# WATERFRONT PROTECTION

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## Abstract

Ships may be highly valuable assets that may be subjected to attack by terrorists (domestic and foreign). When developing a waterfront protection plan you may want to ask: (1) How valuable is the asset, (2) What are the consequences of a successful attack, (3) What are the threats, (4) What are the vulnerabilities, and (5) What are the cost tradeoffs? Some of the consequences include: loss of life, economic loss of ship and cargo, loss of port use, loss of profit, environmental damage, the effects of secondary detonation and intangible effects of public fears and perceptions. In general, the more valuable the asset and the greater the consequences of an attack, the more protection should be considered. The concept of risk can help serve to help evaluate the tradeoffs and amount of protection to be afforded. Some key features of waterfront protection to consider include: detectors, barriers (deter and delay) and response.

## Value

In general the more valuable an asset, the less risk society is willing to take. This concept underlies many U.S. building codes, financial systems, etc. and therefore serves as one parameter to consider when developing waterfront security.

## Consequences

In general the higher the consequences of something bad happening, the less risk one would be willing to take. Some marine situations with high consequences of attack might include:

- Detonation of an LNG, fertilizer or chemical tanker – the secondary detonation could cause massive damage

- Loss of highly populated cruise liner – many lives lost; cruising is an optional recreational activity and a major downturn in sales could occur quickly resulting in high economic loses

Therefore, the consequence a successful attack serves as a parameter to consider when developing a waterfront security plan. Note that "success" for example, might be simply attacking an LNG tanker. The attack could cause a great deal of terror and produce huge economic impact, even if the secondary detonation did not materialize.

## Vulnerabilities

Vulnerability to attack is a key consideration. For example, it would be logical that a double-hulled tanker would tend to be much less vulnerable to a boat bomb attack than a single-hulled tanker and analytical methods can be used to assess vulnerabilities of various ships to various weapons/attacks.

**Threats**
Waterborne threats to commercial ships may include:

- Pirates
- Waterborne Improvised Explosive Devices (WBIED's)
- Swimmers/Divers
- Minisubs

WBIED's or "boat bombs" may be especially problematic because:

- There are over 12 million boats in the U.S. (USCG records)
- Boats can generally travel at moderate to high speeds
- Boats can carry moderate to large payloads
- Boats are relatively easy to drive
- Boats can be easy to obtain (buy, rent, steal)

The WBIED threat has been used for well over a hundred years (example, sinking of *CSS ALBEMARLE* in 1864, Figure 1 left and attack on the oil tanker *MV LIMBERG* in 2002, Figure 1 right). This type of attack can be easy, very low cost and highly successful, so the emphasis of this paper relates to the WBIED threat.

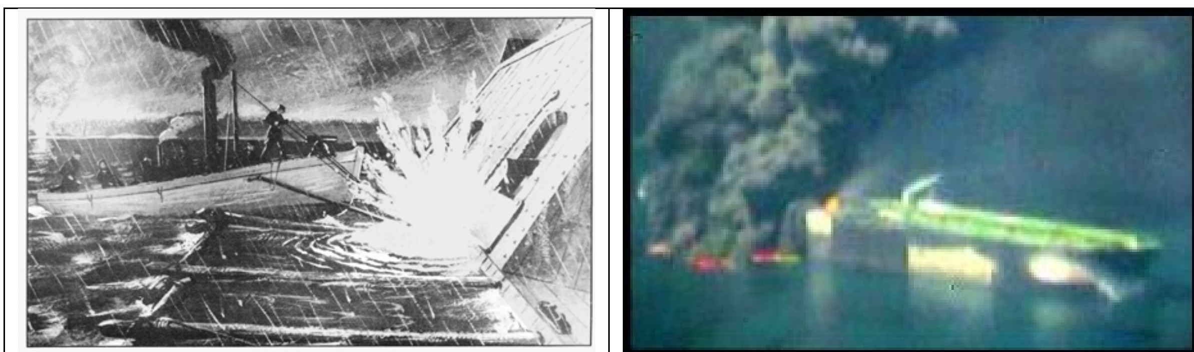


Figure 1. Example WBIEDAttacks

Threats therefore need to be considered when developing a waterfront protection plan.

**Risk**
Risk serves as an indicator of how to invest valuable resources. For example, society in general is not willing to take much risk, for example in commercial flying (Table 1). Therefore, a risk of probability of failure of $P_f = 10^{-6}$ is used in commercial aviation (i.e. there is only a 1 in 1,000,000 chance that a commercial jet will be lost in a given year, Figure 2). Commercial airline passengers are not willing to take much risk, these jets are vulnerable and the consequences of failure are relatively high (hundreds of people on

board and each cost many millions of dollars).  This is why TSA invests heavily in commercial airline security.

Routine merchant ships have few people on board and typical cargo is somewhat inert, so society / design standards / codes specify a relatively high risk of approximately $\boldsymbol{P_f} = 5 * 10^{-2}$ (i.e. a 1 in 20 chance of loss in a given year, Figure 2).  This means that society is willing to take 50,000 times more risk with routine merchant shipping than with commercial airliners.

Another way to look at it is, if a port with routine inert merchant shipping were only attacked by terrorists once every 20 years, then the current standards (Figure 1) would suggest that not much investment in terrorist protection would be required (i.e. the risk is acceptable).   On the other hand, a large modern cruise ship can cost many times more and carry an order of magnitude more passengers than a commercial jet, so the risk standard for cruise ships should be set accordingly.

This risk approach would suggest that scarce waterfront protection dollars would be best directed towards:

- Highly valuable assets
- Assets where the consequences of a successful attack could be high
- Assets that are also vulnerable to terrorist attack

| ***Probability of Failure, $P_f$*** | ***Cumulative % Avoidance*** | ***Society Reaction*** |
|---|---|---|
| $10^{-1}$ | 90% | Unacceptable |
| $10^{-2}$ | 99% | Unacceptable |
| $10^{-3}$ | 99.9% | This level is unacceptable to everyone.  When risks approach this level, immediate action should be taken to reduce the hazard. |
| $10^{-4}$ | 99.99% | People are willing to spend public money to control hazards at this level.  Safety slogans popularized for accidents in this category show an element of fear (e.g., “the life you save may be your own”). |
| $10^{-5}$ | 99.999% | Though rare, people still recognize these hazards, warn children (e.g. drowning, poisoning).  Some accept inconvenience to avoid such hazards (e.g. avoid air travel). |
| $10^{-6}$ | 99.9999% | Not of great concern to the average person.  People are aware of these hazards, but feel “it can never happen to me” – a sense of resignation if they do (e.g., an act of God). |

Table 1. People's Willingness to Accept Risk (After Kesse and Barton, 1)

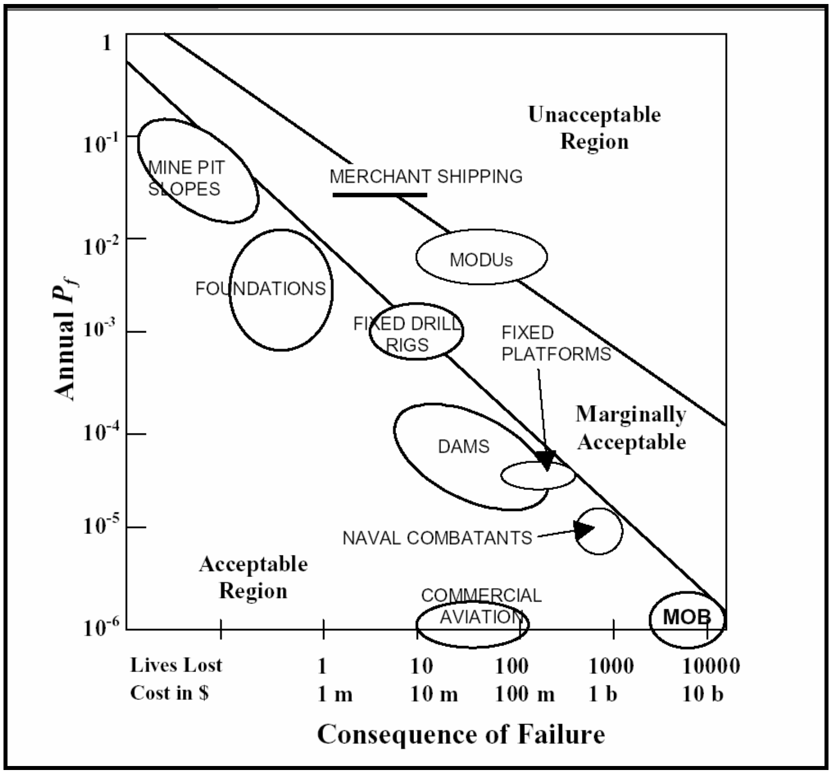



Figure 2. Sample Risk Diagram (after Bhattracharya et. al.)

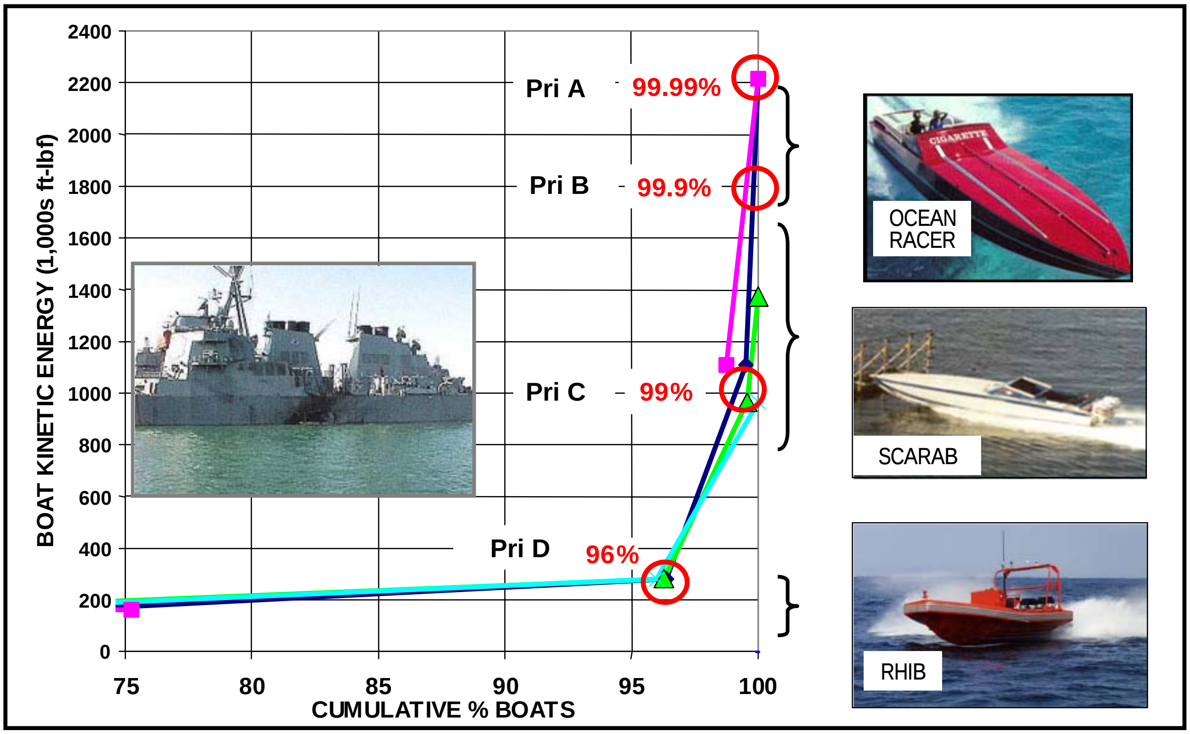
**WBIED Threat**

Only a terrorist may know if, when and where he may strike by boat attack (if at all). The distribution of boats in the U.S. (Figure 3) gives some guide of the possible threat. Tests and analyses show that boat kinetic energy (i.e. one-half times mass times velocity squared) is a good single parameter to characterize the boat. Figure 3 illustrates the cumulative distribution of boat kinetic energies in the U.S.

Possible boat barrier design criteria are also illustrated in Figure 1. An important feature to notice is that the 96% level is a "break point". Relatively cost effective systems can be provided to meet the "break point". Reducing the cost below the "break point" achieves some cost savings, but results in a very rapid increase in risk. Therefore, the minimum recommended working capacity of a boat barrier would be 280,000 foot*pounds.

An example illustrates the thinking involved in specifying a waterfront protection system. Assume a 6-foot diameter marine fender barrier (Figure 4) is purchased at an approximate cost of $875 per foot. Attack tests and analyses show this system has an ultimate boat stopping capacity of 160,000 foot*pounds. If a terrorist picked an attack boat at random, then there would be about a 70% chance that he could not get over the boat barrier quickly. However, if he selected one of the larger 4 million boats in the U.S.

he could easily get over the barrier without damaging the boat, without slowing down and without incapacitating personnel on board (if any). In this case a lot of money is spent and very little security obtained. A net system can provide much higher cost effective boat stopping (Figure 5).




| Asset Priority | % Boats Stopped | Boat Stopping Required* | Notes |
|---|---|---|---|
| A | 99.99 | 2,200 | Asset of extreme value, vast consequences |
| B | 99.9 | 1,800 | Very valuable and high consequences (LNG?) |
| C | 99 | 1,000 | Valuable with significant consequence (cruise?) |
| D** | 96 | 280 | Value and some consequences (double-hull tanker?) |
| E | N.A. | None | Routine merchant shipping |

Figure 3. Boat Distribution in the U.S. and Boat Barrier Design Criteria for Consideration

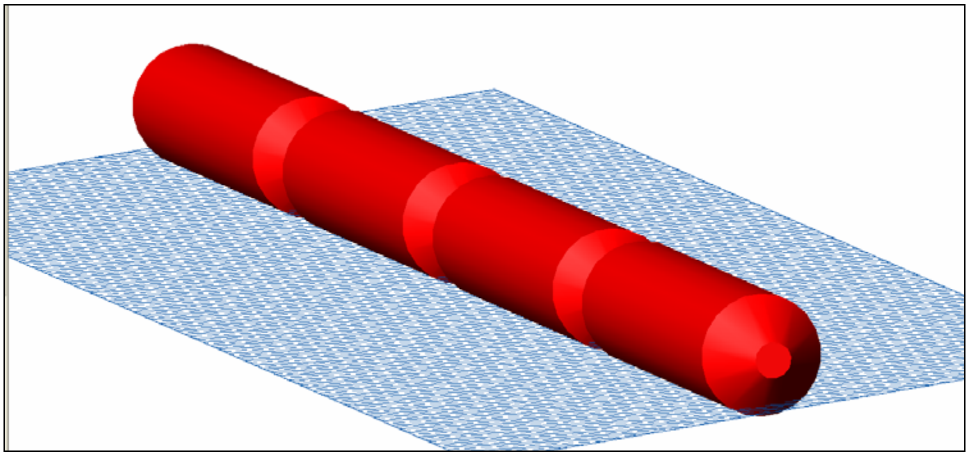


Figure 4.  6-Foot Diameter Waterfront Boat Barrier

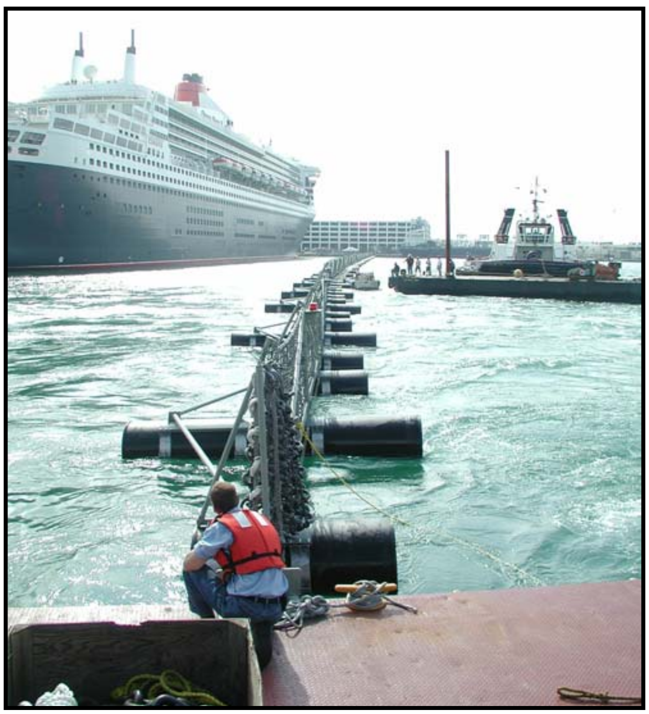


Figure 5.  Net-Based Waterfront Boat Barrier
Port Security Barrier (photo by Harbor Offshore, Inc.)

**Time**
A key problem with boats is that they can travel at moderate to high speeds. A boat traveling at 30 knots, for example, travels 600 feet in only 12 seconds (Figure 4). This makes it difficult to respond to an unimpeded attacking boat.

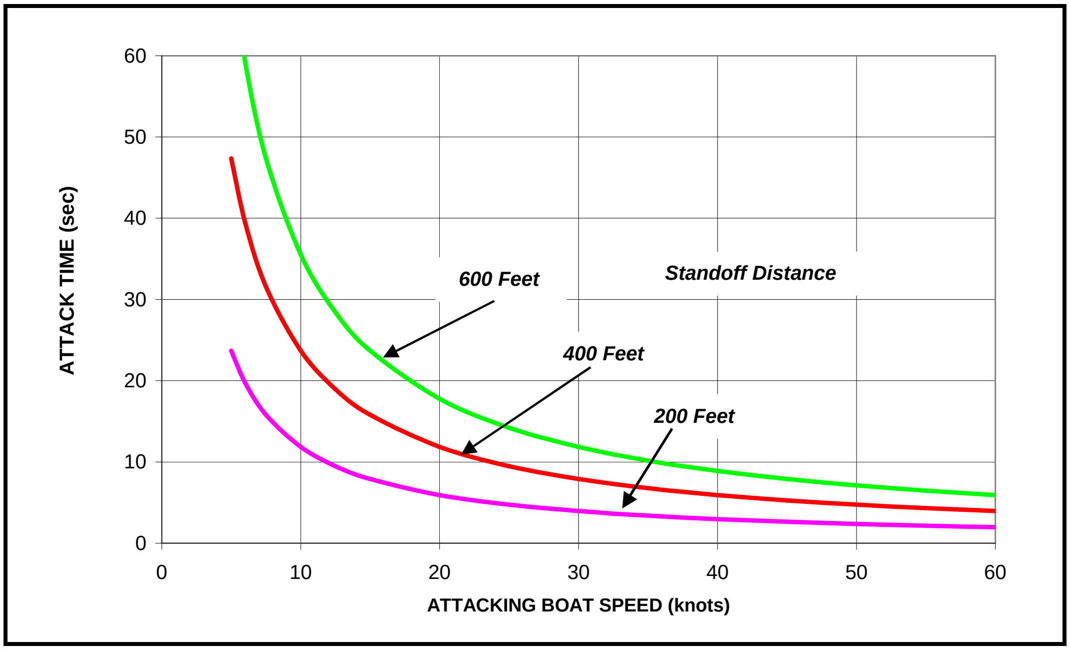



Figure 4. Time

**Waterfront Protection – A Balanced System**
All of the factors discussed above suggest that a balanced waterfront protection system is needed to protect very valuable/vulnerable ships from the WBIED threat as follows:

WATERFRONT BOAT BARRIERS – Boat attack can occur at high speed and with little warning. Therefore, even if the threat can be detected, there will be little time to respond. Therefore, an effective waterfront boat barrier is needed to actually delay an attacker to enable a response. A waterfront boat barrier: (1) needs to be effective to reduce risk to an acceptable level, (2) serves to discourage attack in the first place, and (3) detectors should be able to see through the boat barrier to prevent a terrorist using he barrier at a hiding zone.

DETECTORS - Any barrier made by man can be defeated with enough time, explosives, etc. Therefore, detecting (patrols, cameras, radar, etc) attempts to defeat the waterfront boat barrier are needed.

RESPONSE - A timely and effective response is ultimately needed to defeat a determined terrorist group heading towards a target.

**Summary and Conclusions**

A risk assessment suggests that valuable waterfront protection dollars may be best spent protecting highly valuable assets that are vulnerable with high consequences in the case of a successful terrorist attack. The WBIED or "boat bomb" threat is especially problematic because there are many boats in the U.S., they are easy to drive, they can carry rather large payloads, they can travel at high speeds and they are easy to obtain. Protecting valuable/vulnerable ships against the waterfront against the WBIED threat, if required, needs a balanced waterfront protection system that includes:

1) Effective waterfront boat barriers
2) Reliable detection
3) Meaningful response

If any of these elements are not provided, then why bother?

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**References**

1) Kesse and Barton, "Risk Assessment and its Application to Flight Safety Analysis", Sandia National Laboratories, SAND89, 1982.
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