince William Sound, Alaska, revealed that the immediate cause of the accident was a combination of poor communication between the third mate and the master, and miscalculation on the part of the third mate. This was, of course, human error. However, after further investigation, the error could be traced back to "latent" flaws in the system. These included inadequate company policies and procedures regarding operating with a smaller crew, noncompliance with federal statutes regarding work schedules for deck officers, and noncompliance with company policies on internal drug and alcohol policing procedures.

At this time, there are no established theories or procedures to adequately address this issue, even though various concerned organizations are trying to create an intrinsically safe environment by recognizing that human beings are not infallible, and that systems must be designed, built and operated so that they are error-tolerant.

Passenger evacuation

A more limited objective more easily reached is how to minimize casualties and loss of life in fires and other emergencies aboard ship. IMO has been very active concerning this issue and has developed guidelines based on human factor principles to address emergency escape systems. Typically, the components of such a system are ship management philosophy, ship systems design considerations, crew training and passenger safety awareness.

Emergency stations

The ship evacuation system is based on the premise of first getting all passengers to a muster station. This is an area where passengers can be gathered in an emergency, accounted for, given instructions and prepared for abandoning ship, if necessary.

The old practice of assigning passengers to a particular lifeboat is largely discontinued. Instead they are assigned to muster stations, from where they can be directed by designated crew members to a nearby embarkation station. All escape arrangements, such as routes, corridors, sign postings, safety instructions and crew training are developed from this standpoint.

Safety instructions

A major objective is to enable passengers to find their way out of enclosed spaces in the event of a sudden disaster when normal evacuation procedures cannot be followed.

Ideally, the environment itself should provide clues to direct a stranded passenger out of an enclosed space, especially in poor lighting and other stressful conditions such as smoke or fire. However, since this is not always possible, a combination of briefing on ship safety and evacuation systems, posting of signs, instructions, low-location lighting and directional arrows at strategic locations are used. Specifically, the evacuation system is designed and instructions conveyed so that each passenger:

- is aware of the basic ship layout, including the location of muster stations and survival craft;
- knows his or her position relative to the muster station and an open deck at any given location;
- can find an escape route from any enclosed space to an open deck, and also find an alternate route in the event of an obstruction;
- is aware of lifejacket stowage locations and how to don them; and finally
- is aware of emergency procedures.

Continued on page 40

Continued from page 39

Design issues

Design issues are the meat of regulations under the International Convention for the Safety of Life at Sea (SOLAS). These regulations deal with structural and active fire-protection issues, including detailed equipment and material specifications. They also deal with life-saving equipment standards, and their carriage and configuration requirements on board ships.

These SOLAS regulations are continuously updated to keep pace with technological advancements.

IMO instruments

The many guidelines addressing the issues of safe evacuation of passengers are contained in IMO instruments, such as codes, resolutions and Marine Safety Committee (MSC) circulars. Some of these are:

IMO resolution A.760(18) on symbols related to life-saving appliances and arrangements;

IMO resolution A.757(18) on standards for calculation of the width of stairways forming means of escape on passenger ships;

IMO resolution A.752(18) on guidelines for the evaluation, testing and application of low-location lighting on passenger ships;

IMO resolution A.770(18) on minimum training requirements for personnel named to assist passengers in emergency situations aboard ship.

MSC circular 617 on guidelines for passenger safety instructions;

shipboard safety emergency plan (under development); and

emergency escape arrangements for passenger ships (under development).

Crew training

In addition to the crew being trained to operate and maintain fire-fighting and life-saving equipment, selected crew members are trained in crowd control and the psychological aspects of dealing with passengers in shock or trauma.

Directions

In the past few years, the IMO has included human factors in all its deliberations and has instructed its committees and subcommittees to consider the role of the human element in all their work. An important result of this effort is an IMO document, *"The International Management Code for the Safety Operation of Ships and for Pollution Prevention (International Safety Management {ISM} Code)."*

More recently, the Maritime Safety Committee established a steering committee and panel of experts to review the safety of existing Ro/Ro passenger ferries in light of the tragic sinking of the *Estonia* in the Baltic in September 1994. Among some of the subjects to be reviewed are life-saving appliances, on board evacuation arrangements and communications issues, particularly when ships have multinational crews and passengers. The working group will review basic designs and operational principles of RO/RO ships, and identify hazardous situations they may encounter and propose corrective measures in areas not properly covered.

Summary

A human factors approach toward complex marine systems is now internationally established and accepted. As the many IMO instruments start taking effect, an ever increasing number of shipping companies should start operating in an inherently safe environment.

Mr. Rajiv Khandpur is a naval architect, Compliance and Enforcement Branch, Merchant Vessel Inspection and Documentation Division.

Telephone: (202) 267- 1241.

Carnival Cruise Lines' Ecstasy (below) and Fantasy.

The grounding of the Star Connecticut in 1990 demonstrates deficient watchstand performance.

Bridge resource management can prevent human errors

By Mr. Eric Sager

Introduction

The National Transportation Safety Board (NTSB) has followed the development of bridge resource management as an alternative to traditional bridge management methods for many years. Bridge resource management is defined as effectively using all available resources to achieve safe operation.

Bridge resource management has demonstrated many ways it can prevent marine casualties for commercial and public vessels. Specifically, when investigative analyses of accidents identify officers' deliberate or inadvertent oversights of available information, failures to use available navigation bridge equipment or inadequate use of personnel, there is a good possibility that management and the use of bridge resources could be improved.

Practice

Underlying effective management of bridge resources is an understanding that every officer and crew member uses resources to enhance and coordinate their activities with others on the watch. The use of bridge or vessel resources is not considered the domain of masters alone, and resources may be effectively managed by a variety of approaches or styles, including those resulting from cultural differences.

It is the sense of shared responsibility for safe and efficient ship operation that defines bridge teams. Resources for officers and crew normally include operational information, such as charts, operating manuals and other publications, and ships' navigation equipment and other instruments.

There are also reciprocal roles for mariners using bridge resource management. The master (or conning officer or pilot) must integrate the resources for any given passage or watch, using leadership skills and command authority. This task may include allocating work to personnel. At the same time, the master must indicate his willingness to accept operating information from subordinates.

The role for others on the watch is to perform their assigned tasks responsibly, to help determine plans for vessel navigation, and to be aware of departures from plan or from the expected performance of others. They must make any discrepancies known in time to avert operating errors.

Intercultural or language differences can often be circumvented by deliberate, clear master-to-pilot briefings, and by providing expectations of job performances for multi-national crews.

Continued on page 42

Continued from page 41

Skills and training

Bridge resource management skills enable the planning and deliberate actions for pilots, officers and crew members to perform as a coordinated entity.

These methods and skills are not new. Many effective officers have learned good use of resources from experience or have practiced them intuitively. Shiphandling, seamanship or specialized proficiency with equipment and electronic gear are competencies that coexist with (but are not the same as) the methods for effective use of bridge resources.

As training in bridge resource management takes hold in training facilities in the United States and abroad, subject matter and learning exercises have varied among schools. However, there are common concerns and instructional methods.

Five generic categories of knowledge and skill development frequently identified with bridge resource management training are:

1) development and performance of watch or pilot briefings;

2) maintaining awareness of conditions and circumstances pertaining to the passage (i.e., situational awareness);

3) identifying error chains;

4) bridge/vessel communication; and

5) integration (coordination) of bridge/vessel resources.

It is believed that training in and competent execution of these categories will produce better bridge management, and, therefore, safer vessel operation.

***Queen Elizabeth 2* is drydocked after touching bottom in Martha's Vineyard Sound in 1992 due to miscommunication between ship's officers.**

Casualties

Three recent casualties investigated by the NTSB illustrate deficient officers' performance and the usefulness of bridge resource management training.

The grounding of the passenger ship *Queen Elizabeth II (QE2)* on August 7, 1992, resulted from deficient coordination of watchstanding activities between several officers and the pilot on the bridge.

The ramming of the anchored *Urduliz* by the aircraft carrier *USS Dwight D. Eisenhower* on August 29, 1988, resulted from a progressive series of errors, beginning with the commanding officer's inadequate knowledge of the operational proficiencies of the officers conning the ship. One deficient action led to another until the casualty was unavoidable.

The grounding of the tanker *Star Connecticut* near Barber's Point, Hawaii, on November 6, 1990, demonstrates the relationship between situational awareness and workload, and communication problems between the master and a subordinate.

Queen Elizabeth II

The *Queen Elizabeth II (QE2)* grounded in Vineyard Sound, Massachusetts, during passage from Martha's Vineyard to New York. The NTSB's investigation determined that traditional management practices on the bridge actually segregated the navigation activities of the ship's officers and those of the Massachusetts State pilot who was conning the passage.

The investigation determined that the pilot had not informed the officers of his intended outbound course and the master assumed the pilot had another course in mind. The discrepancy between these two expectations was not known until the pilot ordered the helmsman to alter course (according to his plan). After the *QE2* steadied on the new course, the second officer determined the new course line would take the vessel across a shoal and informed the first officer, who in turn informed the master.

The master told the first officer to tell the pilot to return to the original trackline that he had approved on the ship's charts. The pilot complied and the course was changed. The second officer noticed that the revised course passed over a 39-foot sounding, but said nothing because he knew that the draft of the vessel was 32 feet four inches. (This calculation was accurate when the vessel was at the dock, but did not take into account "squat" characteristics while underway at 25 knots in shallow water. The NTSB believes that the *QE2* was between four and one half to eight feet lower in the water by the stern at the time of the grounding.)

The *QE2* struck rock while proceeding at an estimated speed of about 25 knots.

The absence of an effective briefing between the pilot and master clearly resulted in misunderstood expectations among the ship's officers about the outbound course. Unknown to these officers, the pilot had chosen to use his own navigation methods and courses rather than consult with the navigation officer who had laid out a trackline approved by the master. The officers reacted by following a strict adherence to their chain of command for communicating about the pilot's altered course and relaying the master's decision back to the pilot.

Although the chain of command facilitated accuracy and control of the information flow, it also prevented a realistic critical assessment of the situation and of the master's decision. Consequently, the course change was made without due consideration of ship speed and bottom clearances.

It is probable that if the officers and pilot had discussed the revised trackline over the rocky shoal more openly, they would have recognized the risk of striking bottom because of the squat characteristics of the ship at high speeds. A less formal communication chain should have enabled an integration of decision-making for returning to the master's preferred course. The proper result of this decision-making process would have been either a reduction in speed or a change of course. In bridge resource management terminology, there would have been an opportunity for more open discussion between the officers, crossing lines of authority. This cooperative action could have produced a better decision than one using traditional bridge management methods.

Cooperative thinking that improves the quality of operational decisions is an important contribution of bridge resource management that theoretically results from integrated personnel actions.

The NTSB concluded that the use of bridge resource management techniques would have been useful for Cunard Lines, LTD., officers.

Continued on page 44

Continued from page 43

Dwight D. Eisenhower and *Urduliz*

The aircraft carrier *USS Dwight D. Eisenhower* collided with the anchored ship *Urduliz* at Hampton Roads, while returning to Norfolk, Virginia, after a six-month deployment. The NTSB investigation determined that the casualty occurred because of a series of navigation and shiphandling errors that should have been promptly recognized by the officers conducting the transit. When the commanding officer was made aware of the situation, he was able to maneuver the carrier to lessen the damage, but the collision could not be avoided.

All electronic navigation equipment, steering and emergency systems were operational on the carrier. A visual navigation plotting team and a radar navigation team were taking fixes and had reported that the vessel was to the right of the intended trackline several minutes before the collision. Compass heading changes were noted as negligible.

The commanding officer, the officer of the day and the navigation officer were on the bridge throughout the channel transit. Normally, an officer of the day reports directly to the commanding officer, however, the officer of the day conning the ship was the assistant navigator and was supervised by the navigator.

The decisions and actions that led to the casualty began with the commanding officer's expectations that the navigation officer would adequately plan and monitor the progress of the ship during the transit of the restricted channel.

The navigator's sea duty experience was separated by eight years of aviation duty, although he had completed numerous transits of Hampton Roads on the *Eisenhower*. The officer of the day was qualified for conning while underway during the six-month deployment, but the inbound transit was his first experience in a restricted waterway.

Before their arrival, the commanding officer and navigation officer had discussed whether they should use a professional harbor pilot. The navigator recommended against it, expressing confidence in their ability to make the passage by themselves at Hampton Roads. Reportedly, the use of pilots had been discouraged by the Navy, and the commanding officer agreed with the navigator.

As the *Eisenhower* proceeded inbound, the officer of the day and the navigator were using visual piloting methods. To keep up with the rapidly changing conditions in the restricted waterway, it was necessary for them to forgo plotted fixes on the chart. Instead, they navigated visually, using prominent objects to serve as references.

The ramming of the anchored Urduliz by the aircraft carrier USS Dwight D. Eisenhower on August 29, 1988, resulted from a progressive series of human errors.

About nine minutes before the collision, the navigator ordered the officer of the day to reduce speed from five to three knots. The officer of the day ordered the helm to reduce rpms. The wind was off the port beam at about 20 knots and the normal complement of aircraft had been flown off earlier, reducing the ship's draft. The navigator apparently was unaware that the speed reduction would adversely affect the controllability of the ship.

While these activities were going on, the commanding officer was preoccupied with the presence of official visitors (including two admirals) on the bridge, who were associated with the festive arrival of the ship.

About three minutes before the collision, the visual navigation team had obtained a fix that determined the *Eisenhower* to be 380 yards to the right of the intended trackline and the officer of the day ordered left 10° rudder. Then, several minutes after reducing the speed, the officer of the day told the commanding officer of the speed change. The commanding officer immediately recognized the danger and took over maneuvering of the vessel.

However, the starboard side of the *Eisenhower* struck the bow of the *Urduliz*, which became caught under the overhang of the flight deck. The anchored vessel scrapped down the side of the carrier and was dragged about 1,000 yards.

The navigation and shiphandling errors were probably caused by the inexperience of the officers conning the vessel. The commanding officer was unable to monitor the performance of the bridge watch personnel because of his participation in official activities unrelated to the transit.

There was no evidence that bridge resource management was used during the inbound transit. If it had been practiced, the officers may well have recognized the implications of their decisions before the casualty was unavoidable.

Although the investigation determined that the officers were engaged in many activities requiring considerable attention and energy during the transit, there was evidence that customary priorities were not observed for safe ship operation in restricted waters.

The NTSB determined that none of the officers involved in the casualty had received bridge resource management training, even though they were otherwise extensively trained. The board recommended that the Navy develop and carry out a program of bridge resource management training for shipboard commanding officers, navigators and other bridge navigational personnel.

Continued on page 46

Contineud from page 45

Star Connecticut

The *Star Connecticut,* a 723-foot long United States tank ship, grounded on a reef soon after a nighttime departure from a single point mooring off Barbers Point, Hawaii. The ship's master, the junior third mate and a helmsman were in the pilot house. A mooring master in training was also present as an observer.

The master was notably competent and familiar with the vessel and nighttime departures from the Barbers Point facility. The investigation determined that he unexpectedly found himself responding to a progressively increasing workload caused by the disembarkation of the mooring masters.

The third mate had taken a fix and marked it on the chart at the request of the master. However, the mate did not volunteer information about their position, and when asked the depth of the water, provided only the chart soundings.

The master checked the charted position himself and saw they were in trouble. Current had set the vessel toward shore and there was not enough time to maneuver the vessel clear.

The master's reactions to the unexpected high workload were "classical" in that he concentrated on the subordinate tasks of the disembarkation to the detriment of the overall situation of current conditions and the location of the vessel. In hindsight, he would have been able to remain fully aware of the currents and the set of the vessel if he had delegated monitoring of the disembarkation to another officer. He may also have recognized the need to be more explicit in his request for information from the new third mate.

This predicament occurred even though the master knew the unpredictability of the Barbers Point currents and had recently completed a crew coordination type of course.

Another finding of the investigation was the familiar reaction by the third mate of not taking the initiative when it was imperative for the master to know their location.

The third mate had recently graduated from a four-year maritime school and was working on his first large commercial vessel. If he had been effectively trained in bridge resource management, he would have been more aggressive in informing the master of their position as soon as it was determined without waiting for an order to reply.

Thus, NTSB believes, that this casualty would have been avoided if the master and third mate on the *Star Connecticut* had received effective training in workload management, the consequences of high workload for situational awareness, and factors that inhibit or facilitate communication with subordinate officers.

The determination of communication problems in the *Star Connecticut* casualty prompts an additional distinction regarding the meaning of "communication" in bridge resource management. In one sense, it is viewed as the transfer of information to intended officers or crew members with accuracy and timeliness. Communication in this context is the result of effective bridge resource management practices and enables effective coordination.

An alternative use of the word refers to interpersonal skills for listening or for conveying information in clear, compelling ways. For example, if the third mate had developed effective advocacy skills for upward communication, he would have warned the master without hesitation of the set of the vessel. Communication skills in the latter sense enable or facilitate effective bridge resource management.

The NTSB recommended to Texaco Marine Services, Inc., that bridge resource management training be provided on a recurrent basis. The investiation illustrated the tendency for experienced officers to revert to previous management habits at times of demanding workloads or in emergencies.

Conclusion

Individual performance failures on the navigation bridge have been demonstrated to result from social, organizational and institutional factors. These factors can be addressed in part where crew members share responsibility for safe ship operation, rather than depend exclusively on individual competencies. The NTSB concludes that bridge resource management can prevent certain kinds of human error on the navigation bridge.

Mr. Eric Sager is a senior investigator, Human Performance Division, Office of Surface Transportation, National Transportation Safety Board, 490 L'Enfant Plaza, S.W., Washington, D.C. 20594-2000.

Telephone: (202) 382-6628.

Mariner's Seabag

Examination question

Considerable comments have been received from license applicants concerning this test question.

INTERNATIONAL ONLY: Which statement is true, according to the rules?

A. A fishing vessel has the right of way over a vessel constrained by its draft.

B. A vessel engaged in fishing shall, so far as possible, keep out of the way of a vessel restricted in its ability to maneuver.

C. A vessel not under command shall avoid impeding the safe passage of a vessel constrained by its draft.

D. A vessel restricted in its ability to maneuver shall keep out of the way of a vessel not under command.

This question relates to the situations in rule 18. The correct answer, B, is specifically mentioned. However, it has been stated that answer D is also correct.

Rule 18 does not specify the responsibilities between a vessel not under command and a vessel restricted in its ability to maneuver. Both vessels are similarly defined in rule 3. The former vessel "is unable to maneuver as required by the rules," and the latter "is restricted in its ability to maneuver as required by the rules."

When these two types of vessels are closing so as to involve risk of collision, rule 2 becomes effective. Rule 2(b) states, "In construing and complying with these rules, due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these rules necessary to avoid a collision."

Some texts do not agree with this interpretation and specifically state that the vessel not under command has the right of way. However, rule 18 does not address the relationship between these types of vessels because, by definition, they cannot maneuver as required. In such a situation, both vessels have the responsibility to take appropriate action to avoid collision; there is no stand-on or give-way vessel.

In response to comments by one maritime educator, further research was done by the Coast Guard's Office of Chief Counsel, which supported answer B as being correct.

The question was submitted also to the Navigation Safety Advisory Committee. In a meeting held in January 1995, following a lively discussion, a narrow margin of the members supported the validity of the question and answer. This item will be discussed at a future meeting if rule 18 can be clarified.

Applicability of the Rules of the Road

Some mariners may be confused over the extent of the Rules of the Road examination required when testing. The boundary lines marking the division between inland and near coastal/ocean waters do not coincide with the demarcation lines for the Rules of the Road. The Rules of the Road demarcation lines are closer to the shore. An applicant for an inland license who tests only on the inland rules is limited to service on vessels that do not navigate to seaward of the demarcation line, and a limiting endorsement is placed on the license. In order to remove the limitation, an applicant is required to pass an examination on the International Rules of the Road.

The following deck questions should be answered using chart number 12221TR, Chesapeake bay Entrance.

Deck

Use 10° W variation for all problems. The gyro error is 3° E. The height of eye is 25 feet (7.6 meters). The deviation table is:

HDG. MAG	DEV.	HDG. MAG	DEV.
000°	0°	180°	1° E
030°	1° W	210°	2° E
060°	2° W	240°	3° E
090°	4° W	270°	3° E
120°	2° W	300°	2° E
150°	1° W	330°	1°E

1. The National Weather Service provides 24-hour weather broadcasts to vessels transiting the Chesapeake Bay Bridge Tunnel area on which frequency?

A. 147.45 MHz.
B. 162.55 MHz.
C. 181.15 MHz.
D. 202.35 MHz.

2. At 1752, your position is LAT 37° 04.3' N, LONG 76°06.4' W. On a flood current, you should expect to be set to the ________________.

A. north northwest
B. south southwest
C. east southeast
D. east

3. Your 1752 position places you ____________

A. less than 0.5 mile westward of York Spit Channel
B. less than 0.5 mile eastward of York Spit Channel
C. greater than 0.5 mile westward of York Spit Channel
D. greater than 0.5 mile eastward of York Spit Channel

4. What is the average velocity of the maximum flood current at the Tail of the Horseshoe?

A. 0.6 knot.
B. 0.9 knot.
C. 1.3 knots.
D. 1.6 knots.

5. From your 1752 position, you steer 307° pgc at 9 knots. At 1805, you obtain these visual bearings: Old Point Comfort Light 232° pgc, and Chesapeake Bay Tunnel North Light 130° pgc. What are the latitude and longitude of your 1805 position?

A. LAT 37°06.1' N, LONG 76°08.1' W.
B. LAT 37°06.0' N, LONG 76°08.4' W.
C. LAT 37°05.9' N, LONG 76°07.7' W.
D. LAT 37°05.9' N, LONG 76°08.0' W.

6. At 1810, you sight a buoy on your starboard side labelled "19." This buoy marks____________

A. a submerged obstruction in York Spit Channel
B. the visibility limit of the red sector of Cape Henry Light
C. the side of York Spit Channel
D. the junction of the York Spit and York River Entrance Channels

7. Based on a DR, at approximately 1817, you would expect to ______________________.

A. enter a traffic separation zone
B. depart a regulated area
C. cross a submerged pipeline
D. depart a restricted area

8. At 1845, you obtain a loran fix using the following information:

9960-X-27252.0
9960-Y-41432.0
9960-Z-58537.5

Your latitude is ______________________

A. 37°10.7' N
B. 37°10.9' N
C. 37°11.0' N
D. 37°11.2' N

9. Your 1900 position is LAT 37°12.9' N, LONG 76°13.5' W. You change course to 317° pgc and slow to 8.0 knots. What is the course per standard magnetic compass?

A. 331°.
B. 329°.
C. 311°.
D. 309°.

10. If the visibility is 11 miles, what is the luminous range of New Point Comfort Spit Light "4?"

A. 0.5 mile.
B. 3.8 miles.
C. 4.3 miles.
D. 5.0 miles.

11. According to your track line, how far off New Point Comfort Spit Light "4" will you be when abeam of this light?

A. 0.9 mile.
B. 1.2 miles.
C. 1.5 miles.
D. 1.8 miles.

12. At 1930, you take a fix using the following radar ranges:

York Spit Light - 3.6 miles; New Point Comfort Spit Light "2" - 2.0 miles; and York Spit Swash Channel Light "3" - 2.5 miles.

Your longitude is ______________________

A. 76°16.5' W
B. 76°16.8' W
C. 76°17.0' W
D. 76°17.2' W

13. What was the speed made good from 1845 to 1930?

A. 6.2 knots.
B. 7.6 knots.
C. 8.3 knots.
D. 9.4 knots.

14. What is the height above water of Davis Creek Channel Light "1?"

A. 6 feet (1.8 meters).
B. 15 feet (4.6 meters).
C. 17 feet (5.2 meters).
D. 24 feet (7.3 meters).

15. If you have 17.3 miles to reach your destination from your 2000 position, and want to be there at 2230, what speed should you make good?

A. 5.7 knots.
B. 6.1 knots.
C. 6.5 knots.
D. 6.9 knots.

ANSWERS

1-B, 2-A, 3-A, 4-B, 5-D, 6-C, 7-B, 8-D, 9-B, 10-D, 11-A, 12-B, 13-C, 14-B, 15-D.

If you have any questions concerning Nautical Queries, please contact G-MVP-5. Telephone: (202) 267-0707.

Final rule

CGD 90-051, Double hull standards for vessels carrying oil in bulk (33 CFR parts 155 and 157; 46 CFR parts 30, 32, 70. 90 and 172) RIN 2105-AD61 (March 10).

In an interim final rule published on August 12, 1992, the Coast Guard established regulations for the design standards of double hull vessels pursuant to the requirements of section 4115 of the Oil Pollution Act of 1990 (OPA 90). This rule adopts the interim final rule as final with minor changes to definitions.

DATE: This rule was effective April 10, 1995.

Addresses: Unless otherwise indicated, documents referred to in this preamble are available for inspection or copying at the office of the executive secretary, Marine Safety Council (G-LRA), Room 3406, Coast Guard headquarters, 2100 Second Street S.W., Washington D.C. 20593-0001, between 8 a.m. and 3 p.m., workdays. Telephone: (202) 267-1477.

For further information, contact: Mr. Robert M. Gauvin, project manager, Merchant Vessel Inspection and Documentation Division.
Telephone: (202) 267-1181.

Final rule

CGD 91-030, Direct user fees for inspection or examination of United States and foreign commercial vessels (33 CFR part 143 and 46 CFR part 2) RIN 2115-AD78 (March 13).

The Omnibus Budget Reconciliation Act of 1990 requires the Coast Guard to establish user fees for Coast Guard services related to the inspection and examination of United States and foreign commercial vessels. Fees in this rule are based on existing vessel inspection program requirements and services. The fees are established for the purpose of recovering costs associated with providing Coast Guard vessel inspection services.

DATE: This rule was effective May 1. 1995.

Addresses: Unless otherwise indicated, documents referred to in this preamble are available for inspection or copying at the office of the executive secretary, Marine Safety Council (G-LRA), Room 3406, Coast Guard headquarters, between 8 a.m. and 3 p.m., workdays. Telephone: (202) 267-1477.

For inquiries and payment information during initial implementation of the rule, call, toll-free, 1-800-941-3337.

For further information, contact: Mrs. Denise J. Mursch. Planning Staff (G-MP-2)
Telephone: (202) 267-0785.

Notice of proposed rulemaking

CGD 91-212, National Driver Register and criminal record review in issuing licenses, certificates of registry or merchant mariner's documents (46 CFR parts 10 and 12) RIN 2115-AD93 (March 13).

The Coast Guard proposes regulations to implement the provisions of OPA 90 that permit it to review information from the National Driver Register on an applicant prior to issuing or renewing a license, certificate of registry or merchant mariner's document. This proposal also addresses OPA 90 provisions that permit the Coast Guard to review the criminal records of applicants prior to issuing or renewing a license, certificate of registry or merchant mariner's document. In addition, it proposes regulations that permit criminal record checks of any individual applying for a raise in grade or license or certificate of registry; a renewal of a license, certificate of registry or merchant mariner's document; or an endorsement of a merchant mariner's document with a new expiration date. The proposed rulemaking will provide the Coast Guard an opportunity to identify an applicant who has been convicted of certain motor vehicle offenses or certain crimes.

DATE: Comments must be received by June 12, 1995.

Addresses: Comments may be mailed to the executive secretary, Marine Safety Council (G-LRA/3406) (CCD 91-212), Coast Guard headquarters, or delivered to room 3406 between 8 a.m. and 3 p.m., workdays. Telephone: (202) 267-1477. Comments on collection-of-information requirements must be mailed also to the Office of Information and Regulatory Affairs, Office of Management and Budget, 725 17th Street, N.W., Washington, D.C. 20503, Attn: Desk Officer, Coast Guard.

The executive secretary of the Marine Safety Council maintains the public docket for this rulemaking. Comments will be part of this docket and available for inspection or copying at room 3406, workdays, between 8 a.m. and 3 p.m.

For further information, contact: Mr. James Cratty, project manager, OPA 90 staff. Telephone: (202) 267-6740. This telephone records messages 24 hours a day.

Notice and request for comments

CGD 95-023, Marine safety investigation process review (46 CFR parts 4 and 5) (March 22).

The Coast Guard conducts marine casualty investigations to determine the cause of casualties. The findings of an investigation may lead to proceedings for the suspension or revocation of a merchant mariner's document, the assessment of a civil penalty, or to criminal prosecution. The Coast Guard is reviewing its marine safety investigation process to identify possible improvements, and is seeking input from the public.

DATE: Comments must have been received by May 1, 1995.

Addresses: Comments may be mailed to Mr. W. D. Rabe, commandant (G-MMI), Coast Guard headquarters, or may be made by telephone at (202) 267-1430, or by fax at (202) 267-1416.

For further information, contact: Mr. D. W. Rabe, Marine Investigation Division.
Telephone: (202) 267-1430.

Notice

CGD 95-015, Load lines: barges on Lake Michigan (March 31).

The Coast Guard proposes to amend its current policy exempting unmanned, river-service, dry cargo barges operating on Lake Michigan between Chicago (Calumet Harbor), Illinois, and Milwaukee, Wisconsin, from the requirement that they have a Great Lakes Load Line Certificate. In order to qualify for the exemption, the barges must meet certain specified requirements intended to provide a level of safety equivalent to that provided under the Great Lakes load line regulations. Also, the Coast Guard proposes to exempt similar barges under the same requirements operating between Chicago (Calumet Harbor), Illinois, and St. Joseph (Benton Harbor), Michigan. These changes should facilitate the movement of goods along these routes while maintaining an equivalent level of safety.

DATE: The exemption was effective March 31, 1995. Comments must be received by May 15, 1995.

Addresses: Comments may be mailed to the executive secretary, Marine Safety Council (G-LRA/3406) (CCD 95-015), Coast Guard headquarters, or delivered to room 3406 between 8 a.m. and 3 p.m., workdays.
Telephone: (202) 267-1477.

The executive secretary of the Marine Safety Council (G-LRA/3406) (CGD 93-081), Coast Guard headquarters, maintains the public docket for this rulemaking. Comments will become part of this docket and will be available for inspection or copying at room 3406, workdays, between 8 a.m. and 3 p.m.

For further information, contact: Mr. William Hayden, Naval Architecture Branch, Marine Technical and Hazardous Materials Division.
Telephone: (202) 267-2988.

Interim Final rule

CGD 79-116, Qualifications for tankermen, and for persons in charge of transfers of dangerous liquids and liquefied gases (33 CFR parts 154 and 155; 46 CFR parts 12, 13, 15, 30, 31, 35, 78, 90, 97, 98, 105, 151, 153 and 154) RIN 2115-AA03 (April 4).

The Coast Guard is issuing an interim rule that sets out qualifications for tankermen, and for persons in charge of, and assisting in, the handling, transfer and transport of oil and certain hazardous liquid cargoes in bulk aboard vessels. It intends to establish training standards, operational requirements and a certification procedure to ensure that these persons are competent to perform their duties even during emergencies. Implementation of this rule will improve the handling, transfer and transport if these cargoes and reduce the risk and severity of spillage from tank vessels.

DATE: The interim rule will be effective March 31, 1996. Comments must be received by June 30, 1995.

Addresses: Comments may be mailed to the executive secretary, Marine Safety Council (G-LRA/3406) (CCD 79-116), Coast Guard headquarters, or delivered to room 3406 between 8 a.m. and 3 p.m., workdays.
Telephone: (202) 267-1477.

For further information, contact: LCDR David Paxton, project manager, Merchant Vessel Personnel Division. Telephone: (202) 267-0224.

Continued on page 52

Continued from page 51

Notice of proposed rulemaking

CGD 94-040, Vessel rebuilt determinations (46 CFR part 67) RIN 2115-AE85 (April 5).

The Coast Guard proposes to revise its rules regarding rebuilt determinations to provide guidelines to clarify the standard for determining when work on a vessel constitutes a rebuilding of that vessel. The rebuilt standard has been criticized as too subjective to provide guidance to vessel owners, who often must make critical business planning decisions with the outcome of a potential rebuilt determination by the Coast Guard in mind. The proposed guidelines, if adopted, would establish clear upper and lower thresholds relevant to rebuilt determinations and would provide for greater certainty to vessel owners making business decisions regarding work to be performed on their vessels.

DATES: Comments must be received by July 5, 1995.

Addresses: Comments may be mailed to the executive secretary, Marine Safety Council (G-LRA/3406) (CCD 94-040), Coast Guard headquarters, or delivered to room 3406 between 8 a.m. and 3 p.m., workdays. Telephone: (202) 267-1477).

The executive secretary maintains the public docket for this rulemaking. Comments will be part of this docket and will be available for inspection or copying in room 3406, workdays between 8 a.m. and 3 p.m.

For further information, contact: Ms. Laura Burley, Vessel Documentation and Tonnage Survey Branch, Merchant Vessel Inspection and Documentation Division. Telephone: (202) 267-1492.

Final rule; request for comments

CGD 92-072, OST Docket No. 50248, Great Lakes pilotage rate methodology (46 CFR parts 401, 403 and 404) RIN 2105-AC21 (April 11).

The Department of Transportation is amending the regulations concerning Great Lakes pilotage by amending the procedures for determining Great Lakes pilotage rates, and revising the financial reporting requirments mandated for Great Lakes pilot associations. The purpose of these changes is to improve the ratemaking process. This final rule does not change the existing Great Lakes pilotage rates and charges.

DATES: This rule is effective on June 12, 1995. Comments must be received by May 11, 1995. Late-filed comments will be considered only to the extent practicable.

Addresses: Comments should be sent, preferably in triplicate, to docket clerk, OST Docket No. 50248, Department of Transportation, 400 7th Street, S.W., room PL-401, Washington, D.C. 20590. Comments will be available for inspection here from 9 a.m. to 5:30 p.m., workdays. Unless otherwise indicated, documents referred to in this preamble are also available for inspection or copying at this address. Comments should not be sent to the Coast Guard docket.

For further information, contact: Mr. Scott A. Poyer, project manager, Merchant Vessel Personnel Division. Telephone: (202) 267-6102. Or contact Mr. Steven B. Farbman, Office of the Assistant General Counsel for Regulation and Enforcement, Department of Transportation, room 10424. Telephone: (202) 366-9306.

Notice of proposed rulemaking termination

CGD 87-069, Carriage of bulk solid materials requiring special handling (46 CFR parts 90, 97 and 148) (April 13).

The Coast Guard is terminating rulemaking intended to amend the Coast Guard's regulations for the carriage of certain bulk solid materials. The proposed rules would have added to the list of materials permitted under the regulations materials carried under Coast Guard special permits issued pursuant to this regulation (special permits) and other materials contained in the International Maritime Organization (IMO) Code of Safe Practice for Solid Bulk Cargoes (IMO Bulk Solids Code or "BC Code"), including coal. The Coast Guard wishes to focus its available resources to actions of the highest priority; therefore, the Coast Guard is terminating further rulemaking under docket number 87-069.

DATES: This proposed rulemaking was terminated April 13, 1995.

For further information, contact: Mr. Frank K. Thompson, Hazardous Materials Branch, Marine Technical and Hazardous Materials Division. Telephone: (202) 267-1217.

Notice of availability and request for comments

CGD 95-031, Application for recertification of Cook Inlet Regional Citizens' Advisory Council (April 20).

The Coast Guard announces the availability of the application for recertification submitted by the Cook Inlet Regional Citizens' Advisory Council for June 1, 1995 through May 31, 1996.

The application may be reviewed at the council's office, 910 Highland avenue, Kenai, Alaska 99611-8033 between 8 a.m. to 5 p.m, workdays. Telephone: (907) 283-7222,

DATE: Comments must be received by June 5, 1995.

Addresses: Comments may be mailed to the executive secretary, Marine Safety Council (G-LRA/3406) (CCD 95-031), Coast Guard headquarters, or delivered to room 3406 between 8 a.m. and 3 p.m., workdays. Comments will be available for inspection or copying in room 3406 during the same period.
Telephone: (202) 267-1477.

For further information, contact: Ms. Janet Jackson, Marine Environmental Protection Division.
Telephone: (202) 267-0500.

Notice

CGD 95-032, National Preparedness for Response Exercise Program (PREP) area exercise schedule for 1996, 1997 and 1998, annual workshop, and availability of the PREP guidelines and training elements. (April 20).

The Coast Guard, the Environmental Protection Agency, the Research and Special Programs Administration and the Mineral Management Service, in concert with the states, the oil industry and concerned citizens, developed the PREP. This notice announces the proposed schedule of the area exercises for 1996, 1997 and 1998, and solicits industry members to lead area exercises for 1996. It also announces the annual public workshop to discuss PREP guidelines and the overall PREP program to be held on June 14, 1995, in Alexandria, Virginia, and the availability of the PREP guidelines and training elements.

DATES: Industry members interested in leading an area exercise or participating in a government-led area exercise should submit their requests directly to the Coast Guard or Environmental Protection Agency on-scene coordinator no later than May 15, 1995.

The annual PREP scheduling workshop is slated for June 14, 1995, from 9 a.m. to 5 p.m. at the Best Western Old Colony Inn in Alexandria, Virginia. Comments on the schedule or scheduling process should be submitted no later than May 15, 1995.

Addresses: Written comments should be mailed to the Commandant (G-MEP-4), Room 2100, Coast Guard headquarters. ATTN: Ms. Karen Sahatjian.

PREP guidelines and training elements are available at the Government Printing Office.
Telephone: (202) 512-1800.

For further information, contact: Ms. Karen Sahatjian, Marine Environmental Protection Division.
Telephone: (202) 267-0746.

Interim final rule with request for comments

CGD 89-050, Vessel identification system (33 CFR part 187) RIN 2115-AD35. (April 25).

The Coast Guard is establishing a vessel identification system (VIS) as required by statute. It includes guidelines for state vessel titling systems, procedures for certifying compliance with the guidelines, and rules for participation in the system for undocumented vessels. VIS, in conjunction with current Coast Guard vessel documentation information, will provide a nationwide pool of vessel and vessel owner data to help in identifying and recovery of stolen vessels and deter vessel theft. A mortgage covering the whole of an undocumented vessel, perfected in a state that participates in VIS and holds certification of compliance with guidelines for state vessel titling systems will have preferred mortgage status.

DATES: This rule is effective April 24, 1996. Comments must be received by July 24, 1995.

Addresses: Comments may be mailed to the executive secretary, Marine Safety Council (G-LRA/3406) (CCD 89-050), Coast Guard headquarters, or delivered to room 3406 between 8 a.m. and 3 p.m., workdays. The executive secretary maintains the public docket for this rulemaking. Comments will be available for inspection or copying in room 3406 during the same period.
Telephone: (202) 267-1477.

For further information, contact: CDR Keith Cameron, Information Management Division (G-MIM).
Telephone: (202) 267-0385.

Notice of meeting

The Chemical Transportation Advisory Committee (CTAC) will meet on June 8, 1995, from 9:30 a.m. to 3 p.m., in Room 2415, Coast Guard headquarters. The meeting is open to the public.

For further information, contact: CAPT Kevin J. Eldridge, executive director, or LT Rick J. Raksnis, executive assistant, CTAC, Coast Guard headquarters.
Telephone: (202) 267-1217.

Citizen's view from Alaska

By Ms. Marilyn B. Leland

People are only human. Time and time again, we are faced with this inescapable, very simple truth. As long as our oil transportation systems depend on human performance, human behavior and human judgment, the "human element" will be a major cause of maritime casualties. It is ironic that so basic a truth has received so little attention in the past.

Fortunately, this has changed dramatically as industry, regulators, policy makers, mariners and ordinary citizens begin to tackle pieces of this intimidating monster we call the "human" element. Make no mistake, it is intimidating. For all of our technological expertise, it is the difficulty of managing human behavior that so often trips us up.

A group representing citizens affected by the 1989 *Exxon Valdez* spill, the Prince William Sound Regional Citizens' Advisory Council is particularly concerned about human factors in maritime casualties. The *Exxon Valdez* was a textbook case of human factors, including error.

In much smaller and less damaging ways, we see human factors crop up time and again, in actual casualties, near misses and might-have-beens.

Needs assessment

"Human element" is difficult to get one's arms around — it is huge. After much discussion, we at the council determined that full-fledged research into the subject was beyond our budget or capabilities. But working in concert with our counterpart at Cook Inlet, in 1994, the two councils jointly commissioned a "human factors needs assessment." This project had two purposes: to identify research topics in the area of human factors, and to focus on particular human factor problems unique to Alaska.

The information obtained through the needs assessment was intended for the State of Alaska, as it prepared to commission research projects on prevention, response and amelioration of oil and other hazardous substance spills.

The two citizens' councils retained Dr. Thomas F. Sanquist of Battelle Seattle Research Center and Dr. Martha R. Grabowski of Rensselaer Polytechnic Institute (see article on page 10) to conduct the needs assessment.

The project consisted primarily of interviewing 40 individuals from a broad spectrum of Alaska's maritime community. Particular attention was paid to balancing the numbers and types of interviewees.

Those interviewed included representative tanker masters and crews, ship escort response vessel system personnel, Coast Guard, Alaska Department of Environmental Conservation, major shipping company executives and Southwest Alaska Pilots' Association personnel.

Based on the interviews, the consultants categorized research topics into nine subjects in two broad categories — those that focus on individuals, and those that focus on organizations or systems.

Boom contains oil spilled by Eastern Lion in Port Valdez. *Photo by Bill Roth of the Anchorage Daily News.*

Eastern Lion incident

Although it received little national attention, an oil spill in Port Valdez on May 21, 1994, was another in the long list of human-caused casualties. In the case of the tank vessel *Eastern Lion*, the crew first failed to confirm their assumption about the source of excess water in the wing tank. The crew noticed the problem five days before the oil spill, assuming it was a stripping valve. In fact, it was a small hole under the bellmouth that resulted in a leak of about 8,400 gallons of crude oil. Fortunately, most of it was contained and recovered.

The first error, failing to confirm the source of the water leak, was compounded by the crew's failure to speak up about it when the oil spill occurred. Coast Guard officials said that the spill could have been prevented altogether if they had known about the water leak when the tanker arrived at the terminal. Instead, it was days before that information came to light.

Research topics

Individual operator

- *Personnel skills, resources and certification.* Research the impact of changes in the maritime industry on personnel skills and resources needed, and corresponding certification requirements.

- *Fatigue.* Research impacts of seasonal variations in daylight and time zone crossings, investigation of effective sleep-work-rest cycles and alternative watchstanding schedules, and impacts of sleep disruption on work patterns and effectiveness.

- *Automation and technology.* Those interviewed expressed considerable concern about new technology, especially in terms of its utility and how technology creates more work through increased demands on operators.

- *Training.* Research topics include training in the use of automated systems (respondents reported that training in new equipment is frequently minimal or non-existent and learning is done on the job), the utility of intact crew training for bridge resource management and the utility of personal computer-based simulators for continuing training.

Continued on page 56

. . . "As long as our oil transportation systems depend on human performance, human behavior and human judgment, the "human element" will be a major cause of maritime casualties. It is ironic that so basic a truth has received so little attention in the past."

Continued from page 55

Organizations or systems

- *Changes in the maritime industry.* Recent rapid changes in direction in the industry, particularly the number and type of new regulations and requirements. "Brain drain" was also mentioned, along with the impact of rapid changes on individual morale and motivation. Other topics in this area include the effect of post OPA 90 changes in the Alaska Maritime System, new skills requirements and ways to achieve them, and employee migration patterns and their impact.

- *Individual and organizational behavior.* Mentioned most often were needs for communication, effective decision-making, information sharing and "system-wide" appreciation of the impact of small changes on the safety and effectiveness of the entire maritime system.

- *Policies and regulation.* Assess the impact of small changes in the maritime industry, organizations, vessels and facilities, and regulatory organizations. Respondents suggest an analysis of whether all the changes make the system safer and whether the resulting system makes sense.

- *Oil spill response.* Human factors are an issue in spill response. Topics suggested for research include developing "reasonable" oil spill response expectations, especially in adverse weather conditions.

- *Facilities and inland marine transport.* A few of those interviewed suggested research into the relationships between the terminal and vessel; safety and effectiveness of inland marine transportation, and safety and effectiveness of Alaska storage facilities.

Future projects

The results of the study were used by the State of Alaska as guidelines for selecting research and development projects related to human factors. Advisory council representatives worked with the state's Hazardous Substance Spill Technology Review Council evaluating research proposals. Among those recommended for funding are two relating to human factors. (Projects are to be funded by the *Exxon Valdez* criminal settlement.)

The first project would address enhancing readiness training in three ways: 1) develop a risk assessment of marine fatigue specific to Alaska, 2) review "readiness" manuals and training procedures on oil tankers in Alaska, and 3) develop an "alertness assurance training module" for masters, mates and pilots.

The second project recommended is a series of workshops on human performance, organizational systems and the maritime system. The purpose of the workshops would be to open lines of communication among researchers and principals in the marine industry, other industrial and transportation sectors, and state and federal governments.

The Alaska Department of Environmental Conservation will decide whether these projects will be funded.

Conclusion

The citizens of our region will be watching with great interest the results of all human element research, both in Alaska and around the world. The Prince William Sound Regional Citizens' Advisory Council congratulates industry and regulatory agencies for the attention being focused in this area so critical to oil spill prevention.

Ms. Marilyn B. Leland is deputy director of the Prince William Sound Regional Citizens' Advisory Council, 750 W. 2nd Avenue, Suite 100, Anchorage, Alaska 99501-2168.

Telephone: (907) 277-7222.

TECHNOLOGY'S IMPACT ON HUMAN RISK

By Dr. Vernon L. Grose

There is no escape. We are caught up in a tyrannical technical tempest. On every hand, the products of technology clamor for our attention -- their siren song luring us to surrender to their charms.

But there is a price to be paid for technological seduction. That magic term "automatic" -- when tantalizingly offered to shift gears, open doors, made coffee, pump blood, plot unseeable courses or calculate income tax -- has a subtle intent: to remove us from involvement. Ostensibly to help us, to extend our capabilities, to provide comfort -- technology can end up dominating us. It is more than friendly assistance. Could its ultimate goal even be to convert us into "automatons" -- people who respond unthinkingly by satisfying technology's demand for predetermined behavior? Mastering a new software program for your computer -- whether by on-screen tutorial or massive handbook -- illustrates this possibility. Who masters whom?

The legendary open-sea collision of the Italian luxury liner *Andrea Doria* with the Swedish freighter *Stockholm* -- when both ships were equipped with the very latest navigation technology -- raised numerous questions about human risks that had been heightened by such technology. Among them were boredom, inattentiveness, rationalization, overconfidence and disbelief. If anything, the navigation aids may have enticed their operators to commit the very errors that those aids were intended to prevent. And this is not unusual. That needless loss of 50 lives -- and another "unsinkable" ship -- illustrates how *beneficial technology* inherently involves *human risk.*

Technological scheming?

Technology can be defined as a *scientific method for achieving a practical purpose*. But we generally expand it to mean "the totality of the means employed to provide objects necessary for human sustenance and comfort." So the term *technological* is applied to anything resulting from improvements in technical processes that either (a) increase productivity of machines, (b) eliminate manual operations, or (c) convert performance of certain tasks from subjective to objective mode.

Could technology's touted *artificial intelligence* ever become capable of conspiracy? Could it wrest control away from -- and end up dominating -- its creators? Need we fear technology? Of course not. But we do need to respect its effect on us.

Rendering technology anthropomorphic, therefore, has a purpose -- to raise our sensitivity to factors that we may not have identified and examined for their inherent risk. The "herd instinct"-- even among the brightest technologists -- must constantly be overcome lest we fall captive to intellectual incest. So let's agree to treat technology temporarily as though it possesses personality.

Man-machine interface

The familiar -- but perhaps outmoded -- idea of a *man-machine interface* suggested a clean, sharp boundary where technology stopped and human behavior began or vice versa. While convenient to describe certain situations where people directly touched, operated or utilized machines to perform work otherwise accomplished manually, its simplicity proved a disservice because it overlooked -- even concealed -- the spectrum of effects, including *risks*, produced when technology snares us.

Continued on page 58

Continued from page 57

The Generation of Human Risks

Self-Hazardous Behavior *Risk created and incurred personally*

Co-Generative Actions *Two or more contribute to one's risk*

Production Externalities *Pollution, hazardous wastes*

Behavior of Other Individuals *Crime, speeding, drunken driving*

Nature *Earthquake, flood, aging, genetic mutations*

Economic Conditions *Poverty-induced disease, stress-related illness*

Government Policies *Environmental impact on health, likelihood of war*

Figure 1

Figure 1 proposes that there are many sources of human risk. Each of those sources -- representing a spectrum of varied personal control over risk -- is elaborated in my book, *MANAGING RISK: Systematic Loss Prevention for Executives*. But we need to examine how all these generated risks are impacted -- created, eliminated or translated -- when manufactured products replace, diminish or augment personal involvement.

Why is Technology so Attractive?

Technology's enchantment exists only because of an all-encompassing premise: ***people desire to be OTHER THAN THEY ARE***. Where is that person who hasn't wished -- at some time in their life -- that they were either smarter, freer, richer, fatter or skinnier, faster or slower, older or younger, or better looking? Is there not a universal human trait of desiring to be just a little bit different than we find ourselves to be? For example, would transportation exist if everyone and everything were precisely where they were desired to be? That *dissatisfaction differential* is the technologist's dream.

But what is technology's *ultimate* promise? All of us share a secret desire to be God -- to be unlimited in all dimensions, to know all things, to exert unrestrained power, to be omnipresent, to see and control without being on-scene. We all identify with "Superman" at times. And technology certainly teases us with that possibility.

Technology also plays on two more of our weaknesses to persuade us. First, we are easily duped by -- and readily surrender to -- pleasure, comfort or ease. Second, we are charmed by watching something easily happen with machines that requires so much of our human effort to accomplish.

When technology dangles all these tantalizers in front of us, we are generally wise enough, of course, to realize that we will not end up being God if we are *totally removed* from the decision-making loop -- if we as persons are no longer needed. To illustrate, your computer can not only *write* checks -- it can *pay* them without your involvement. Most of us, however, probably still want to play a meddling (controlling) role even though it slows the process immensely. This points to a built-in contradiction between (a) falling under technology's spell and (b) becoming God.

Overriding these subconscious aspects of human nature, however, technology continues to attract us with its track record. Lasers, satellites for weather forecasting and worldwide communication, simulators of all kinds, computers, ultrasound imaging, bomb-defusing robots, radar, sonar . . . the list seems endless. Who can argue with that success?

The Aided v. Unaided Gap

The late Herman Kahn, a futurist intellectual, once said: "Intellectuals deal only with second-hand information." Kahn concluded that their love of lofty concepts, ideas and abstractions is sufficiently removed from reality that they are unable to perform very practical tasks like changing a tire or fixing a leaky faucet. Worse yet, they disdain those who hunt, fish, or hike because such activities bespeak a primeval crudity unworthy of human sublimity.

The gap between "2nd-hand" intellectualism and "1st-hand" practicality has a close parallel to another gap -- one between human behavior aided and unaided by technology. Just as intellectuals would not survive were it not for a society that understands and performs menial tasks, so the *technologically-aided* are subconsciously dependent on the *technologically-unaided*, who maintain a fundamental grasp of reality -- thereby sustaining a foundation upon which technology can build. Counterfeiters do not print $3 or $7 bills; neither do technologists augment non-real functions.

Figure 2 depicts this gap. When technological wonders liberate us from the weariness and exhaustion of human toil, we fall captive to a new paradigm fraught with undesirable -- even frightening -- human behavior. *We need to be needed*, and when we're *not*, it is risky indeed. Boredom is inevitable when we shift from *doing* to *monitoring* -- as airline pilots using "glass cockpits" will testify. Even self-esteem suffers from this shift because the honest pilot must confess that he now only monitors mechanisms that can fly the aircraft unassisted.

Continued on page 60

Figure 2

HUMAN ROLE REVISION

Technologically - Unaided	*Technologically - Aided*
Involved, creative innovator	Observer or monitor of displays
Required to be present	Free to be remote from activity
Limited in time and space	Released in time and space
Physical exertion required	Free from physical exertion
Restrained by mental capacity	Captive to produced results
Responsible for all activity	Dependent on synectic design
Information-deficient	Data-overloaded
Overworked	Likely to be bored
Dealing with fundamental realities	Detached from basic realities

Continued from page 59

Benefit and risk are twins

The *benefits* of technology are linked inexorably to *risks*. "There is no free lunch," as the saying goes. When technology snares us, however, we initially feel only its benefits. Its associated risks appear later, having failed by default to be foreseen. Many risks are even assimilated into our way of life never to be identified, per se. Carpal tunnel syndrome -- the No. 2 source of worker compensation claims -- was unknown in the industrial workplace until personal computers arrived.

The *benefit* of turning over to automatic devices the complexity of managing the efficient delivery of fuel to an airliner's engines is monumental indeed. But are you aware of any *risk* in doing so? Consider the incredible account of Air Canada Flight 143 -- a brand new 767 widebody aircraft -- running completely out of fuel halfway to its destination. Why? Because benefit and risk are twins. The 767 was the first Air Canada aircraft operated metrically. A mix-up between imperial pounds of fuel *loaded* and kilograms of fuel *required* resulted in less than half the necessary fuel being aboard at takeoff. This serious measurement error was compounded because the flight crew had no advanced warning about the fuel state. The "low fuel warning" system had been disabled earlier when a mechanic pulled the wrong circuit breaker on a defective fuel processing unit.

Perhaps nowhere are technology's risks to humanity more insidious, however, than in the communications revolution produced by computers. A few lonely voices like Svan Birkerts have flagged such societal risks as "a vanishing assumption of coherence" -- attributable to computer domination. In his *The Gutenberg Elegies: The Fate of Reading in an Electronic Age,* he observes that we are left with a fragmented sense of time, a reduced attention span, impatience with sustained inquiry and shattered faith in institutions. Birkerts claims that the microchip has altered our sense of reality and changed our primary relationship to the world. Some of that altering may prove either beneficial or inevitable. But a majority of it introduces vast risk — possible dissolution of life and culture as we have known it throughout history.

Technology and Transportation

Technology is an outgrowth of modern science. Its products have enriched human life immeasurably. Consider technology's contribution just to *transportation*. It has provided us with vehicles like ships, trains, automobiles, aircraft and spacecraft that have amplified our God-given capabilities to move around the earth. If we think of vehicles as *extensions* of walking, running and relocating ourselves, we acknowledge that wheels or hulls replace our feet, engines substitute for our hearts and lungs, and steering mechanisms translate our desire to move in a different direction.

But transportation vehicles do more than extend our natural abilities. In terms of energy, they also *multiply* the consequences of actions we take while operating them. Notice how ships are named **TITANIC**, trains **BULLET**, automobiles **TORNADO**, aircraft **GALAXY** and missiles **TITAN**. There is more truth than poetry in those names. Vehicle operators have fearful amounts of energy at their disposal.

Beyond multiplied energy, all vehicles -- whether ships, trains, automobiles or aircraft -- become *impersonal shrouds* that we wrap around ourselves. They cloak us with an anonymity, authority and autonomy that medieval potentates would have drooled to possess. When a vehicle operated by John Jones comes toward you, you do not recognize *John Jones*, You see an extrinsic *vehicle*.

How can a vehicle's impersonal anonymity magnify risk? One example: it easily *disguises its operator*. A stunning Rolls-Royce, stupendous oil tanker or shiny Learjet can be a mask that hides an unintentional murderer or an unwitting cause of cataclysm -- that operator incapacitated by alcohol. It is easy to spot the skid-road boozer staggering down the street. But the same person operating a transportation vehicle goes undetected and unsuspected. So multiplied *capability* can also mean multiplied *tragedy*.

Combining then these vehicle aspects -- (1) they extend our human capabilities, (2) they multiply the energy at our disposal, (3) they hide our identity, and (4) they provide a cloak for catastrophe, we can deduce that transportation vehicles become a *mismatched, unbalanced link* between their operators and recipients of their massive, but unintended energy unleashed on the unsuspecting. *Without question*, technology increases the dimension of risk through this linkage.

Where is Technology Taking Us?

Sin's *fascination* always outweighs -- and is divorced from -- its *fee* . . . at least upon initial entertainment. While technology has no moral connotation, the same *fascination-fee* principle applies to it.

We are always rushed to *ponder* -- if we can proceed. But proceeding to adopt technological prodigies without weighing their possible pitfalls sets off a series of subtle, subconscious surrenders. At the outset, we surrender our *first-hand knowledge*, *involvement* or *understanding* of something to accept technology's substitute for it. Examples include microwave ovens, automatic transmissions, computers, or "idiot-proof" cameras. The day when we built a fire to bake, shifted gears, made arithmetic calculations or weighed aperture against shutter speed is over for most of us. Those surrenders are more than labor-saving substitutes. They represent "lost art" -- forfeited capability. And its gone before you realize it -- generally never to be recovered.

That "first-hand" surrender is closely followed by capitulating to *disengagement*. We neutralize our brains and accept answers produced without our participation. Speed-dialing a telephone is a simple illustration. No longer do we remember phone numbers. That is a blessing that belies any thought of risk. Yet, in an emergency -- away from the speed-dialed phone, the ability to recall a phone number can be critical.

Recollect the Air Canada fuel-exhaustion incident? It ended in a miracle that illustrates the risk of disengagement. The captain *happened* to be a glider pilot, and the first officer *happened* to have trained years earlier at a little-used World War II airfield. Combined, those two factors *happened* to enable a dead-stick landing at that airfield from 41,000 feet with no casualties. In other words, the crew was able to employ extraneous knowledge that is not -- and never has been -- part of airline crew training. Does this even not suggest that technology is capable of capturing and removing us so far from practicality that we could -- should our technological augmentation fail -- be "adrift in space" with no tether back to objective existence?

The direction that genetic technology is driving our ethical understanding and moral conscience also must not be overlooked. Andrew Kimball in his book, *The Human Body Shop: The Engineering and Marketing of Life,* notes that, as technology advances, increasing numbers of human body forms are becoming economically valuable -- products for sale. First there was blood -- followed by organ transplants, sperm and eggs, female reproductive systems, embryos and genes. The human body, once held in esteem -- even as *sacred*, is fast becoming simply a biological machine with interchangeable parts. The answer to that age-old question, "Who am I?" gets ever more indeterminable.

Each bit of abandonment to technology is so disguised by benefit that it appears not long until we gamble with becoming totally removed from *reality* -- that fundamental comprehension of nature and its immutable laws. But where is the ultimate boundary of disengagement -- or is there one? How far can we go in being replaced totally by devices?

Perhaps technology's roots in modern science provide a clue. In some circles, science has been corrupted into *scientism* (i.e., belief that science provides answers to the ultimate questions of life). When that occurs, a probabilistic (thus *uncertain*) field of endeavor becomes twisted into a faith of *certitude*. The latter, of course, removes all possibility of objectivity. Its antidote lies in recognizing the limits of scientific work. And because science is limited, its offspring, *technology*, is too.

What are the limits of technology? They probably lie in its focus. Technology primarily aims at doing. It tends to favor QUANTITY (*amount, speed or number*) over QUALITY (*nature, role or attribute*) of HUMAN LIFE (*spiritual or inner existence, sense of well-being or personhood*).

Therefore, there should be no concern about ultimately becoming dominated by technological products. On the other hand, we must exercise constant prudence to assure that human needs and desires direct technology -- not vice versa.

Continued on page 62

Continued from page 61

What Must We Do?

We are still the potters, not yet the pottery. We initiate. Technology can take nothing from us that we do not surrender. The key lies in knowing *when* we surrender -- and on what *terms*. What would *you* include in the latter?

How many of us, when buying a new computer or any other technological product, thoughtfully list all our needs and then weigh competitors *exclusively* against those criteria? How often does such a list *exceed* the capability of *any* candidate product? How soon is the ultimately-selected product obsolete? Answers to these questions likely prove that *technology* leads the *user* -- not vice versa. A case can thus be made -- regarding technology -- that we (a) are reactive to it, (b) allow it to determine our relationship to it, and (c) fail to exercise foresight in its use.

But this is an era of management change in business, industry and government. The U.S. Coast Guard, for example, has recently adopted a new perspective: *"The business of the Coast Guard is risk management."* Consider then the following seven practical suggestions for minimizing human risk produced by technology:

Recognize the Unrecognized -- Include in the approval process for any new technological products a new deliberate activity that attempts to foresee how *culture, behavior* and *values* will change in the distant future if the product is installed. Leapfrog over immediate expectations to peer into the 5-to-20-year time frame. This is beyond the familiar cost-benefit analysis or environmental impact statement. Employ creative people capable of seeing well beyond today -- and provide management endorsement of this effort. How does reducing labor avoid increasing sloth? How can the virtue of pondering be sustained as calculative speed increases?

Study the Exceptions -- We still value and pay highly for things made by hand -- those whose machine-produced equivalents are disdained by the sophisticated. Why is that? Examine that premise -- ferret out what it is that resists technological advance. Maybe a secret lies there.

Solicit Oppositional Thought -- Engage those committed, for a variety of reasons, to the status quo -- who are students of the past. Historians, sociologists, theologians, anthropologists and scholars are possible candidates. Submit the proposed benefits of a technological innovation to them, requesting that they evaluate those benefits from their perspective. Ask for their most *negative* reactions to the proposed change. As we move from *keyboard-to-voice-to-visual* command of computers, we need to examine and weigh the tantalizing benefits very carefully. Ask the right questions, bring all thought to closure and periodically revisit decisions to develop guiding trends.

Discount Change as Progress -- Go beyond cost, schedule, size, weight, reliability, safety, maintainability and performance to a separate paradigm of "progress." Technology's "steamroller" effect -- newer is better -- generally precludes any conscious effort to evaluate whether the new product will, ipso facto, produce a better workplace, civilized work environment, enhanced organization, refined mission, uplifted morale, worker integrity, or management efficiency. By this qualitative assessment, a sensitivity to objective review will develop. What if someone had pondered seriously 30 years ago what risks children would experience by electronic consumer devices -- television, computers, audio amplifiers? Would they have foreseen hearing impairment, abandonment of reading as a learning source, atrophy of creative imagination, or widespread ignorance of history?

Shun Stalling -- Technology can increase human risk in an unsuspecting manner. The "critical incident syndrome" defined in Figure 3 will become severe if technology delays timely executive response to identified risk. The larger the role played by technology, the more likely this syndrome will expand -- primarily because financial investment in technology makes managers less likely to abandon it. Thus inertia against change tends to increase with technology. A correlate of this inertial reticence is a subconscious law -- that replacing technological products with manual operators is a backward step. Only technology is allowed to promise progress.

CRITICAL INCIDENT SYNDROME

Intuitive and often overractive response to a situation that has required management attention and correction for some time, but continues to be neglected until triggered by an unexpected loss of great magnitude, whereupon corrective resources previously unavailable are released in abundance.

Figure 3

Integrate Communication -- Computers compute. They are also vital to many realms of communication. But as super computers are evolving, their innovators are learning that computational power cannot remain the singular goal it once was. Such capability must be combined with communication. A broader rule can be drawn from this realization. When adopting any technology, there must be recognition that it ultimately contributes to a communicative need or format. The insurance industry has been described as "suffering from an overabundance of data but no information." *A messenger must make sense, regardless of how soon he arrives.* Simulators are wonderful creations -- saving us from real-life penalties while we acquire critical skills. However, the simulator design -- by skipping over or omitting communicative factors vital to good decision-making -- has the potential of introducing human risk of greater consequence than that being knowingly simulated. For example, there are both United States air carrier pilots and air traffic controllers for whom English is a second language -- introducing a high communicative risk that simulators seldom simulate.

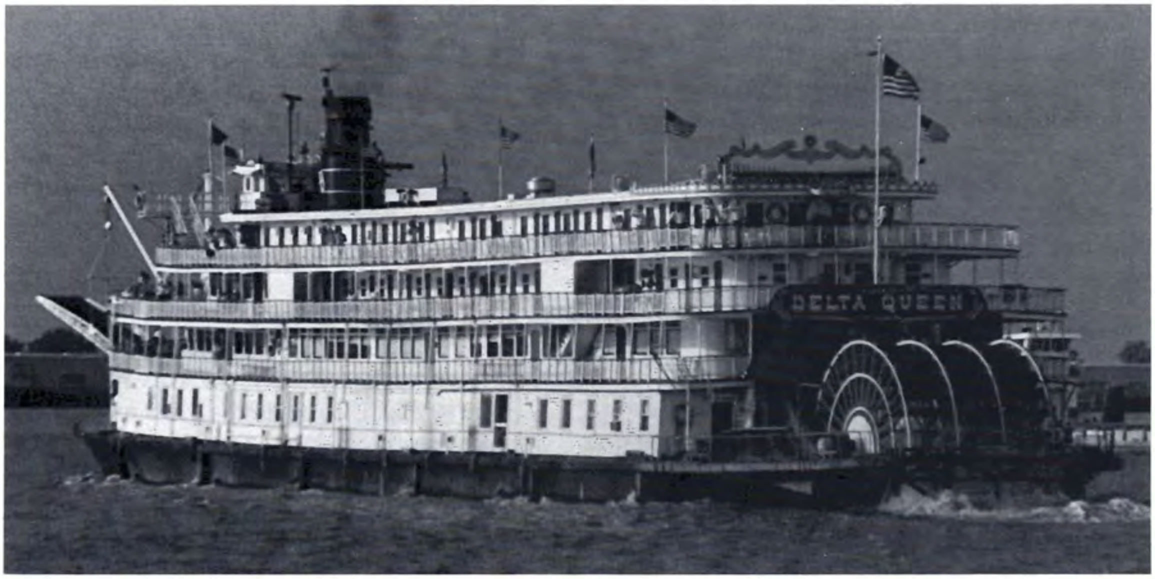
Overlap Human and Technology -- An abrupt man-machine interface does not exist, as has been earlier noted. Instead, there is a wide *zone* where both behavioral and automatic functions interact. Failing to perceive this blurred realm -- and thereby assuming a sharp cutoff or demarcation of responsibility for either creates a high risk of incorrectly assigning, attributing or expecting performance. For example, an automatic radar plotting aid -- mandated by law for maritime navigation and collision avoidance -- could be assumed to be fully capable of precluding all collisions. That erroneous assumption has been dubbed a "recipe for disaster." Instead, a prudent policy might be to exercise constant skepticism that *any* human function is ever totally replaced technologically.

We are in danger of overlooking the *truly* significant by easing the path by which the *seemingly* significant is attained. Technology increasingly depersonalizes human risk by expanding its leverage -- as exhibited by the "fatality density" of an airliner crash. The importance of *thoughtful* decision-making must not be lost. Hopefully, these seven proposals will encourage further discourse on this important subject.

Dr. Vernon L. Gross is chairman of the Omega Systems Group, 1400 South Joyce Street, Suite 1021, Arlington, Virginia 22202. Telephone: (703) 892-1905.

Editor's note: This article is under a copyright which precluded the normal editing process to achieve adaptation to Proceedings style.

Keys to crisis management



The riverboat Delta Queen races up Mississippi River in New Orleans. *Photo by former YN3 Joseph Relle.*

Spotlight on Port of New Orleans riverboat operations

By Dr. John R. Harrald

Under the Ports and Waterways Safety Act, the Coast Guard is responsible for ensuring "an acceptable level of risk" in United States navigable waters. This language is often interpreted as a mandate for preventing the human errors and mechanical failures that lead to accidents.

The prevention of accidents is the goal of any safety program, but an exclusive focus on eliminating initial failures ignores critical elements in reducing risk. The failure to consider all components of the waterway system when trying to decrease risk may lead to unintended adverse consequences. Interventions made in the name of safety may actually increase the vulnerability of the system to catastrophic events.

An accident is the result of a crisis in a complex system. Such a crisis occurs when a sequence of events puts the waterway system at risk of catastrophic failure. The effective management of this system in crisis is essential to ensure that errors or failures are captured, not magnified, and accidents are avoided or their effects minimized.

The *Exxon Valdez* oil spill in Alaska and the AMTRAK train derailment and ramming of the Big Bayou Canot Bridge in Alabama are well documented examples of the failure to capture and compensate for piloting errors made during severe environmental conditions (ice in Prince William Sound and poor visibility in the bayou). The initial errors started a causal chain leading to an environmental catastrophe in Alaska and the loss of 35 lives in Alabama.

New Orleans study

A risk study of the Lower Mississippi River was conducted recently for the Port of New Orleans, Louisiana. It is not difficult to envision a catastrophic event in the Mississippi River where seemingly minor errors or failures could result in ramifications much greater than the *Exxon Valdez* oil spill or the AMTRAK derailment and collision.

As in many other ports and waterways, the introduction of riverboat gambling has dramatically changed the risk profile of New Orleans. Coast Guard regulations and industry practice ensure that the gaming vessels are well designed and constructed, pose minimal fire hazards, and are crewed by experienced, qualified personnel.

Risk, however, has two components — the probability of an event and its impact. These elements of risk are properties of the waterway system, not attributes of any individual vessel. The origins of a causal chain of events are often independent of the vessel at risk.

The explosive growth of gaming boats and other high density passenger vessels in United States waters significantly increases human exposure to risk and magnifies the potential impact of an accident. A maritime casualty similar to the sinking of the *M/S Estonia* in the Baltic Sea on September 28, 1994, resulting in almost 900 fatalities is possible in New Orleans and other United States ports.

Although a catastrophe such as a collision involving a high-density passenger vessel in the Port of New Orleans is not highly probable, many individual factors in the risk equation are common and high-risk situations exist in the port with a disturbing frequency. For example, the Coast Guard captain of the Port of New Orleans has reported an alarming rate of power or steering loss incidents involving deep-draft vessels on the Mississippi River.

During three to four months a year, typically corresponding with the heavy tourist season, high water conditions in the port produce currents over six knots, posing a significant hazard to all down stream traffic and moored vessels. Reportable casualties in the lower Mississippi are five times more likely during periods of high water than during low water conditions.

If current plans for gaming boats are carried out, three riverboats with a combined capacity of more than 10,000 passengers would join the Algiers-New Orleans ferry and four passenger excursion boats in the five-mile stretch between Gretna and Algiers points. These vessels would operate mostly during afternoons and evenings, the peak periods of river congestion.

How will New Orleans react to a crisis of a large out-of-control vessel carried by high water currents into a congested traffic area with high-density passenger vessels and unmanueverable river tows? Is the port capable of crisis management to avert the potential tragedy? Will proposed vessel traffic management initiatives improve its crisis management system?

System response

A system may be defined as a set of related parts working together to achieve a common goal. It is regulated by both environmental factors and internal feedback.

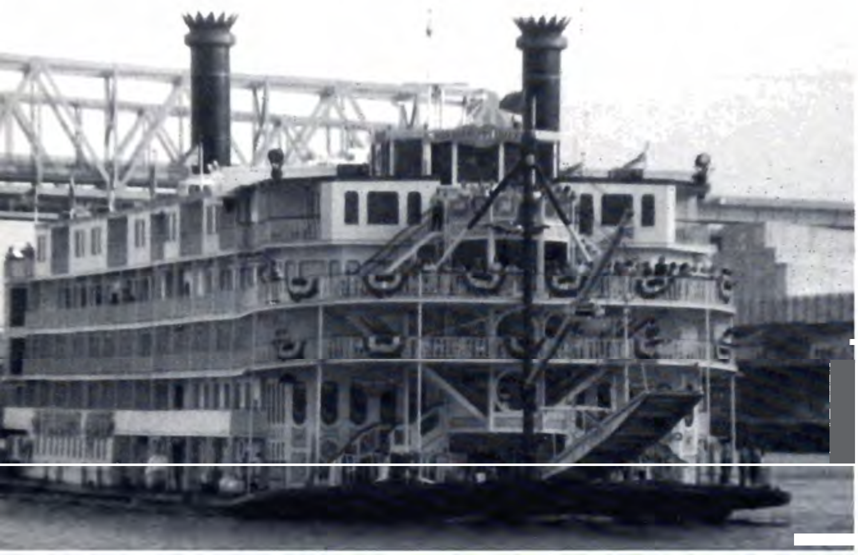
Each vessel involved in a hypothetical New Orleans disaster is an independent subsystem. In this port, two or more deep-draft vessels with state pilots, several high-density passenger vessels with licensed officers and one or more river tows could be involved.

External to the vessels are two Coast Guard traffic control towers and watchstanders at Governor Nicholls Wharf and Gretna. The Army Corps of Engineers-maintained channel, the Coast Guard aids to navigation and the Federal Communications Commission (FCC)-assigned frequencies are also part of the waterway system. The concept of acceptable risk is an essential system goal.

The New Orleans waterway system is loosely linked. Its elements are coupled during a crisis by radio communications and visual information. This loose coupling can be an advantage during a crisis, since allowing vessels to communicate directly minimizes errors due to information overload. However, in a loosely linked system, a vessel may operate in a aberrant manner, which could present an unmanageable risk. If the system is not monitored, this behavior could go undetected and lead to catastrophe.

The core elements in our waterways system are the masters, pilots, operators and Coast Guard traffic light operators. These individuals share a common culture and know how each other will react in a crisis and can communicate vital information and intentions with minimal verbiage. They have the same "mental map" of the hazard being faced based on years of similar experience. The ability of this informal system to react to crises and restore itself to an acceptable level of risk is critical and should be considered by those seeking improvements through state-of-the-art technology.

Continued on page 66



__Delta Queen__ passes under Crescent City Connection ~~in New Orleans~~. Photo by former YN3 Joseph Relle.
Photo by former YN3 Joseph Rel

Continued from page 65

Technology

The current waterway system in New Orleans has significant, well recognized, technological short-comings. Communications and navigation technology is marginal and available frequencies are inadequate. Limited Coast Guard budgets have restricted aids to navigation and traffic management improvements.

Traffic lights effectively control traffic, but they are hardly state of the art and are limited to a ten-mile section of the river. Funds were only recently found to operate the New Orleans traffic control light year-round, in spite of its acknowledged effectiveness. As a result of these technological limitations, all system participants may not become aware of a state of crisis and will not be able to initiate actions necessary to avoid catastrophe.

Socio-economic influences

Understanding the link between the external socio-economic environment and the strategy of the organizational system is critical for successful risk reduction.

The socio-economic environment includes organizational and cultural factors that, although not clearly defined, significantly affect the system. These include the organization, skills, resources and objectives of external stakeholders such as environmental, citizen and economic groups.

For example, the environmental sensitivities in the Pacific Northwest led to a significant state emphasis on marine safety, support of vessel traffic systems and the creation of strong state oversight agencies. On the other hand, the influence of the petrochemical and gaming interests in Louisiana have focused public perception on economic benefits. Public expectations of the likelihood and impact of a catastrophic event highly influence the political willingness to spend public funds on prevention and response activities.

High-reliability systems

The objective of risk management is to create a highly reliable system, not a technological showpiece. High reliability systems not only prevent errors from occurring, but respond to crises by detecting and counteracting errors that slip through the cracks.

High reliability system features identified by Dr. Karlene Roberts, professor at U.C. Berekley, include:

1- adaptive learning components; (Key personnel must be able to adapt and adjust during a crisis to assess lessons learned from each event.)

- avoidance of unanticipated "baffling interactions" between vessels; (Clear and unambiguous communications between vessels in the waterway is the most critical element of system safety.)

- minimization of indirect communications between vessels; (This implies that direct communications between pilots, for example, is superior to a VTS-mediated conversation during a crisis.)

- adherence to high standards of responsibility and accountability through continuous training; (The standards for masters and pilots must stress this.)

- clearly stated goals that are universally understood; (Safety must be a primary goal of all system economic and operational participants.) and

- organizational culture centered on reliability and safety. (This culture must be understood by those trying to change the system for public policy or economic gain.)

High-performance systems not only set goals, they establish feedback loops to check performance and reward systems to encourage goal-directed behavior.

The introduction of high-risk activities with potential huge economic rewards are the greatest threats to crisis management capabilities of the current system.

Conclusions

The waterway system in the Port of New Orleans is loosely coupled with decentralized decision making. Necessary interactions and communications are clearly understood by the professional river operators and pilots in the system. Such a system can rapidly respond to a crisis and take appropriate actions to avoid a potential catastrophe.

The safety-oriented culture shared by state and river pilots, towboat operators, port officials and Coast Guard regulators provides a common understanding of the system and its problems. A proliferation of safety advisory committees and associations in the port area manifests this culture. However, the advent of non-maritime related owners of gaming boats and the increased number of ships from non-traditional maritime flags and companies tend to dilute this culture.

More worrisome are external influences that degrade the culture rather than reinforce it. Riverboat gaming has introduced new economic and political stakeholders to the waterway system. The economic success of the casinos is tied to the river location and parking availability; and local and state government budgets depend on their share of casino revenues.

Economic ambitions can outweigh often poorly understood safety considerations. For example, state law requires that river gaming boats sail to preserve the exclusive licenses issued to land-based casinos. Political pressure is mounting to force the master to get underway, even when he or she determines it not to be prudent. Vessel cruising routes, however, are established by parish boundaries without regard to commercial traffic and are enforced by state police.

The preservation and enhancement of the safety-oriented maritime culture in the Port of New Orleans is the most important task facing waterways managers. Three other critical items are needed to support this culture. They are:

- the creation of a learning system,
- the establishment of a more efficient auditing capacity, and
- the improvement of response components.

Continued on page 68

Stern view of Delta Queen. *Photo by former YN3 Joseph Relle.*

Continued from page 67

The ability of the system to learn from errors and events is limited by the lack of an integrated program. Each of four pilot's associations in the area have their own program, but there is little information shared between them, and even less between the towboat and deep-draft industries.

The most ominous development in the lower Mississippi is that the advent of gaming boats has created an emergency response demand for which the system has no solution. The Coast Guard is planning for this potential emergency with resources at hand. However, except for one response boat, neither the industry nor the state or federal governments have added resources to the response capabilities of the system.

Lower Mississippi professionals recognize that there is a strong probability that the system will experience a crisis which must be controlled to avoid a catastrophe. The system has many high-performing attributes to detect and capture errors and failures before they result in disaster, but there are major weaknesses that could allow the causal chain to spin the system out of control, causing the loss of hundreds of lives.

Many weaknesses could be overcome with the appropriate application of technology. However, reliance on technology to replace the system could be counterproductive. A tightly linked technological system may not perform as well during a crisis than the present loosely coupled system that relies on the common culture of its professional core.

Strong, knowledgeable Coast Guard and industry leadership must ensure that external socio-economic influences and technological temptations do not destroy the parts of the existing system that work well.

The worst maritime disaster in United States history was the explosion and sinking of the riverboat *Sultana* in 1865 with the loss of 1,450 lives. This casualty led to the creation of the nation's first marine safety program — steamboat inspection.

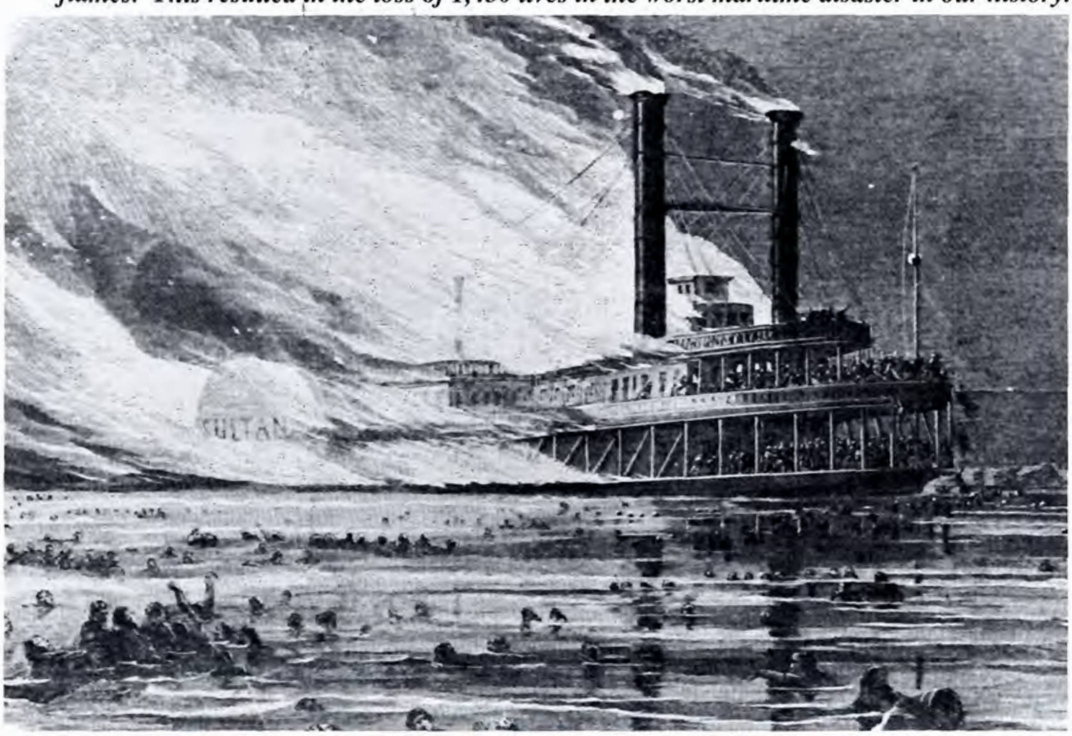
If a modern river disaster results in a similar loss of life, the public response would again lead to dramatic economic and regulatory changes. The gaming boat and excursion industries might not survive economically after a catastrophic incident. Coast Guard safety programs, heavily scrutinized after the *Exxon Valdez* spill, will be declared inadequate and congress will impose changes.

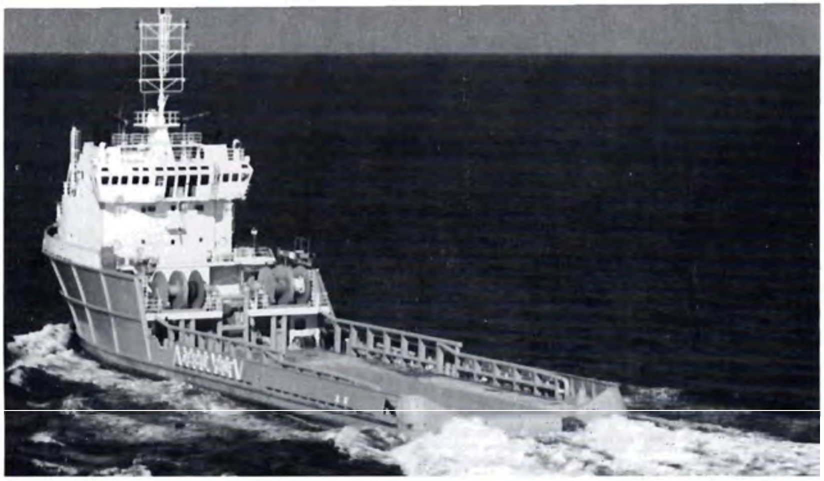
Regardless of the efficiency and effectiveness of our prevention programs, errors and failures will occur. Preserving and enhancing the ability of today's waterway systems to avoid catastrophes through sound crisis management must be a primary goal of United States waterways management programs.

Dr. John R. Harrald is director of the Instiitute for Crisis and Disaster Managment at The George Washington University, Washington, D.C. 22052. Telephone: (202) 994-7153.

Sultana photograph below is courtesy of the Steamship Historical Societiy, University of Baltimore.

On April 27, 1865, the paddle-wheel steamer Sultana cruised up the Mississippi River with 2,376 passengers. About 2 a.m., a boiler exploded, the vessel caught fire and was soon engulfed in flames. This resulted in the loss of 1,450 lives in the worst maritime disaster in our history.





This offshore supply vessel is empty now.
How much should it hold?

???Overloaded???

By LT Kevin D. Camp

This question is asked by Marine Safety Office (MSO) Morgan City, Louisiana, of offshore supply vessel and crewboat owners at random. This is being done under "Operation Safeboat," a program which randomly checks vessel compliance with stability regulations.

Authorized by 46 CFR 1.01-10, Operation Safeboat strives to heighten awareness of safe loading practices and conditions, and to enforce compliance with provisions of the stability letters, which establish cargo loading limitations on offshore supply vessels and crewboats throughout the MSO Morgan City inspection zone.

Inspectors from the MSO and Marine Safety Detachment (MSD) in Houma, Louisiana, refrain from routine inspection activities for the day a few times a year to make unannounced visits to the loading docks throughout the zone. The emphasis is placed not only on proper cargo loading, but also on heightening the level of awareness for cargo loading and stability concerns with vessel master, owners and affiliated hiring companies.

The process

Each inspected vessel found at the dock is boarded regardless of loading condition. If a vessel is being loaded or already loaded, the master is asked to do three things:

(1) calculate the total cargo weight ,

(2) prove the cargo is within the vertical center of gravity limits of the stability letter, and

(3) provide current conditions of all tanks.

If the vessel is not loaded, the master is asked to demonstrate his knowledge of cargo loading, vertical center of gravity, and tank conditions. If the master is unable to perform these tasks, the inspection department chief, his or her assistant or the MSD supervisor is informed, and, in turn, contacts the owner and/or operator of the vessel to require the problem be corrected before the vessel is allowed to get underway.

In addition, the inspectors contact representatives of the hiring company (i.e., the dispatcher, dock supervisor, or facility manager) to determine the total planned load for each vessel, and also to determine their level of awareness of weight limits, vertical center of gravity limits, load line limits and freeboard limits continued in the stability letters.

If the representatives cannot satisfy the inspector of adequate knowledge of the loading limit of each vessel at the dock, Coast Guard officers will discuss the issue with upper management officials of the hiring company, stressing the vessel's safety and the company's training program.

Bottom line

Any vessel which is overloaded must be reloaded properly according to stipulations in its stability letter before it can depart. The determination of what and how much cargo to offload or shift is up to the master and hiring company representatives.

If the stability letter is not on board, the vessel is held at the dock, and cargo operations are halted until it is placed on the vessel.

Reception

Not surprisingly, vessel masters have been very receptive and cooperative. Several have expressed appreciation for the Coast Guard's efforts to educate crew members in safe vessel loading. They recognize that safety awareness and education is the surest way to avoid temptations to overload the vessel.

Specifically, this operation has pointed out that a vessel is not necessarily capable of carrying more cargo just because there is empty space on the cargo deck.

Lt Kevin D. Camp is assistant chief, Inspection Department, Marine Safety Office Morgan City, Room 232, 800 David Drive, Morgan City, Louisiana 70380. Telephone: (504) 384-2406, Ext. 132.

Panamanian registered tank vessel Maistros I.

Death blamed on human error

By LT Mike Edgerton

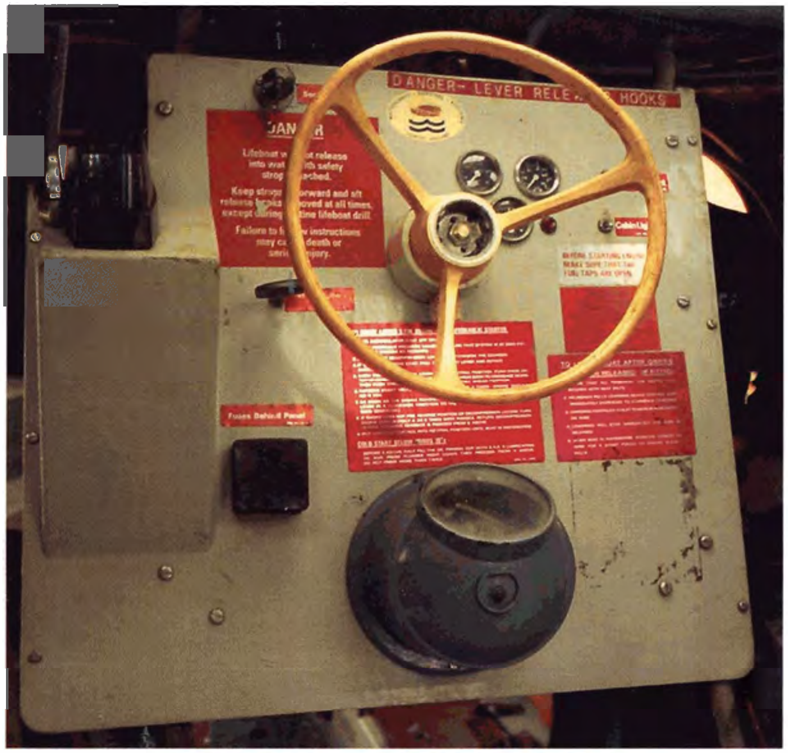
On September 14, 1994, the Panamanian registered tank vessel *Maistros I* reported that an enclosed life boat had dropped into the water from its stowed position, killing one crew member and injuring another. The subsequent investigation targeted human error as the cause of the casualty, which took place in Big Stone Anchorage in Delaware Bay.

Incident

Before the casualty, the *Maistros I* (formerly the *Chevron Horizon*) was sold and the new owners requested an inspection by the vessel's classification society in conjunction with the renaming and reflagging of the vessel. During the investigation, the new crew was required to conduct life boat drills.

When the drill was conducted on the starboard life boat, the third assistant engineer and a fitter entered the port life boat for unknown reasons. Shortly thereafter, this life boat dropped from its stowed position and killed the third engineer and injured the fitter.

The fitter reported in an interview that he was on a smoke break when the third engineer asked him to prepare the port life boat for the survey. While he was working in the midsection of the life boat, he noticed that the third engineer was working near the engine cover located in the aft section. A few minutes later, the fitter felt the boat lurch and fall. He grabbed a bench, held on and suffered superficial injuries during the boat's fall. He did not know for sure what caused the life boat to be released.



Note large number of red signs and the homemade sign at the top of the control console in the port life boat of the Maistros I.

Crew background

The crew of the *Maistros I* were Greek and Russian nationals. After traveling for more than three days via rail and air from Russia, the crew reported to the vessel on the afternoon of September 13, 1994. None had served aboard the *Maistros I* before.

The third assistant engineer was a native Russian who had been issued his third class engineering certificate for diesel engines by the Russian Ministry of Merchant Marine in 1991. He had been trained in personal survival and life saving at sea, and had a certificate in training in survival craft. The fitter, also Russian, had no formal shipboard survival training.

Investigation

A thorough examination of the life boat and its releasing gear was conducted by investigating officers from the Coast Guard's Marine Safety Office(MSO)/ Group Philadelphia and a staff engineer from the Merchant Vessel Inspection Division. They discovered that the releasing mechanism and hooks were operating normally and reset without difficulty.

It was noted that a glass cover which prevents tampering with the hydrostatic release was missing. The absence of broken glass indicated that the cover was missing before the casualty. In addition, a hollow rod was found nearby which was the proper size to prop up the hydrostatic release. No one could explain exactly what the rod was doing there, although it might have been used to activate the bilge pump.

All signs and instructions on the port life boat were in English. Nearly all the signs were in red, including those addressing non-emergency procedures. This coupled with the third engineer's unfamiliarity with English may have decreased the importance of the red signs and caused him to disregard other signs.

Perhaps, more importantly, the "DANGER" sign describing releasing procedures was missing, and was replaced by a homemade sign on the top of the control console.

Continued on page 72

Port life boat of Maistros I after casualty.

Continued from page 71

Two large holes on the outside of the life boat caused by ladder rungs on the davits indicate that both releasing hooks were released at the same time, and that the boat fell evenly until it hit the davits.

Human error

The accident was attributed to human error. The third engineer either mistakenly activated the releasing gear or accidentally disturbed the lever enough to release the life boat.

Several factors contributed to the casualty. First, the life boat's console was deficient because of the presence of a plethora of red signs of varying importance. This could have desensitized the operator to vital emergency signs. Furthermore, the sign concerning the releasing gear was missing and replaced by a homemade sign which was in the wrong place.

Perhaps the most critical aspects of the case, however, were its human factors. The vessel's new crew had traveled steadily for more than three days to an unfamiliar ship. Upon arrival, the ship was undergoing a rigorous classification survey and crew members were expected to perform all associated tasks.

The unfamiliarity of the crew with the vessel, the language barriers, the improper labeling of the life boat console, and the fatigue experienced by the crew all contributed to the casualty.

LT Mike Edgerton is the chief of Vessel and Waterways Operations, MSO/ Group Philadelphia, 1 Washington Avenue, Philadelphia, Pennsylvania 19147-4395.

Telephone: (215) 271-4895.

Stress

in the maritime workplace

By CAPT M. K. Riewer

There are very few working environments in which an individual is exposed to more constant, unrelenting stress than in the maritime workplace. The mariner is exposed to noise, physical exertion, inadequate nutrition, weather extremes, close proximity to others and the simple treachery of the environment in which he or she works.

It is impossible to eliminate all the risks inherent in an ever-changing environment. It is hoped, however, that by recognizing the factors and their collective impact upon the individual mariner, they can be alleviated.

Offshore supply vessel maneuvers near drilling platform.

Working environment

Offshore supply vessels

These vessels are typically between 150- and 250-feet long with four decks: navigation bridge, accommodation, main deck and engine room/ tank deck.

These vessels serve in two capacities — as miniature freighters carrying supplies out to offshore platforms or as stand/by vessels providing a floating logistics base alongside a platform. They may be equipped to provide fire-fighting assistance and to evacuate platform crews in emergency situations.

As part of the stand-by duty, offshore supply vessels often have to maneuver near the stationary platform to load or discharge needed equipment, supplies or fuel. The people working on deck are completely dependent on the skill of the master and the crane operator who must judge accurately the motion of the vessel and the wildly swinging load. An error in judgment results in damage to the vessel, the load or a badly injured crew member.

Continued on page 74

Continued from page 73

Tugs and towboats

The design of a tug or towboat can vary as much as its primary task. It ranges from 26 to 300 feet, and its pulling power can be from 50 to 50,000 horsepower. Its accommodations range from shacks to modern, well-designed quarters.

Statistically, the deck of a towing vessel is the most dangerous workplace in the maritime industry. Nowhere is the margin of safety narrower. An individual working on deck is the soft link between the tremendous power of the tug and a half a million dead-weight tons of a merchant ship. A nylon line under strain can part with enough kinetic force to shatter steel and dismember a body.

The tug boat George S. stands by for action at Smith Island, Alaska.
Photograph by M. K. Riewer.

The Wm H. Zimmer tows coal barges on the Ohio River.

The commercial fishing vessel Freedom lowers nets for large catch.

Commercial fishing vessels

Modern fishing vessels have changed a good deal since the days of *"Moby Dick"* and the Grand Banks cod schooners. Fishing vessels range from 18-foot lobster skiffs to 350-foot world-ranging super-seiner.

Commercial fishing equipment ranges from single ganglines of hooks retrieved by hand onto wooden spools to spectacular arrays of computer-stabilized engine, fishing and navigation controls.

A fisherman's tasks have not changed. Only the tools differ from those in use since antiquity. Fishermen must position themselves on rolling, pitching decks and haul in nets loaded with tons of fish, hoping that their rigging will hold, the hydraulics not fail and the refrigeration systems function until port is reached.

For as long as people have put to sea, there have been stories of ships lost without a trace. A fishing vessel earns nothing tied up to a dock, and often will sail when other craft remain in harbor. Only in the past ten years has serious efforts been made to increase safety in the fishing industry.

Maritime industry reforms have taken effect in the mandatory installation of safety, radio navigation and communication equipment; structural and propulsion inspection, and the generation of stability tables for fishing vessel loading.

Until very recently, officers commanding these vessels were not required to be licensed. Licensing requirements have done more to create a safer environment than any other development. Officers who violate these regulations will lose their licenses and livelihoods.

It is unfortunate that some owners, particularly of United States vessels which are financed by foreign corporations, routinely jeopardize the lives of their crews as a normal course of doing business. A wrongful death settlement can be appealed for years. It is only when the government enforces the laws it has passed will safety in the maritime industry be a reality.

Continued on page 76

Crew member works on deck of small tow boat Champion.
Photograph by John Keon.

Champion tows its load alongside a pier in Los Angeles, California.
Photograph by James M. Riewer.

Continued from page 75

Physical environment

To truly examine the sources of stress in the maritime industry, the physical environment must be looked at. There are very few workplaces today where individuals put themselves at risk on a daily basis. The industry is a small, insular world where news of accidents passes swiftly.

A) Physical exertion

The basic environment of the sea does not change. A vessel may spend weeks sailing along in a glassy calm or doing beam rolls. To work or just go about the basic necessities of life on board a rolling, pitching platform is tiring. The effects of this exertion can be cumulative. Add to a state of physical exhaustion the effects of noise, exposure, dehydration and inadequate or improper nutrition, and you have an individual whose physical and mental resilience is badly depleted.

B) Noise

One of the most significant factors of subconscious stress is noise. Only in the past few years has recognition been given to its profound, detrimental effect on the physical well-being of an individual. Whether its source is the main engines, the constantly running generators, or the ship's radios and loudspeakers, there is nowhere on board a vessel when a person can avoid constant, often injurious levels of noise.

C) Fear

Whether conscious or unconscious, fear is a factor in the level of stress that an individual may have to endure for extensive periods of time. Anyone aboard a vessel operating in low visibility will be apprehensive. It matters little whether the vessel has electronic aids to navigation. The seafloor is littered with the remains of vessels that entrusted their safety solely to electronics. Everybody on board knows this.

D) Close quarters

Proximity to other people is a significant factor in mental stress. A person is suddenly placed in the company of strangers and confined for weeks at a time. Inclement weather can exacerbate friction caused by this proximity.

One individual may have poor personal hygiene, another may have an annoying habit and another may insist on trying impose religious beliefs on others. There are very few places on board a vessel of any size where an individual can be alone. Close proximity is at best stressful, at worst, the cause of violence.

To achieve a structure of authority without creating an environment in which the individual feels burdened or antagonized is difficult, but it can be done. It is known as leadership.

E) Abuse under color of authority

One source of stress almost unknown in land-based situations is mental and physical abuse under color of authority.

Only in the maritime environment is one individual placed above others in such a position of complete, absolute authority. It is unfortunate that some officers take advantage of the situation to assert their authority in mentally and physically abusive ways. Overwork, hazing, verbal and physical abuse, short rations — all things that would lead to criminal prosecution on land are inflicted upon crew members by captains and officers.

It is necessary that the master of a vessel instill recognition and acknowledgment of his or her authority. This can be done in a non-abusive manner. Decisions cannot be made by committee in the marine environment, but it is unrealistic to expect that any individual will submit willingly to an abuse situation.

Summary

An individual who goes to sea should not have to surrender his or her basic rights. A human being has the right to a safe a working environment as possible, hygienic living conditions, proper nutrition and fair, humane treatment by the officers in charge.

As new generations of better-educated seafarers come up the gangway for the first time, they will be less tolerant of abuses than their predecessors. These new generations are also better trained, reducing the need for officers to exercise a level of scrutiny that may be perceived as oppressive.

Recognition of the physical components of stress will lead to their elimination, or at least to improved designs that will lessen negative impacts upon individuals.

Improved consideration of an individual's need for privacy will go a long way toward reducing the stress of confinement imposed by long voyages.

CAPT M. K. Riewer is an independent maritime consultant, 529 Avenue F, Redondo Beach, California 90277.
Telephone: (310) 316-9466

Champion escorts sailing vessel Estella nee Kilauea in Los Angeles, California.
Photograph by James M. Riewer.

Cover photos

Front cover: The merchant vessel *Swallow* grounded on Amaknak Island in the North Pacific in 1989.

Rear cover: The research vessel *Weatherbird* grounded in Sheepscot River, Maine in 1992.

Both casualties were caused by human error.

U.S. Department
of Transportation

**United States
Coast Guard**

2100 Second St., S.W.
Washington, D.C. 20593-0001