Practical Application of Risk Analysis in Development of Harbor Safety Plans

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I am going to discuss an example of how people have applied concepts of risk in the real world—a practical, nonscientific application of risk management by California Harbor Safety Committees in the development of harbor safety plans. For those of you who are not familiar with Harbor Safety Committees, and I suspect there are fewer and fewer of you, I will provide a little background. Then I will present a brief overview of the risk analysis process we used, describe two very different examples of issues to which we applied the process, and conclude with an evaluation of the effectiveness of the process.

In California in 1990 the Lempert, Keene, Seastrand Oil Spill Prevention and Response Act, the Act for short, required formation of Harbor Safety Committees for the five major harbors in the state. These local committees were to include representatives of the ports, tanker operators, pilots, dry cargo vessel operators, commercial fishing or recreational boaters, labor, tug or barge operators, environmental organizations, and the California Coastal Commission, or, in the case of San Francisco, the San Francisco Bay Conservation and Development Commission. In addition, nonvoting representatives of the U.S. Coast Guard, the U.S. Army Corps, and the U.S. Navy were invited to participate. This is a representative cross section of the port community. The entity charged with establishing these committees and keeping them running was the Office of Spill Prevention and Response (OSPR).

The five committees, in Humboldt Bay, San Francisco, Port Hueneme, Los Angeles/Long Beach, and San Diego, were responsible under the Act "for planning for the safe navigation and operation of . . . vessels within each harbor" and for preparing "a harbor safety plan encompassing all vessel traffic within the harbor."

Although the mandate of the five committees was the same, the differences between the harbors were vast. Vessels entering San Francisco Bay may travel 43 mi (69.2 km) upriver to the Port of Sacramento. By contrast, it's about 4,300 ft (1311 m) from the entrance to Port Hueneme to the back of the harbor. The petroleum traffic varies from a few barges a year in one port to over 700 tankers per year in another. Some have world class vessel traffic systems, and others have none. Winds, wave heights, currents, visibility—all vary greatly from one harbor to another. And, as I know from having served on the Humboldt, Port Hueneme, Los Angeles/Long Beach, and San Diego Committees, the cultures of the committees varied as well.

Despite these differences, the process used to develop harbor safety plans was basically the same for all five harbors.

Committees were required by the Act and its implementing regulations to examine specific issues and propose pertinent recommendations in the harbor safety plans. For instance, committees were to determine when tankers must have tug escorts of sufficient size, horsepower, and pull capability when entering, leaving, or navigating in the harbor. Other issues to be addressed included anchorage designations, communication systems, navigational aids, traffic routing during construction and dredging projects and emergencies, channel design, sounding checks, conflicts with small vessels, and whether to establish or expand a vessel traffic system within the harbor.

All these issues were first to be examined in terms of the current environmental and operational conditions in the harbors and not just in some idealized, hypothetical context. For instance, what were the present channel depths, navigational aids, anchorages, and contingency routing plans? What were the types of vessels and cargoes, the weather, tidal ranges, and geographic boundaries? Also required was a 3-year history of accidents and near accidents. The list ends with "any additional issues that could impact safe navigation." And that was all just a summary.

This checklist in the Act amounted to a de facto risk inventory, and our informal application of risk review included a modified "what-if" analysis. None of us thought at the time that we were doing a risk analysis. Indeed, a pilot recently told me that the term risk analysis was scary and that the pilots had never done a formal risk analysis before. After thinking about it, however, he decided that pilots do informal risk analyses every day.

Using this checklist from the Act, we began to work together to develop our first harbor safety plan. Basically, we used the expertise of committee members for brainstorming. And as you might deduce from the list of representatives, that expertise spanned a wide range. Slowly, one of the most important aspects of the process began to develop: the building of trust between representatives of industry and government. From the viewpoint of several industry representatives, trust was essential so that members of industry could speak honestly of problems without fearing that government would, in their eyes, "overreact." As they put it, they were able to describe the problem without having a new regulation come down the next week. They came to believe that they could use the committee as a forum for developing workable regulation packages.

The trust that developed between environmentalists and industry representatives was also essential, because, although environmentalists cannot throw new regulations at industry, they do have a good deal of influence in the arena of public opinion. Speaking for the four Harbor Safety Committees on which I served, the trust that developed among representatives of government, industry, and the environmental movement allowed them to constructively work cooperatively on even highly charged, politically sensitive safety problems. A critical element in the building of this trust was the continuity of the committees. Members were appointed for 3-year terms and many were reappointed.

We used the expertise of committee members from the maritime industry with the added benefit of the perspective of those outside the industry. I am overgeneralizing, but industry came to the table with the attitude that "we've been doing it this way for years and haven't had an accident yet." The nonindustry members, on the other hand, came to the table with memorable past events in mind for ports with a history of disasters: Halifax Harbor, 1917, two ships collide, 1,600 dead, 6,000 injured; Texas City, 1947, two ships collide, 500 dead; Los Angeles Harbor, 1976, a ship explodes, 10 dead and about 100 injured. Although such disasters are by no means commonplace, just as oil spills the size of the *Exxon Valdez* are hardly commonplace, they are all memorable enough to color the public's perception. In discussing these different frames of reference with industry representatives, I was gratified to hear that at least some of them grew to value the exchanges that took place among committee members. These industry representatives considered the committee a "good forum for discussion which made everyone step back and look at what their interests and biases were." An example one member gave was the establishment of a formal Vessel Traffic Service in Los Angeles/Long Beach. During initial discussions within the Harbor Safety Committee, dating back to 1991, many in industry did not see the need for mandatory vessel traffic services, but the Coast Guard, OSPR, and many ship masters favored development of such a system. Through the ensuing discussions among various parties, though, industry came to recognize the value of the Vessel Traffic Information System to facilitate communication in the port complex and supported its installation, which occurred in 1994.

I'll now describe two very different issues that two of the committees addressed. The first is a relatively simple success story, and the other is the most complex issue with which we dealt.

For years, many San Francisco pilots and ship masters entering the Bay felt uneasy coming under the Golden Gate Bridge in conditions of poor visibility. Such conditions were not infrequent, because San Francisco Bay typically has 1,500 h of fog annually, and visibility is often less than 500 ft (152 m). The collision of two tankers in heavy fog in the Golden Gate in 1972, which caused massive environmental damage, certainly added to this concern. When the first racon was installed in San Francisco Bay on the sea buoy by the pilot station, the pilots saw its value and wanted one installed on the bridge. As you may recall, two of the items on our lengthy checklist of issues to review were bridges and aids to navigation. Shortly after the San Francisco Harbor Safety Committee was formed, the problem was discussed by the committee. A member described it as an issue looking for a venue. In the ensuing discussions, some expressed the "haven't had a problem yet" approach. Others used the example of a San Francisco pilot who was coming from upriver and approaching the Richmond-San Rafael Bridge, which had a racon installed. He had a strong current behind him when a large sudden squall caused the bridge to be obscured by rain on his radar return. The only way to determine the bridge opening while making the critical approach was with the racon signal. In contrast, in

Tampa Bay when a sudden squall obscured a vessel's radar return of the Skyway Bridge, which was without a racon, the ship hit the bridge and killed over 30 people. Ultimately, the San Francisco Committee agreed that a racon placed on the Golden Gate Bridge would reduce the risk of collision under conditions of reduced visibility. The recommendation was forwarded to the Golden Gate Bridge District.

Here, once again, the diversity of the Harbor Safety Committees was valuable. A nonindustry member was active in local politics, acquainted with members of the Bridge District, and familiar with its procedures and politics. This person shepherded the proposal through the various subcommittees for over a year, and the racon was eventually approved and installed. Since that time, racons have been installed on other bridges throughout the state at the request of local Harbor Safety Committees.

In contrast to this simple, apple-pie issue is my other example: Harbor Safety Committees' development of tug escort recommendations. This represents the single instance when Harbor Safety Committees hired an outside consultant to perform a formal risk study. Even in this case, however, the value of the consultant's study depended on the practical, real-world expertise of the committee members, whose input determined the assumptions on which the consultant's model was based.

The Act mandated that development of tug escort regulations was of the highest priority, especially for San Francisco Bay. The San Francisco Committee quickly adopted interim regulations and about 1 year later submitted suggested permanent regulations to OSPR. These recommendations were rejected because the guidelines developed to match tugs to tankers lacked a scientific rationale.

Glosten Associates, the consultant then contracted to provide technical data on the issue, at first adopted a dual-failure standard—in other words, simultaneous loss of both propulsion and steering—as the basis for measuring the amount of tug power needed to safely stop a tanker within the available reach. Industry reacted strongly against the dual-failure assumption. They contended that such a scenario was so unlikely as to be unreasonable, that the force required to be brought to bear was so great that it created other problems, and that there was not a pattern of dual failures in other risk areas.

The Tug Escort Subcommittee, after reviewing failure probability, requested that Glosten calculate demands based on single failure, which the second Glosten study did. The study was based not only on computer modeling but also on full-scale trials. After many meetings, much discussion, and two Glosten studies, the San Francisco Harbor Safety Committee voted 12 to 1 to adopt a single-failure standard for development of matching criteria. The dissenting vote was by the representative of an environmental organization, who contended that, although dual failures were rare, the consequences could be so catastrophic that it was prudent to base the criteria on that eventuality. OSPR promulgated permanent tug escort regulations for San Francisco Bay based on the committee's recommendations and using the single-failure standard.

The Los Angeles/Long Beach Committee had early on called for tug escort/assist inside the breakwater. As we began to look at marine casualties in the harbor area, we saw that 1 in 100 commercial vessels, or one per week, sustained some type of steering or propulsion failure during the inbound or outbound transit. I might add, this is a good example of the value of collecting and analyzing incident or near-miss data.

The committee decided that this mechanical failure rate, combined with the decreasing amount of navigable waters inside the breakwater because of fill projects, was a risk to tankers transiting the relatively narrow breakwater entrances. We decided the risk justified requiring tug escorts outside the breakwaters, which had not been considered before. Implementation of the scheme was delayed, however, until the second Glosten study was completed in San Francisco, because we believed that the study might provide helpful technical insights.

The subcommittee developed a tug escort scenario of stopping a tank vessel within 3,000 ft (914 m). After extensive technical analysis and debate, the subcommittee determined that the Glosten single-failure study was transferable to the conditions in the approaches to Los Angeles/Long Beach Harbor. Glosten was hired to validate this conclusion and determined that the results were not transferable. As part of this third report, Glosten provided examples of braking forces needed to stop a tank vessel within 3,000 ft. These braking forces were extremely high and were neither practical nor workable in Los Angeles/Long Beach Harbor. It would have taken a significant portion of the harbor complex's entire tug fleet to escort a single tank vessel. Furthermore, the number of tugs that would be needed to provide the required braking force could not simultaneously be applied to a tank vessel. A new scenario was needed.

Before Glosten could proceed further with the third report, it was necessary for the Harbor Safety Committee to develop some basic assumptions. What goes into a model determines what comes out, and the Tug Escort Subcommittee worked long and hard to come up with a set of assumptions about tanker speeds, tug capabilities, currents, and transfer and reach distances. Again, according to both industry and government representatives, the key was the ability to see the issue through someone else's eyes. The Los Angeles/Long Beach Tug Escort Subcommittee decisions were always consensus based, which was not always easily attained.

In the previous studies, the goal was assumed to be the ability to apply enough force to stop a disabled tanker, and Glosten did not specifically address turning forces.

Los Angeles/Long Beach Subcommittee members determined that, based on the geography of the Los Angeles/Long Beach Harbor and the location of the federal breakwater, it might be a safer option in many cases to try to turn a disabled ship outside the breakwater instead of trying to stop it. If the vessel was within 3,000 ft of the breakwater, then the recommended procedure would be to guide it through the entrance as there was adequate reach inside to stop the tanker before it reached the dock. We proposed that Los Angeles/Long Beach require tugs to have adequate braking capability to meet an inbound speed-restricted tanker far enough outside the breakwater to either halt the tanker before it grounded on the breakwater or help steer it through an opening if it failed closer to the breakwater.

The third Glosten study provided a force matrix for both turning and stopping, and the committee recommended that state regulations be amended to incorporate tug-to-tanker matching requirements as specified in that matrix. These regulations are now in force. An interesting footnote is that the Los Angeles/Long Beach criteria could cover a dual as well as a single failure, even though that was not the intention.

Now for a quick evaluation of the effectiveness of the process as a risk analysis mechanism, albeit from a prejudiced source.

The process was successful in that it resulted in plans that were accepted and implemented. In addition, there is an ongoing forum in which emerging safety issues can be addressed. Unlike some formal risk analysis documents that just sit on a shelf, the Harbor Safety Plans positively affect the day-to-day safety operations of the ports. Some plans are even on the Internet.

The diversity of the group contributed to the success of the process in several ways. The wide-ranging experiences and expertise of those on the committee were critical in identifying problems and developing solutions. Through the process, members developed a more holistic view of the port operations and gained an appreciation for the complexities of the workings of the port. For instance, recreational boaters, through working with pilots on the committee, came to realize that it was often impossible to see small boats from the pilothouse of large vessels. Both groups believe the resulting improvements in communication are responsible for a decrease in the number of small recreational boats interfering with large vessels in shipping channels.

By bringing these diverse parties to the table in a proactive way, we solved problems that otherwise would have had these groups meeting on opposite sides of the barricades by the time the issue became public. A pilot stated that input from outside of industry was good because, without it, industry could not always see the forest for the trees.

The committee was a forum for discussion of what risks we were willing to tolerate. The risks we were looking at were not only to commerce but also to the environment and to public safety. Because industry was not the only party at the table, decisions were not determined solely by cost-benefit analysis.

When we had to call the outside scientific experts, we did, but one cannot do an entire Harbor Safety Plan in that manner. Individual committee members thought that decisions that were taken regarding risk-benefit analysis and risk assessment were based on their input and therefore reflected their particular concerns. This is not to say that Harbor Safety Committees are a panacea for port safety problems. The diverseness of the group certainly led to occasions when the conflicting interests could not be reconciled. Those occasions, however, were amazingly few and far between. It was a practical, reality-based process that, within the constraints posed by time and money, was a very effective way of improving harbor safety.