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ADA Access to Passenger Vessels: Finding Safety Equivalence Solutions for Weathertight Doors with Coamings

Phase 1: Background and History

Prepared for:

Architecture and Transportation Barriers Compliance Board — Washington, D.C.

Prepared by:

U.S. Department of Transportation
Research and Special Programs Administration
John A. Volpe National Transportation Systems Center — Cambridge, Massachusetts

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This report examines possible approaches to provide for both marine safety and disability access at doors into passenger accommodation spaces on U.S. passenger vessels. The Architecture and Transportation Barriers Compliance Board's ultimate objective is to assist designers and operators in improving wheelchair access without compromising the vessel safety provisions of the sills at these doorways. This report contains the results of "Phase 1" of the project, which are 1) to examine the application of the current governing safety regulations; and 2) to present several brief technical case studies examining the design and regulatory review of weathertight doors on K and T boats.

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Table of Contents

Figures

Tables

Appendix

ACRONYMS

ADA	Americans with Disabilities Act, 1990
ADAAG	ADA Accessibility Guidelines for Buildings and Facilities (2003)
ATBCB	Architecture and Transportation Barriers Compliance Board
CFR	Code of Federal Regulations
COI	Certificate of Inspection
COTP	Captain of the Port
ILLC	International Load Line Convention
IMO	International Maritime Organization
MBTA	Massachusetts Bay Transit Authority
OCMI	Officer in Charge of Marine Inspection
PVA	Passengers Vessels Association
PVAAC	Passenger Vessel Access Advisory Committee

1 Introduction

1.1 Purpose of Report

The purpose of this report is to examine possible approaches to provide for both marine safety and disability access at doors into passenger accommodation spaces on U.S. passenger vessels. The sponsoring organization is the Architecture and Transportation Barriers Compliance Board ("the Board", or ATBCB), an independent Federal agency, whose mission is to improve accessibility for people with disabilities. The Board's objective here is to assist designers and operators in improving disability access without compromising the vessel safety provisions of the high sills at some doorways. The high sills are known as coamings in marine parlance and their purpose is to prevent the entry of water into the passenger spaces served.

This report includes the results of "Phase 1" of the project, which are:

1. The need for and application of the current governing safety regulations; and
2. Brief technical case studies examining the design and regulatory review of weathertight doors on K and T boats.

Phase 2 is to follow and will be a research project to develop Americans with Disability Act (ADA) Access Guidelines for complying manual door designs which provide an equivalent coaming protection.

The focus of this study is on the small-sized classes of regulated U.S. passenger vessels, known as Subchapter T and Subchapter K boats, named after the relevant sections in Title 46 ("Shipping") of the Code of Federal Regulations (CFR). These boats generally are less than 100 gross tons and carry more than six passengers. Other sections of Title 46 regulate smaller boats carrying up to six passengers and larger vessels of greater than 100 gross tons. T and K boats make up the overwhelming majority of passenger ferries and excursion vessels, such as dinner boats and whalewatchers, which are available to the general public. Vessels operating in international waters and subject to international marine safety codes are not included in the study.

1.2 Organization of Report

Chapter 2 is a brief description of the relevant safety regulations and the underlying safety philosophy and the ADA Accessibility Guidelines mobility-impaired access guidelines, as well as the current practice in the U.S. passenger fleet. Chapter 3 presents the case studies on passenger vessels with weathertight doors having no coamings. Chapter 4 is a summary of findings and recommendations.

2 Background

Under Coast Guard domestic regulations, certain doors in passenger vessels leading from the outside ("the weather") into passenger accommodation spaces must have sills (also known as coamings) of varying heights to prevent the entry of water. However, under the American with Disabilities Act Accessibility Guidelines (ADAAG), an accessible door cannot have a threshold that is higher than 1/4 inch or 1/2 inch, if beveled. If ADAAG threshold provisions were applied to passenger vessels, at certain doors, the coaming requirement and ADAAG threshold requirement would conflict. The following sections detail the provisions of the Coast Guard regulations and the ADAAG guidance, as well as summarizing the current practice in the U.S. passenger fleet.

2.1 Relevant Coast Guard Regulations and Practice

It is useful at the outset to set the U.S. passenger fleet and the Federal regulations within the larger context of the international fleet and its safety codes, and to provide some definitions of marine safety concepts as they relate to the most elemental need: to keep water out of the boat and preserve the integrity of the "watertight envelope" provided by the hull. The hull structure consists of the shell, its bottom and sides, and the main deck, and it carries the payload by displacing water (except in cases of "lift" craft such as hydroplanes and hovercraft, a very small minority of passenger vessels). Its geometric and loading configuration defines its stability and provides reserve buoyancy for safe responses to external forces such as waves, wind, and water on deck.

The very first marine safety regulations resulted from the Merchant Shipping Act of 1871 (Great Britain), which addressed seaworthiness and later were substantially adopted as the first international code, the International Load Line Convention (ILLC). The essence of the ILLC was to provide for adequate hull structure and reserve buoyancy, prevent overloading, and to ensure watertight integrity. A significant feature of the latter was to address water that gets on the "weather decks", by rain, spray, and, most importantly, boarding waves. For merchant cargo ships, storm-driven waves sweeping the deck (also known as "green water") are a serious hazard to this day. The danger is twofold: accumulation of water on deck and downflooding into spaces below. Both degrade reserve buoyancy and stability.

The ILLC addresses this hazard through the "conditions of assignment", a detailed set of specifications for all structures above the main deck and all openings into the hull and superstructure, including cargo hatches, doorways, ventilator pipes, port holes, and others. The conditions of assignment aim to provide topside design features that will prevent entry of water and shed it quickly over the side; many of these are adapted for use in the CFR's subchapters addressing ship safety in general and passenger vessel safety in particular. The CFR covers nearly all of the United States passenger vessels operating in United States waters. The ILLC pertains only to a handful of United States vessels operating on international voyages, as well as all of the foreign flagged cruise ships operating from U.S. ports.

Properly designed topside structures and openings are “weathertight”. The distinction between watertight and weathertight is the following:

- “Watertight means designed and constructed to withstand a static head of water without any leakage” (46 CFR 114.400 and 175.400). This refers to structures that must withstand hydrostatic loading for extended periods of time, including the hull bottom and sides, main deck plating, tanks, and “subdivision bulkheads”. The latter are meant to contain the spread of water that enters the hull as a result of hull breach due to collision, grounding, etc. All weldments and penetrations of such structures are subject to strict testing requirements to ensure that no leakage occurs under the particular design conditions of the vessel.
- “Weathertight means that water will not penetrate in any sea condition” (46 CFR 114.400 and 175.400). This refers generally to topside structures subject to occasional and short exposure to water on deck, from boarding waves or wind driven rain and spray. Regulations specify arrangement and height for weathertight appurtenances, as well as load and welding specifications, which are generally less stringent than for watertight structures.
- In short, the watertight hull envelope keeps water out from below where the sea’s hydrostatic pressure supports the vessel’s weight, and the weathertight structure keeps it out from above, where access and operations necessitate openings of many kinds into the hull and superstructure.

It should also be borne in mind that most marine regulations, including international codes, take account of the vessel’s area of operation, that is, some safety requirements vary according to the severity of conditions anticipated. Many U.S. T and K boats operate in relatively benign waters, as defined and certificated by the Coast Guard, and therefore, in some cases, meet less stringent requirements than those for boats in harsher environments, in ocean operations, for example.

2.1.1 Code of Federal Regulations

The relevant issues in the CFR for these purposes are the definitions for all types of passenger vessels, areas of operation as applied to Certificates of Inspection (COI) and for the purposes of stability requirements, and the weathertight door coaming regulations themselves.

2.1.1.1 Passenger vessel definitions

The definitions for passenger vessels are found first in 46 CFR, Part 70, Table 70.05-1(A) “Classes of vessels examined or inspected under various Coast Guard regulations. Discussion for these purposes is confined to vessels whose primary purpose is carriage of passengers and does not include oceanographic research vessels and other commercial vessels that sometimes carry passengers for hire, for example, tankers or fishing boats. The table defines, in descending order of size, Subchapter H, Subchapter K, Subchapter T, and Subchapter C passenger boats.

The definitions and particular subchapter citations follow, along with examples of each:

- Subchapter H (46 CFR 70.05) – Vessels of 100 gross tons or more, carrying more than twelve passengers. Examples: Staten Island Ferries (vessels up to 3,335 gross tons and 6,000 passengers) and passenger/vessel ferries of the Washington State Ferry service (up to 4,988 gross tons and 2,500 passengers). Subchapter H vessels are inspected by the Coast Guard.
- Subchapter K (46 CFR 114.110) – Vessels of less than 100 gross tons, carrying more than 150 passengers, or has overnight accommodations for more than 49 passengers. Examples: New York Waterways passenger only ferries carrying up to 350 passengers. Subchapter K vessels are inspected by the Coast Guard.
- Subchapter T (46 CFR 175.110) – Vessels of less than 100 gross tons, carrying 150 or less passengers, or has overnight accommodations for 49 or less passengers. Examples: most catamaran and monohull whalewatchers, Harbor Express (Boston) catamaran ferries. Subchapter T vessels are inspected by the Coast Guard.
- Both Subchapters K and T exempt vessels operating exclusively on non-navigable inland waters (e.g., landlocked lakes), certain research vessels, lifeboats, and foreign vessels subject to acceptable international or national inspection laws.
- Subchapter C (46 CFR 24.05) – Subchapter C includes all uninspected passenger vessels. Those less than 100 gross tons are allowed to carry six or fewer passengers, at least one of whom is for hire. Representative examples are charter sailing vessels, charter fishing vessels, and small water taxis. Uninspected vessels of more than 100 gross tons are allowed to carry twelve or fewer passengers, at least one of whom is for hire. Large charter yachts, also known as mega-yachts, are the best known representatives of this class of vessels. The Coast Guard does not formally inspect these vessels, although they may be boarded for safety examinations.

2.1.1.2 Areas of operation

The CFR and Coast Guard certification and inspection regime takes a dual approach to areas of operation, affecting all passenger vessel types, and in addition allows for a certain amount of judgment by the Officer in Charge of Marine Inspection (OCMI) in the relevant Captain of the Port (COTP) zone.

Most importantly for the aim of this study, the CFR defines “exposed”, “partially protected”, and “protected” waters, for the purpose of applying the stability criteria and regulations to H, K, and T boats. These terms describe the sheltered versus exposed nature of the waters, that is, the severity of waves and swells likely to be encountered therein, as well as the proximity to safe refuge of vessels operating therein. The OCMI has the authority to designate waters as seen fit to account for local conditions. Many of the stability regulations vary in application depending upon the waters plied, for example, the specified “wind heel” load that the vessel must sustain. Included among

these are the “Watertight Integrity” regulations, which regulate openings in the hull and superstructure, including weathertight doors; these are discussed in detail below.

The Coast Guard conducts a regulatory stability assessment for each inspected passenger vessel, the result of which is the stability letter issued to the owner. This letter identifies the type of waters (e.g., “partially protected”) upon which the vessel may operate, given its design and stability characteristics, as well as any loading restrictions deemed appropriate. The stability letter is generally not posted onboard in public view. An example of this document appears in Appendix A.

The Coast Guard also issues a certificate of inspection (COI) for each inspected passenger vessel. The COI addresses many safety aspects including manning and certification of crew, and stability, and specifies operations in well defined areas, including “rivers”, “limited coastwise”, “coastwise”, “Great Lakes”, “lakes, bays, and sounds”, and “oceans”. The COI is posted on board by regulation and is the document that the traveling public are most likely to see. Again, the COTP has discretion to re-designate any area in his zone based on environmental conditions and safety considerations. The COTP can also impose limitations or grant extensions of operating routes based upon stability criteria and unique construction or operating characteristics of the vessel (Coast Guard Marine Safety Manual). An example of the COI also appears in Appendix A.

These two operating area designations are not linked in the regulations. Table 2-1 provides a general guideline as to how they match up in practice. There is a correlation in a general sense only, e.g., the stability designation “partially protected” to COI designation “limited coastwise”, or “exposed” to “oceans”. It is important for the reader to keep in mind that the COTP can alter this correlation depending on local conditions and the design and construction of the individual boat. It should be held foremost that designations for stability purposes are what matter for the purposes of this study.

2.1.1.3 Watertight integrity regulations for Subchapter H passenger vessels

Subchapter H passenger vessels are the largest sized regulated class and are generally subject to the most stringent structures and stability requirements, in both Subchapter H and Subchapter S (“Stability”). Subchapter H specifies plan approval for a wide array of hull structure drawings and annual inspection of watertight doors and subdivision bulkheads. Subchapter S addresses “Watertight integrity above the margin line in a vessel 100 gross tons or more” (46 CFR 171.122), by specifying weathertight closures and coamings for “each opening in an exposed weather deck”. The interpretation is that those openings include only hatches, and not doors into superstructure on the weather decks. The reason for this omission is not clear, although Coast Guard experts felt that such doors would generally be higher above the waterline (and less likely to be exposed to boarding waves) and that the relatively large size of H vessels would preclude a safety problem due to wind driven rain or spray[1]. H vessels subject to the International Load Line Convention would have to meet superstructure and deckhouse door coaming requirements. These, however, are vessels operating in international waters only and

[1] Telephone conversations with LT Parker, Coast Guard Marine Safety Center, and with Tom Jordan, Coast Guard Headquarters, October 2, 2003.

would not include most of the Subchapter H vessels currently documented in the United States.

Table 2-1
Coast Guard Designations of "Waters"

	Designation of Waters for Purposes of Stability Regulations		
	Exposed waters	**Partially protected waters**	**Protected waters**
Definition	Waters more than 20 nautical miles from harbor of safe refuge; applies on Great Lakes from Oct. 1 to April 15.	Waters not more than 20 nautical miles from harbor of safe refuge; applies on Great Lakes from April 16 to September 30.	Sheltered waters with no special hazards, e.g., rivers, harbors, and lakes.
Examples		Puget Sound	Boston Harbor, New York Harbor
Roughly Corresponding COI Designations	*Oceans* – any route more than 20 nautical miles offshore.	*Limited coastwise* – any route not more than 20 nautical miles from a harbor of safe refuge.	*Lakes, Bays, and Sounds* – route on same.
	Coastwise – any route not more than 20 nautical miles offshore on oceans, gulfs, and seas.	*Coastwise* – as designated by OCMI	*Rivers* – route on same.
	Great Lakes – includes St. Lawrence River, from Oct. 1 to April 15.	*Great Lakes,* from April 16 to September 30.	

2.1.1.4 Watertight integrity regulations for Subchapter K and T passenger vessels

The watertight integrity regulations addressing weathertight doors are identical for Subchapter K and T boats (46 CFR 116.1160 and 179.360, respectively). The relevant citations for weathertight doors in Subchapters K and T are identical and read as follows:

***

"(d) A weathertight door must be provided for each opening located in a deckhouse or companionway. Permanent watertight coamings must be provided as follows:

1. "On a vessel on an exposed or partially protected route, a watertight coaming with a height of at least 150 mm (6 inches) must be provided under each weathertight door in a cockpit or a well, or on the main deck of a flush deck vessel.
2. "On a vessel on a protected route, a watertight coaming with a height of at least 75 mm (3 inches) must be provided under each weathertight door in a cockpit or a well.
3. "The height of a watertight coaming for a hinged watertight door need only be sufficient to accommodate the door."

***

A cockpit or well, as described in sub-paragraph (a), is an area of deck set below the weather deck, with the same weather-tightness requirement for all its boundaries. They are given special mention because of the potential for water to become entrapped therein and the necessity to prevent downflooding through doors giving access to spaces below. Cockpits and wells are uncommon on the whole in the inspected passenger vessels fleet, and are usually found on passenger sailing boats. A flush deck denotes continuity of the weather deck from bow to stern at the upper limit of the hull sides.

The paragraph allowing substitution of a watertight door with no required coaming height provision is specifically for vessels with licensed crew and other capable personnel (e.g., offshore drilling rig workers) aboard, who know how to operate a watertight door and can do so in emergency egress situations[2].

Subchapter S "Stability" considerations

Discussions with naval architects and Coast Guard personnel revealed some redundancy and confusion arising from the watertight integrity and coaming provisions of Subchapter S, also part of the Coast Guard's Title 46 regulations. Subchapter S addresses coamings among many stability matters, and applies to all vessels less than 100 gross tons, not just passenger vessels. The design of a small passenger boat requires attention to both Subchapter S and Subchapter T or K. The regulations are

[2] See footnote #1.

sometimes clear in the matter of integrating those requirements (see following paragraph), but are not so with regard to coamings.

One example of clear guidance is that Subchapters K and T explicitly cite Subchapter S intact stability standards (that is, the vessel's ability to stay upright under loading from wind, waves, passenger movement, etc.) for passenger boats with particular physical or operational characteristics. Subpart C of Subchapter T (parts 178.310 – 178.340) specifies compliance with four separate parts of Subchapter S for vessels more than 19.8 meters in length, carrying more than 12 passengers on an international voyage, and having more than one accommodation deck above the bulkhead deck. The point here is not to discuss the technical fine points of these particular provisions, but to illustrate how clearly in one instance Subchapter T guides the user.

The redundancy and differences between Subchapter K or T and S citations for weathertight doors and coamings is not specifically addressed in either Subchapter K or T. The relevant citation for weathertight doors and coamings in Subchapter S (part 171.124 "Watertight integrity above the margin line in a vessel less than 100 gross tons") is similar, but not identical, to those in Subchapters K and T (shown in the first paragraph of 2.1.1.4), and reads as follows:

***

"(d) A weathertight door with permanent watertight coamings that comply with the height requirements in table 171.124(d) must be provided for each opening located in a deckhouse or companionway that –

(1) "Gives access in to the hull; and

(2) "Is located in –

(i) A cockpit;

(ii) A well; or

(iii) An exposed location on a flush deck vessel.

"(e) If an opening in a location specified in paragraph (d) of this section is provided with a watertight door, he height of the watertight coaming need only be sufficient to accommodate the door."

***

There are several subtle differences in the definitions and interpretations of locations onboard where coamings are required. The Coast Guard itself has occasional problems in applying these provisions, as illustrated by an internal memorandum from the Headquarters Office of Design and Engineering Standards on the definition of "weather deck" for the purpose of applying the weathertight door provision[3]. The following points summarize the comparison of and difficulties among the relevant parts of the three subchapters:

[3] "Interpretation of "Weather Deck" as Used in 46 CFR 114.400", April 19, 2002.

- All three subchapters similarly specify 6” and 3” coaming heights for exposed or partially protected routes and for protected routes, respectively. The only perfect similarity among all three subchapters is that these coamings are required for doors in cockpits and wells.
- The differences for exposed and partially protected routes are the following:
    - Subchapters T and K only – “on the main deck of flush deck vessels”. This is fairly prescriptive. The term “flush deck” is clearly defined, but, as the Coast Guard memorandum notes, “unfortunately, there is no definition of ‘main deck” in the subchapter”.
    - Subchapter S only – “for doors giving access into the hull or for exposed locations on flush deck vessels”. This definition requires interpretation by the user on two counts. The first appears to concern downflooding paths into the hull and prevention of water entry into spaces below decks. The second is the assessment of whether a door location is “exposed” (as distinct from the exposure of the boat’s operating route).
- The differences for protected routes are the following:
    - Subchapters T and K require coamings only for doors in cockpits or wells.
    - Subchapter S language is the same as for exposed and partially protected routes, “for doors giving access into the hull or for exposed locations on flush deck vessels”, again requiring interpretation by the user.
- There are several issues of vague or inconsistently used definitions:
    - The Coast Guard memorandum states: “One of the reasons for the perplexity on this issue is that 46 CFR defines ‘weather deck’ inconsistently in subchapters T, K, and S”. In any case, this term does not appear in the weathertight door provisions of any of the subchapters.
    - The term “exposed location” in Subchapter S, is not defined. The Coast Guard memorandum notes that the Subchapter K and T definitions (§ 114.400 and § 175.400) of “weather deck” could provide some guidance (“…a deck that is completely or partially exposed to the weather from above or from at least two sides”). These are two different terms, however. Furthermore, Subchapters K and T do not specify a door’s exposure as a means to determine the coaming requirement.
    - Subchapter S uses the term “above the margin line” in the title of § 171.124. Margin line is a damage stability term for the maximum allowed height of the waterline after damage is sustained. Most commonly, the “main deck” or “bulkhead deck” is immediately above the margin line. All or part of that deck may or not be “weather deck” depending on the design of the deckhouse, bulwarks, and other structures and enclosures.

In summary, the terms of reference in the weathertight door and coaming regulations in these three subchapters can be confusing and subject to various interpretations for particular boats by both industry and the Coast Guard. Subchapter S requires more interpretation by the naval architect and will in some cases be more stringent for

passenger boats operating on protected waters; that is, a door's "exposed" location and/or proximity to a downflooding path might be interpreted to require a 3" coaming where Subchapters T and K require none. T and K are prescriptive in nature and may in some cases be more stringent for boats on exposed and partially protected routes. T and K could require a 6" coaming in a location where interpretation of Subchapter S would not.

Diligent naval architects and regulatory personnel seek safe and reasonable designs based on technical knowledge and experience. They must consider the owner/operator's intended use of the vessel and the will apply the regulations and their own best practice methods as appropriate.

The case studies in Chapter 3 herein include a sampling of anecdotal information on safety "equivalencies" to these regulations granted based on design particulars. The philosophy and safety precepts evident in Subchapters K, T, and S will be brought forward into the Phase 2 work of finding safe, accessible solutions for weathertight doors.

2.1.1.5 Watertight integrity regulations for Subchapter C passenger vessels

Subchapter C covers "uninspected vessels", as described above. Such boats are subject to the construction and flotation requirements that apply to all uninspected boats, but the regulations in Subchapter C are limited to Parts 24–26, which include lifesaving and fire prevention and extinguishing equipment. Those under 100 gross tons include many "open deck" boats without the type of doors addressed herein. Weathertight doors are in any case not required for Subchapter C boats that have deckhouses with doors.

2.1.1.6 "Good marine practice"

The term "good marine practice" describes commonly accepted marine design and construction methods in addition to the requirements of the CFR. Coast Guard regulations describe minimally acceptable features that can be and are often exceeded by the naval architect and the shipyard.

Good marine practice is in no way a universal standard, but varies by service, region, design operating conditions, and even preferences of the owner and the shipyard. In the case of doorway coamings, it is not uncommon to find them on vessels where the service and operations do not require them. It is possible that good "accessible" design practice can change this particular element, with improved awareness by designers and operators.

2.1.2 Hazards and Risks

2.1.2.1 Hazards associated with stability

The hazard addressed by the watertight integrity regulations, and the coaming regulations in particular, is water ingress and downflooding. Protracted exposure to waves and ingress of water, even in incrementally small amounts, can degrade the

vessel from an “intact stability” to a “damage stability” situation. A brief explanation of the concepts of intact stability and damage stability is first in order.

Stability in both modes is the ability of the vessel to remain upright while sustaining applied loads. These loads can be external (e.g., waves, wind, water on deck) and internal (weight shifts such as passenger crowding, movements of liquid or solid cargoes). The vessel’s weight and buoyancy distributions determine its stability characteristics. The ultimate stability hazard is capsize, a fast moving event with the potential to cause devastating loss of life. Prevention of capsize is the aim of the stability regulations. Lesser hazards are associated with non-capsize scenarios in which the vessel’s response to external loading can cause discomfort or injury to passengers, particularly those unused to marine travel. The naval architect addresses these hazards, and they are not covered by the regulations.

Intact stability addresses situations when the vessel is operating in the undamaged, normally loaded condition. The latter descriptor may be one of several conditions that must be checked by the naval architect; examples include 1) full load departure and 2) return with partially full fuel tanks.

Damage stability applies in abnormal conditions when water has entered the vessel following events such as groundings, collisions, and ingress of water due to storm conditions. Domestic and international damage stability regulations are most stringent for passenger vessels as compared to other types, but the reader must bear in mind that the stability and safety of a vessel in this state has been seriously degraded.

2.1.2.2 Regulations and risk

The Coast Guard now sees safety as a risk management process. Risk is the product of an event’s probability and its consequences. The consequences of ingress and downflooding are always serious, that is, the degradation of vessel’s stability. The potential consequences of the capsizing of a passenger vessel – tens or hundreds of lives lost – are unacceptable; therefore, the regulations are intended to minimize as much as possible the probability of that event. The coaming regulations are one element of watertight integrity requirements meant to reduce the probability of significant ingress of water.

This explains why the regulations are tied to definitions of exposure and protection that include a consideration of time, that is, proximity to a safe harbor. In protected waters, sea conditions are less likely to cause significant water on deck, and the proximity of land and emergency services assets further reduces risk, should flooding occur. In exposed or partially protected waters, water on deck and the conditions for downflooding are more likely and “safe harbor” is likely to be at greater distance. The regulations are more stringent in such cases because the likelihood of water on deck is higher and more time is needed to get to safe refuge.

2.1.3 “Equivalents” and “Special consideration”

The CFR allows for review and approval of engineering and design proposals, in both Subchapters K and T, from any regulations, based upon an equivalency of safety. “Equivalents”, described in 46 CFR 114.540 and 175.540 for K and T boats,

respectively, allow for the Commandant to "approve any arrangement, fitting, appliance, apparatus, equipment, calculation, information, or test, which provides a level of safety equivalent to that established by specific provisions of this subchapter". The applicant is required to submit such requests to the Coast Guard Marine Safety Center (a Headquarters unit located in Washington, DC) via the local cognizant OCMI. All such proposals are evaluated strictly on a case-by-case basis.

The "Equivalents" regulations also allow for the Commandant to accept compliance by a high speed craft with the provisions of the International Maritime Organization (IMO) "Code of Safety for High Speed Craft" as an equivalent to compliance with applicable requirements of the relevant subchapter. These requests are also submitted to the Marine Safety Center via the cognizant OCMI. The IMO Code does not specify coamings, but addresses doors in a general way, as follows:

> "**2.2.4** The means of closing openings in the boundaries of weathertight structures should be such as to maintain weathertight integrity in all operational conditions."

"Special considerations", described in 46 CFR 114.550 and 175.550 for K and T boats, respectively, empower the OCMI to "give special consideration to authorizing departures from the specific requirements when unusual circumstances or arrangements warrant such departures and an equivalent level of safety is provided". The equivalent arrangement in these cases pertains only within the particular COTP zone under the OCMI's cognizance and is for particular circumstances of a vessel's design or operations. A special consideration request may in fact be for a particular voyage or event, for example, a boat approved for "oceans" service carrying extra passengers for an event (e.g., a fireworks display) in protected waters, with the appropriate added precautions such as sufficient lifesaving equipment.

Discussions with Coast Guard personnel reveal that there would be several factors to consider in an assessment of safety equivalency for doors without coamings, which are the following:

- Vessel's route
    - COI area of operation
    - OCMI designation of waters in which the vessel may operate, for stability purposes, i.e., exposed, partially protected, or protected
- Door's location – that is, the exposure to or protection from waves, spray, and precipitation
    - Height above design waterline
    - Proximity to bow
    - Proximity to deck edge
    - Purpose and use of weather deck accessed by the door, i.e., the type and frequency of use (e.g., evacuation, embarkation only, passenger seating), and the people who use the door (i.e., passengers or crew)

- Alternate access to interior space – that is, the ability to keep a particular door closed during operations while allowing the desired access through another. As an example, the embarkation doors, which may admit high numbers of passengers to the passenger cabin in short periods of time, may be closed during all operations while other weather doors from the cabin provide access to the evacuation deck.
- Downflooding potential through the interior space accessed and protected by the door
    - Size and configuration of the space
    - Drainage arrangements in the space
    - Downflooding path to lower deck spaces, in order of descending risk
        - Direct access to lower deck, by an unprotected downflooding path, e.g., a stairway
        - Indirect access to lower deck, e.g., protection by an interior door
        - No access to lower deck
- Stability consideration: can it be shown that downflooding can be sustained within the required stability safety margins?
- Doorway design
    - Alternate water barrier arrangements
    - Alternate deck drainage arrangements
    - Operational restrictions on use
    - Other engineering solutions

2.2 ADAAG and Advisory Committee Recommendations

The Americans with Disabilities Act of 1990 (ADA) applies to most passenger vessels. Yet, as of October 2004, no ADA standards or guidelines have been promulgated which specifically address passenger vessel access. However, the ADA Accessibility Guidelines for Buildings and Facilities (ADAAG) does exist and is found in the Appendix to 36 CFR Part 1191. Per ADAAG, the essentials of accessible doorway design are the following:

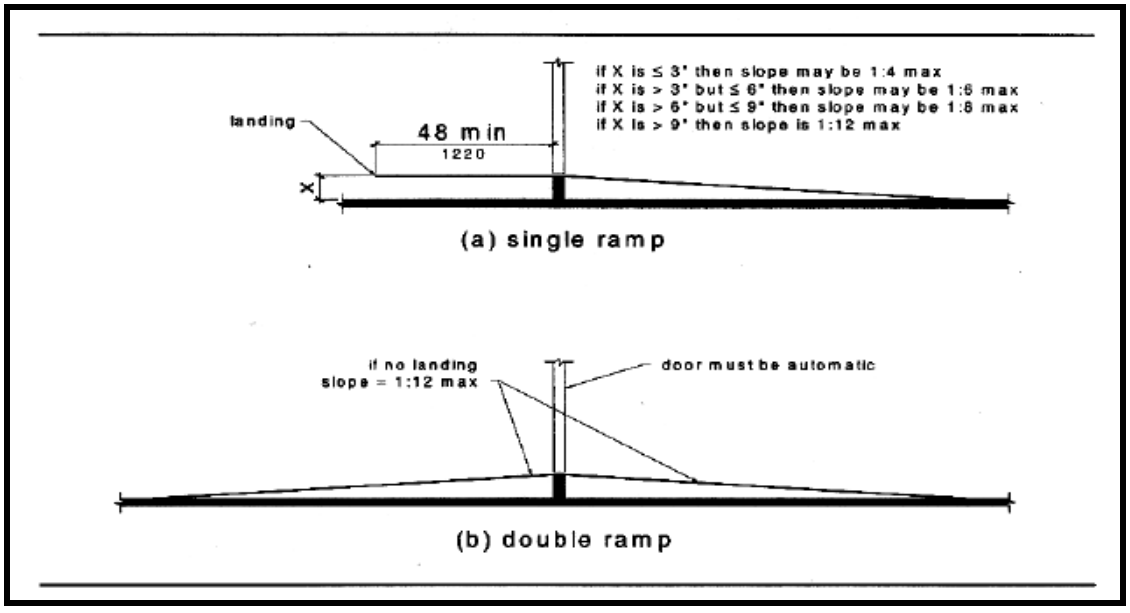
- Clear width of 32”.
- Maximum threshold height of ½”, ¾” for sliding doors.
- Specific maneuvering clearances for many types of doors and approaches to the doors.
- 48” minimum distance between two doors in series.
- Reach range 48” max height for door hardware. Force to operate hardware of less than 5 pounds. Interior doors and exterior sliding doors opening force also less than 5 pounds.

In 1998, the Access Board established a 21-member Federal advisory committee to provide recommendations to assist the Board in developing passenger vessel accessibility guidelines. The committee included disability organizations, industry

trade groups, State and local government agencies, and passenger vessel operators. The Passenger Vessel Access Advisory Committee (PVAAC) submitted a final report "Recommendations for Accessibility Guidelines for Passenger Vessels" in December 2000 (http://www.access-board.gov/pvaac/status.htm). The report mainly addressed Subchapter H and K vessels, with one chapter devoted to certain Subchapter T and C issues. Door specifications for both H and K vessels followed those from ADAAG very closely, with the important exception that PVAAC recognized the conflict between access and safety inherent in the weathertight door coaming regulations.

The Committee developed solutions only for ramping over the coamings, including the double ramp and single ramp methods (see Figure 2-1). Both methods modified a number of ADAAG door requirements to allow coamings and some degree of access to co-exist.

Figure 2-1
PVAAC Coaming and Ramp Solutions



The PVAAC report did not include solutions eliminating coamings from weathertight doors, but in their meetings the Committee noted that ADAAG complying door designs could be developed which also provide an equivalent level of vessel protection as the coamings. The only specific design discussed by PVAAC involved having two doors in series, with the required separation and the operational requirement that one door always be closed.

The PVAAC report specified, without explanation or elaboration, the following for H and K boats:

> **"206.5.3 Weather Deck Access.** Where the main deck of a passenger vessel is greater than 3,000 square feet (280 m^2) at least one exterior door on each accessible weather deck shall comply with 404.2.5 (maximum threshold height of ½") and shall be located on an accessible route that provides access between the weather deck and the interior of the passenger vessel, except where prohibited by an administrative authority having jurisdiction."

The minutes of PVAAC meetings and subsequent discussions with members indicate that the reasons for this specification may be that larger vessels would have doors higher above the water the waterline and that small amounts of ingress from rain and spray could be sustained (similar to the Coast Guard's interpretation of H boat weather deck closure requirements). The size may also allow better opportunities for placing a single accessible door in a low risk location, relative to water and wind.

2.3 Current Practice in the U.S. Passenger Vessels Fleet

The vast majority of publicly available passenger boats in the ferry and excursion trades operating on a regularly scheduled "common carrier" basis are T and K vessels. The age of boats in this fleet ranges up to 100 years, and the majority of those are conventional monohulls predating the ADA of 1990.

Access onto these boats follows, nearly without exception, the safety regulations in Title 46 of the CFR. Weather doors have coamings as specified for boats operating in partially protected and exposed waters. Many other boats have the coamings as a matter of good marine practice, even when the operating area may not require it. Operators and crews are solicitous of passengers' needs in general and of the access needs of disabled people in particular. It has been common practice for crew members to assist passengers in wheelchairs onto the vessels, especially where traditional marine design elements, such as coamings, prevent independent access.

Passengers on K and T boats commonly use weathertight doors for entry into the accommodation area, because the embarkation deck is usually the "main" deck. Interior doors commonly have no coamings. Doors to the weather on decks above the main deck may have coamings, although this is a matter of the designer's preference rather than the regulatory requirements. Passengers very seldom encounter watertight doors, as those doors are found below the main deck in watertight subdivision bulkheads between working spaces like the engine room.

3 U.S. Fleet Case Studies

3.1 The *Flying Cloud* and *Lightning* (Harbor Express)

The *Flying Cloud* and *Lightning* were built at the Gladding-Hearn Shipyard in Somerset, Massachusetts in 1996 and 1997 for the Harbor Express Company. Harbor Express currently operates the boats for the new owner, the Massachusetts Bay Transit Authority (MBTA), in service between Quincy and Hull, Massachusetts, and downtown Boston and Logan Airport.

The particulars of these boats are: 23.3 meters (76.4 feet) in length, 30 knots service speed, 3 crew (captain and two deck hands), 1930 horsepower with waterjet propulsion, 149 passenger capacity, and certification for "Limited Coastwise" service. The Stability Letters rate the boats for service in partially protected waters. They are designed as "bow loaders", that is, the vessel's bow contacts the dock at approximately equal freeboards (height above water to deck) and passengers board directly after the crew opens the gates on the boat (see Figure 3-1). The passengers then proceed to the cabin through double weathertight doors in the forward bulkhead (see Figure 3-2). These doors do not have coamings and have been accepted by the Coast Guard as providing equivalent protection as coamings would.

Figure 3-1
Bow Loading on the *Lightning*, August 14, 2003

Figure 3-2
Access Through the Passenger Cabin Bow Doors

3.1.1 Description

The forward passenger cabin doors are approximately 36” wide each, and are symmetric about the centerline in the forward bulkhead of the passenger cabin, their inboard extremes about 18” apart (see deck layouts, Figures 3-3 and 3-4, and photograph, Figure 3-5). The doors are required to be closed at all times while the boat is operating.

Figure 3-3
Passenger Cabin, Plan View

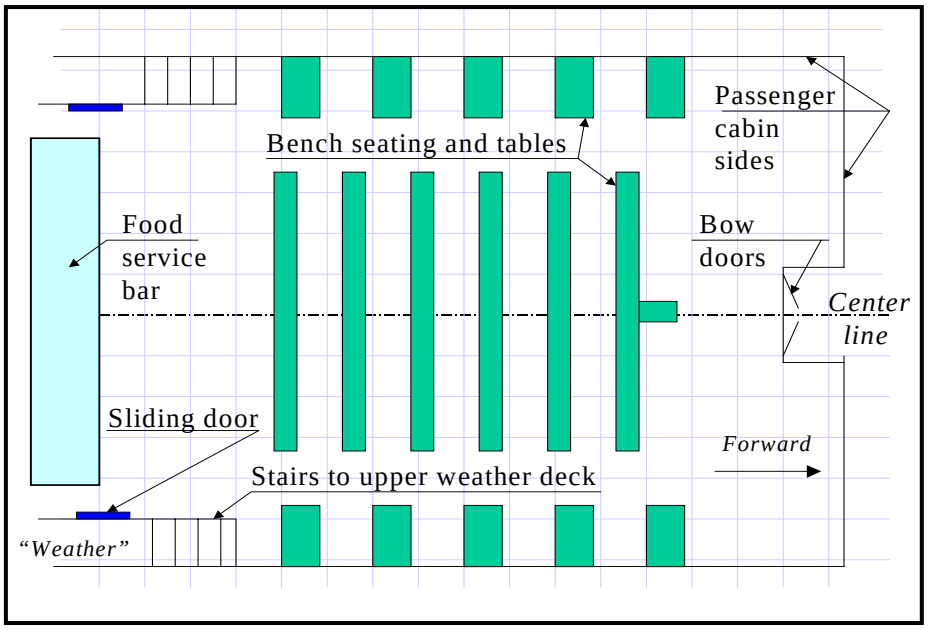


Figure 3-4
***Flying Cloud* Bow Doors, Deck Plan**

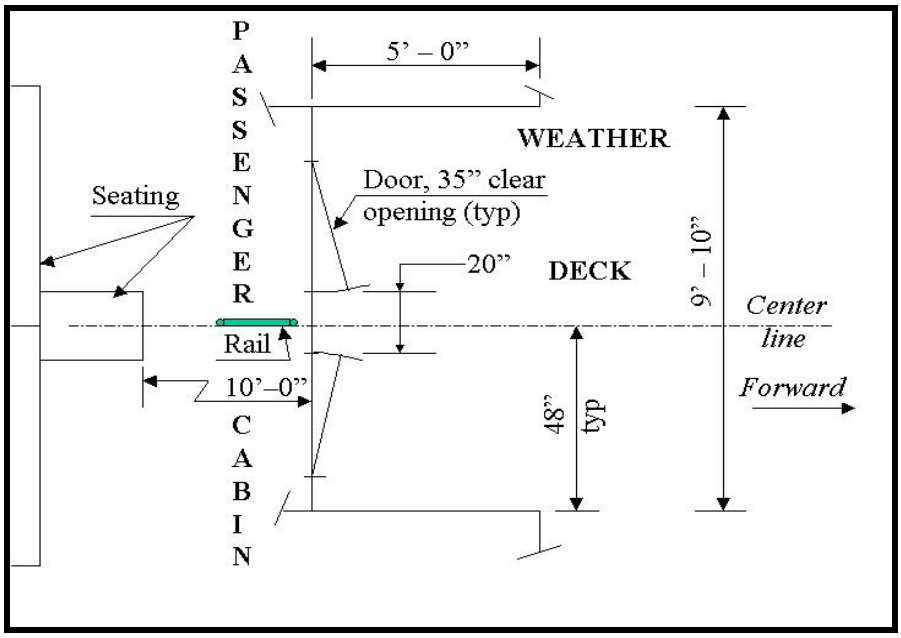
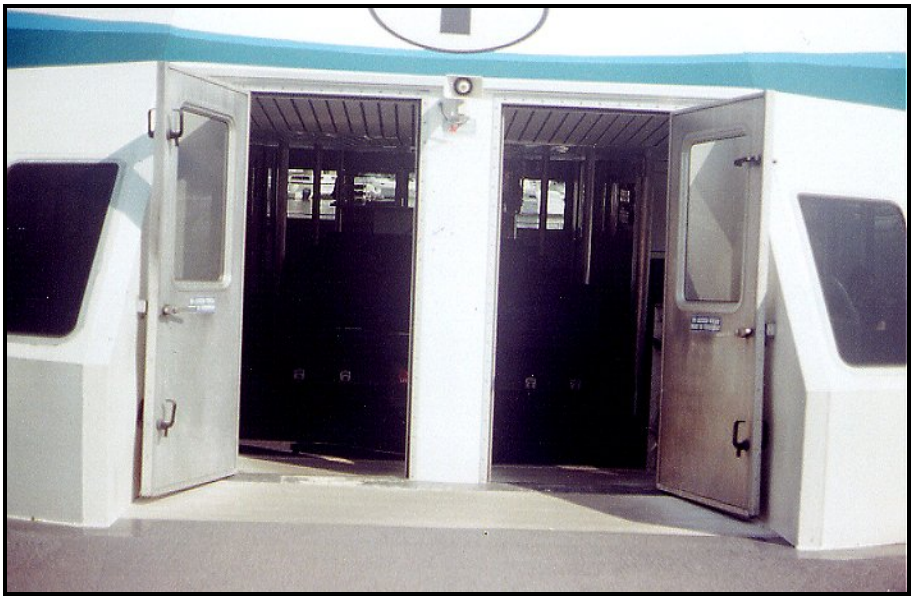


Figure 3-5
Bow Doors, *Flying Cloud*



The status of the bow doors' compliance with the relevant ADAAG door specifications is as follows:

4.13.5 Minimum clear opening of 32 in (815 mm) with the door open 90 degrees.

Status: The clear opening of each of these doors exceeds 32".

4.13.6 Minimum maneuvering clearances at doors that are not automatic or power-assisted shall be as shown in Figure 25.

Status: Figure 25(a), "front approaches – swinging doors", pertains. The maneuvering space on the "pull side", that is, on the weather deck, complies. The maneuvering space on the "push side", that is, inside the cabin, does comply also. The lateral space requirement of 12 inches on the handle side of the door does not pertain because the door is not the "closer and latch" type.

The floor or ground area within the required maneuvering clearances shall be level and clear. The deck line has "sheer" in this area, that is, it declines towards the aft end; this angle also changes with the static attitude of the boat (known as trim and heel) as well as the dynamic motion (pitch and roll). Even in the static standard load condition, the bow doors on these boats do not meet the letter of this specification.

4.13.8 Thresholds at doorways shall not exceed 3/4 in (19 mm) in height for exterior sliding doors or 1/2 in (13 mm) for other types of doors. Raised thresholds and floor level changes at accessible doorways shall be beveled with a slope no greater than 1:2.

Status: The doors meet this standard.

4.13.9 Door Hardware. Handles, pulls, latches, locks, and other operating devices on accessible doors shall have a shape that is easy to grasp with one hand and does not require tight grasping, tight pinching, or twisting of the wrist to operate.

Status: The hardware for each of these doors includes two "dogs" (levered closing devices which secure the door at several points around its perimeter, operable from both sides of the door) in addition to the conventional door handle. These are intended for operation by the crew only and would not be ADAAG compliant in any case for the reason, among others, that one is mounted higher than the guidelines allow. These dogs are required for proper weathertight sealing of the door.

4.13.10 Door Opening Force. The maximum force for pushing or pulling open a door is 5 pounds.

Status: The design specifications for these doors do not include opening force; the specification does not apply to this exterior hinged door.

The doors rest on a very short sill plate (less than ¼" high) and are bounded on both sides by series of aluminum plates, laid transversely, with narrow (3/16") intervening gaps for drainage (see Figure 3-5). Water entering those gaps drains into a segregated cofferdam structure below and then directly to the ocean between the catamaran hulls.

Figure 3-6
Drainage Detail Forward of Doors, *Lightning*

The deck structure in the passenger cabins of *Lightning* and *Flying Cloud* has one important feature: it is completely separate from the watertight envelope of the catamaran hulls. The weather deck (or main deck) is, in this case, the plating and structure forming the top of each hull and is watertight, not weathertight. Transverse structural frames connect the hulls, and all the superstructure, passenger cabin and deck included, sits on top of those frames. Figure 3-6 shows an open access cover and the manhole beneath and illustrates the separate deck structures. All service connections between hull and superstructure (e.g., wiring and piping) have watertight hull penetrations and the spaces within the hulls are unmanned (i.e., there is no regular access to them during operations). Access therein for maintenance and repair is via non-tight hatches in the passenger deck leading to watertight "manholes" in the hull tops.

Figure 3-7
Access to "Main Deck" Manhole, *Lightning*

The passenger cabins on these boats also have sliding doors toward the stern end of the passenger, both port and starboard, providing access for the passengers to the weather decks and stairways to the upper deck. There is very limited weather deck space on the cabin deck, essentially providing landings for the stairways (which are not accessible). The opening force of this door is not known.

The status of the aft sliding doors' compliance with the relevant ADAAG door specifications is as follows:

4.13.7 Minimum clear opening of 32 in (815 mm).

Status: The clear opening of each of these doors exceeds 32".

4.13.8 Minimum maneuvering clearances at doors that are not automatic or power-assisted shall be as shown in Figure 25.

Status: Figures 25(d & e), "front" and "slide side" approaches for sliding or folding doors, pertain. The maneuvering spaces for both approaches are not sufficiently wide, because of the proximity of the snack bar inside and the deck edge on the weather deck.

The floor or ground area within the required maneuvering clearances shall be level and clear. The deck line has less "sheer" in this area, but the deck's angle changes with the static attitude of the boat as well as the dynamic motion, as for the forward doors.

4.13.8 Thresholds at doorways shall not exceed 3/4 in (19 mm) in height for exterior sliding doors or 1/2 in (13 mm) for other types of doors. Raised thresholds and floor level changes at accessible doorways shall be

beveled with a slope no greater than 1:2.

Status: The sliding doors do not meet this standard on either count. The doors' tracks are 1" X 1" X ½" angles welded to the deck, slightly exceeding the height maximum. There is no beveling of the deck on either side of the tracks.

4.13.11 Door Hardware. Handles, pulls, latches, locks, and other operating devices on accessible doors shall have a shape that is easy to grasp with one hand and does not require tight grasping, tight pinching, or twisting of the wrist to operate.

Status: The sliding doors have push-type mechanisms mounted below the 48" maximum height.

4.13.11 Door Opening Force. The maximum force for pushing or pulling open a door is 5 pounds.

Status: The design specifications for these doors do not include opening force; it is therefore unknown whether the doors comply, particularly under the influence of ship's motion.

3.1.2 Discussion

Review of the *Flying Cloud's* file indicates that no equivalency or special consideration was approved for the forward deckhouse doors. Interviews with Coast Guard personnel involved[4] indicate that there are two keys to understanding the acceptance of these doors without coamings. The first is that the doors are always closed during operations, that is, once the boat leaves the dock.

The second, and most important, reason is the separate construction of the passenger cabin deck and of the watertight decks forming the upper bounds of the catamaran hulls. The structure connecting the two hulls, and supporting the superstructure of the cabin and pilot house, lies on top of the hulls' upper watertight boundaries. These hulls, which provide the boat's reserve buoyancy and stability, are strictly segregated from the overlying structure.

The clear reason for the acceptance of this design is that there is no opportunity for downflooding, even if water does enter the passenger cabin. Presuming that all manholes into the hulls' main decks are closed as required (all spaces below are unmanned), there are simply no downflooding pathways for the water to follow. There is a potential concern that the free surface effect of water trapped in the cabin could

[4] CWO Ray Rock currently serves at the Providence MSO, and conducted numerous surveys during construction of the Flying Cloud; he was interviewed over the telephone in August, 2003. LT Jason Hall of the MSO Boston Inspections Department was interviewed on September 8, 2003 at MSO Boston.

also significantly degrade stability; the *Flying Cloud* file does not address that scenario, probably because of the drainage and closure arrangements. It is likely, furthermore, that the excellent transverse stability provided by the catamaran's broad beam can sustain flooding of the passenger deck in the unlikely event that large amounts of water were to gain entry. The designers also took the extra precaution of providing an alternate drainage system both forward and aft of the doors.

3.2 Other Vessels

Research into other passenger vessel operators reveals that many T and K boats have weathertight doors without coamings, located on the main deck. These craft, in fact, are certificated to operate on "lakes, bays, and sounds" waters, and have "protected waters" language in their stability letters. They are, therefore, not subject to the explicit coaming requirements in Subchapters K and T. In the absence of specific knowledge of the designer's intentions and the Coast Guard's review, the likely scenario is that the Subchapter S provisions were not applied in these cases.

The New York Waterways ferries operation is a good example. Many of their boats are bow loaders in commuter service, similar to *Flying Cloud* and *Lightning* in this respect, designed to move large numbers of people on and off quickly. There are sliding double doors in the forward bulkheads of the deckhouses, with no coamings. These doors in the cases of their older, slower boats may even be left open during operations so that passengers can take the air on the bow.

Many of these boats have doors that serve to provide both embarkation access and deck access during operations. Some commuter ferries (e.g., *Flying Cloud* and *Lightning*) have separate doors for these purposes. In the latter case, embarkation and disembarkation are through doors only opened for that purpose, and which are always closed during operations.

Sayville Ferry Service reported operating vessels both with and without coamings, as well as another under construction without coamings, all in respect of the main deck weathertight doors. The COIs for these boats are for "lakes, bays and sounds" and the stability letters for "protected waters", as for New York Waterways boats. The Subchapter T coaming regulation does not apply and there is no "equivalent" or "special consideration" called for. The likely scenario again is that the Subchapter S provisions were not applied in these cases.

The Alaska Marine Highway (AMH) is constructing two high speed vehicle and passenger ferries, the *Fairweather* and *Chenega*, at Derecktor Shipyards in Mamaroneck, New York. These catamarans will be 73 meters in length and will each carry 250 passengers and 35 large vehicles at a continuous-rating service speed of 35 knots. They are classed with Det Norske Veritas (Maltese Cross 1A1 HSLC) and have been accepted by the Coast Guard as fully compliant with international Safety of Life at Sea (SOLAS) and High Speed Craft (HSC) Codes.

Fairweather and *Chenega* will operate between Sitka and Juneau, Alaska, with the DnV "R3" service restriction. R3 means that the vessel must operate within 20 nautical miles of a safe harbor or anchorage in winter conditions and within 50 nautical miles of a safe harbor or anchorage in summer conditions. Project staff has not learned which area of

operation is to appear on these vessels' stability letters; R3 is the rough equivalent of "partially protected" waters.

The Coast Guard indicated to ATBCB that these craft have "minimal coamings". Correspondence with AMH and Derecktor indicates that the doors in question were designed with 1–½" coamings, with grated ramps and deck drains. The weather deck served by these doors is well above the vessel's main deck, at sufficient height that there is no chance of entry by waves on deck. An overhanging deck keeps rain and spray off the adjacent deck as well. Even in the most extreme listed damage condition, there is no chance of sea water entering through the doors in question.

Fairweather and *Chenega* do not require Coast Guard approval of equivalency or special consideration for the weathertight doors in question. The Subchapter K regulations state that coamings are required for doors "on the main deck of a flush decked vessel". The main deck for *Fairweather* and *Chenega* is the vehicle deck, and the passenger accommodation decks are considerably higher, with negligible risk of ingress through the weather doors. These doors would also satisfy the Subchapter S coaming regulation as they are not in an "exposed" location.

4 Summary

4.1 Regulations Review and Case Studies

The intent of the Coast Guard's watertight integrity regulations is to protect against water ingress into passenger accommodation spaces and downflooding into spaces below. The ultimate hazard that the regulations aim to prevent is capsizing, an event whose potential, and unacceptable, consequence is the deaths of many people. The regulations therefore aim to minimize the probability of capsize to the greatest extent possible.

The regulations with regard to watertight integrity for Subchapter K and T passenger vessels include provisions for coamings at weathertight doors and are an important element of the vessel stability regulations found in Subchapters K and T and in Subchapter S "Stability". The two specified coaming heights of 6" and 3" correspond to exposed or partially protected waters and protected waters, respectively, as specified in each boat's Coast Guard Stability Letter.

The new Subchapters K and T post-date Subchapter S, which regulates all vessels under 100 gross tons, and do not specifically supersede Subchapter S's weathertight door coaming regulation. The K and T coaming regulation is prescriptive where S allows for interpretations based upon onboard door location and the associated downflooding potential. The terms of reference in these three subchapters differ and can be confusing. The interpretation of Subchapter S can in some cases result more stringent requirements for passenger boats operating on protected waters, while T and K prescription may in some cases be more stringent for boats on exposed and partially protected routes.

It is evident that different designers make different choices in the application of these coaming regulations. It is the author's opinion, however, that Subchapter T and K regulations are most commonly applied in the current fleet. For the "flush deck" vessels with doors on the "main deck" which make up most of the affected passenger fleet, those regulations allow for coaming-less weathertight doors in protected waters and require coamings in "partially protected" or "exposed" waters.

That state of affairs required re-examination of the premise of the scope of work, that Volpe Center conduct case studies of "exemptions" from the coaming regulation, in light of the intent and application of Coast Guard regulations and procedures. The Coast Guard does not exempt vessels from safety regulations, but will consider and may approve alternate designs or arrangements as providing equivalent safety to the regulation in question, under the "equivalents" or "special considerations" provisions found in both Subchapters K and T.

The correspondence with the Coast Guard by the Access Board and the Volpe Center id not reveal cases of specifically approved "equivalent" designs or "special considerations" in the matter of the coaming regulations for K and T boats. The results of the cases examined are nonetheless instructive, and are summarized below:

- The Coast Guard approved doors without coamings on the *Flying Cloud* and *Lightning*, catamarans operated by the Harbor Express in Boston on "partially protected" waters, without any special approval. The most important reason is the separate construction of the passenger cabin deck and of the watertight decks forming the upper bounds of the catamaran hulls, which allow no opportunity for downflooding, even if water does enter the passenger cabin. In addition, the doors are always closed during operations, and there is a specially designed drainage system both forward and aft of the doors.

  The bow doors used for embarkation and disembarkation meet ADAAG specifications for width and threshold, but not for door hardware or level floor surface. They were, however, observed to be very effective for passengers in wheelchairs. The aft port and starboard sliding doors comply with the width and hardware specifications, but not the threshold and maneuvering space requirements.

- *Fairweather* and *Chenega*, catamaran car and passenger ferries under construction for the Alaska Marine Highway, have weathertight doors without coamings which did not require Coast Guard approval of equivalency or special consideration. The main deck for *Fairweather* and *Chenega* is the vehicle deck, and the passenger accommodation decks are considerably higher, with negligible risk of ingress through the weather doors in question. The ingress hazard is therefore abated due to the doors' locations.

- Many K and T boats are approved for operation with coaming-less doors located on the main deck. The cases examined include several bow-loading ferries with doors in the forward end of the deckhouse, designed to move large numbers of passengers on and off quickly. These boats were found to operate in protected waters, where coamings are not required due to the low likelihood of boarding waves and the near proximity of safe harbors or anchorages.

4.2 Recommendations for Phase 2

The apparent dearth of currently approved alternate designs for coamings does not imply that Phase 2 of this project should not go forward and indeed suggests that the need to develop such designs is more urgent. The task will, however, be more difficult without the guidance of successful examples. The following elements for execution of Phase 2 are suggested:

- Coast Guard participation – The cooperation and formal participation of the Coast Guard is crucial and may require a formal request from either the Board or the Office of the Secretary of Transportation. The Coast Guard should review the philosophical approach to the work in general and the technical approach to specific design solutions. The ultimate result would be their imprimatur on the technical guidance published by the Board, without which the acceptance and success of the document would be doubtful.

- Reconfiguration solution – The work will include an outline of guidance as to where and under what operational conditions doors without coamings are acceptable without special approval, as in the cases described in Chapter 3. The project team will investigate modified arrangements of two passenger vessel types (to be approved by the Access Board), showing an adjusted layout which eliminates the coaming requirement for at least one door and provides the desired access to passenger accommodation areas.

  Reconfiguration may entail more than the simple rearrangement of weathertight doors. Other considerations may include provision of alternate doorways and other modifications addressing downflooding potential.

- Doorway design – Candidate alternate design work should include:
  - Further development of the concepts proposed by the PVA Advisory Committee in their 2000 report.
  - Investigation of removable or hinged coamings and protocols for their use.
  - Investigation of doors without coamings requiring special approval and the development of associated water control and drainage arrangements suitable for common vessel types.
  - Identification of operational practices required for implementation in concert with the alternate designs, for example, the requirement that the door only be operated at certain times.

- Other arrangements, such as double deck construction, that address the hazards and risks in different ways and allow for redesign for accessible doors.

- Assistance from the Coast Guard as may be necessary to identify candidate passenger vessels for the doorway design and analysis. Most observed during the Phase 1 work do not have the weather deck doorway coamings for a variety of reasons, some alluded to above. Volpe Center will work with local Marine Safety Offices (e.g., Boston and Providence) to find such vessels nearby, in order to minimize travel costs. We suggest that monohull K boat and a catamaran (either T or K boat) should be the two types examined for Phase 2.

The Board should also consider an initial investigation of the need for water flow and control modeling, comparing the performance of compliant doors with coamings to alternate door designs. Doors without coamings or ramps could be acceptable if shown to provide equal protection by use of computer or scale modeling simulations. The consideration of such simulation work is beyond the scope of this project, but development of its technical framework could be undertaken in cooperation with Coast Guard safety experts.

REFERENCES

Coast Guard Maine Safety Manual Chapter 3: Documentation of Vessel Inspections.

Code of Federal Regulations, Title 46, Subchapters C, H, K, S, and T.

Passenger Vessel Access Advisory Committee, “Recommendations for Accessibility Guidelines for Passenger Vessels: Final Report”, December 2000.

#

APPENDIX A

Coast Guard Documentation for Inspected Passenger Vessel

1. **Stability Letter**
2. **Certificate of Inspection**

1. STABILITY LETTER

U.S. Department of Transportation
United States Coast Guard

Commanding Officer
United States Coast Guard
Marine Safety Center

[redacted], DC 20590-0001
Staff Symbol: MSC-1
Phone: (202)366-6481
Fax: (202)366-3877

STABILITY LETTER

16710/P002920
Ser H1-9603368
November 6, 1996

Master, FLYING CLOUD; O.N. 1047743
82' 8" x 27' 6" x 8' 4" Catamaran Small Passenger Vessel (T-L)

You are responsible for maintaining this vessel in a satisfactory stability condition at all times and for following the instructions and precautions listed below.

A deadweight survey, witnessed by the U. S. Coast Guard, was conducted on the FLYING CLOUD, O.N. 1047743, at Somerset Massachusetts, on November 5, 1996. On the basis of that survey, and a conservative estimate of the vertical center of gravity, stability calculations have been performed. Results indicate that the stability of the FLYING CLOUD, as presently outfitted and equipped, is satisfactory for operation on Partially Protected Waters, provided that the following restrictions are observed.

DAMAGE SURVIVAL

When operated as indicated below, calculations indicate this vessel will stay upright (no more than 7 degrees of list under ideal conditions) after bottom damage, when the bottom damage is limited to any one major compartment in either hull, and not more than
1 foot 0-1/4 inches upward from the bottom of either hull. A major compartment is the total space between any two adjacent Main Transverse Watertight Bulkheads (MTWB'S). For this vessel, these MTWB's are located at the following longitudinal locations forward of the transom in each hull: 7 feet 10 inches (frame 2), 30 feet 10 inches (frame 8), 46 feet 7 inches (frame 12), and 65 feet 10 inches (frame 17). Calculations further indicate this vessel will stay upright when damage is limited to both hulls (concurrently) forward of the collision bulkheads, which are located in frame 17 of each hull.

Calculations indicate this vessel will stay upright (no more than 7 degrees of list under ideal conditions) after side damage when the side damage is limited to any one major compartment in either hull and not more than 3 feet inboard from the side of either hull. To maintain the vessel upright after flooding (damage), the heeling forces imposed by wind, wave, and passenger movements must be minimized. The calculations do not specifically account for high winds, heavy seas, or the movement of many passengers to one side.

OPERATING RESTRICTIONS

1. ROUTE: Operation on Partially Protected Waters may be permitted. Since the vessel's route is based upon other considerations in addition to stability, you are cautioned that

16710/P002920
Ser H1-9603368
November 6, 1996

Subj: FLYING CLOUD, O. N. 1047743; STABILITY LETTER

the route may be further limited to that specified on the Certificate of Inspection.

2. PERSONNEL: A maximum of 153 persons may be carried on this two deck vessel, of which 149 may be passengers. Up to 100 persons may be carried on the uppermost passenger deck. Since the personnel capacity is based upon other considerations in addition to stability, you are cautioned that the number of persons carried may be further limited to that specified on the Certificate of Inspection.

3. DRAFT AND TRIM: The vessel is limited to a maximum draft of 3 feet 10-1/2 inches above baseline. This corresponds to a minimum freeboard amidships measured from the top of the guard to the waterline of 5 feet 0-1/2 inches. Amidships is located 6-1/4 inches aft of frame 10. Trim shall be minimized.

4. WATERTIGHT BULKHEADS: There are no watertight doors in any MTWB's. No watertight bulkheads shall be removed or altered without the authorization and supervision of the cognizant Officer in Charge, Marine Inspection (OCMI).

5. HULL OPENINGS: Any openings that could allow water to enter into the hull or deckhouse should be kept closed when rough weather or sea conditions exist or are anticipated.

6. TANKS: Any cross-connections between port and starboard tank pairs shall be kept closed at all times when underway.

7. WEIGHT CHANGES: This stability letter has been issued based upon the following light ship parameters:

Displacement	42.91 Long Tons
VCG (Conservative Estimate)	10.60 Feet Above the Baseline
LCG	6.92 Feet Aft of Amidships

Any alteration resulting in a change in these parameters will invalidate this stability letter. No fixed ballast or other such weights shall be added, removed, altered and/or relocated without the authorization and supervision of the cognizant OCMI. The vessel is not fitted with permanent ballast.

8. BILGES: The vessel's bilges and voids shall be kept pumped to minimum content at all times consistent with pollution prevention requirements.

9. SCUPPERS AND FREEING PORTS: Cockpit scuppers and deck freeing ports shall be maintained operable and completely unobstructed at all times.

16710/P002920
Ser H1-9603368
November 6, 1996

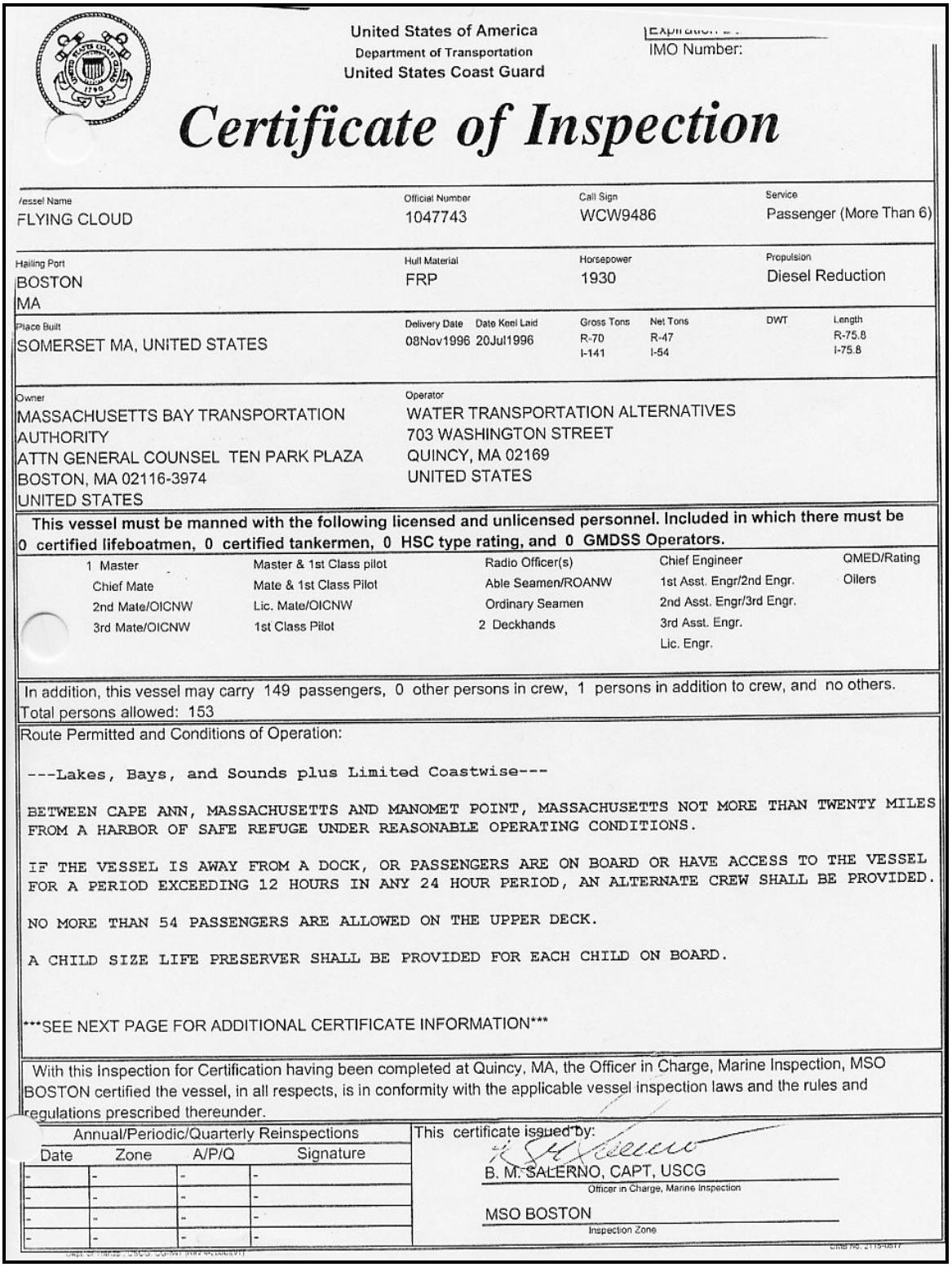
Subj: FLYING CLOUD, O. N. 1047743; STABILITY LETTER

10. LIST: You should make every effort to determine the cause of any list of the vessel before taking corrective action.

This stability letter shall be posted under glass or other suitable transparent material in the pilothouse of the vessel so that all pages are visible.

D C Aurand
D. C. AURAND
Commander, U. S. Coast Guard
By direction of the Commanding Officer

2. CERTIFICATE OF INSPECTION



United States of America
Department of Transportation
United States Coast Guard

Expiration Date:
IMO Number:

Certificate of Inspection

Vessel Name	Official Number	Call Sign	Service
FLYING CLOUD	1047743	WCW9486	Passenger (More Than 6)

Hailing Port	Hull Material	Horsepower	Propulsion
BOSTON MA	FRP	1930	Diesel Reduction

Place Built	Delivery Date	Date Keel Laid	Gross Tons	Net Tons	DWT	Length
SOMERSET MA, UNITED STATES	08Nov1996	20Jul1996	R-70 I-141	R-47 I-54		R-75.8 I-75.8

Owner	Operator
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY ATTN GENERAL COUNSEL TEN PARK PLAZA BOSTON, MA 02116-3974 UNITED STATES	WATER TRANSPORTATION ALTERNATIVES 703 WASHINGTON STREET QUINCY, MA 02169 UNITED STATES

This vessel must be manned with the following licensed and unlicensed personnel. Included in which there must be 0 certified lifeboatmen, 0 certified tankermen, 0 HSC type rating, and 0 GMDSS Operators.

1 Master	Master & 1st Class pilot	Radio Officer(s)	Chief Engineer	QMED/Rating
Chief Mate	Mate & 1st Class Pilot	Able Seamen/ROANW	1st Asst. Engr/2nd Engr.	Oilers
2nd Mate/OICNW	Lic. Mate/OICNW	Ordinary Seamen	2nd Asst. Engr/3rd Engr.	
3rd Mate/OICNW	1st Class Pilot	2 Deckhands	3rd Asst. Engr.	
			Lic. Engr.	

In addition, this vessel may carry 149 passengers, 0 other persons in crew, 1 persons in addition to crew, and no others.
Total persons allowed: 153

Route Permitted and Conditions of Operation:

---Lakes, Bays, and Sounds plus Limited Coastwise---

BETWEEN CAPE ANN, MASSACHUSETTS AND MANOMET POINT, MASSACHUSETTS NOT MORE THAN TWENTY MILES FROM A HARBOR OF SAFE REFUGE UNDER REASONABLE OPERATING CONDITIONS.

IF THE VESSEL IS AWAY FROM A DOCK, OR PASSENGERS ARE ON BOARD OR HAVE ACCESS TO THE VESSEL FOR A PERIOD EXCEEDING 12 HOURS IN ANY 24 HOUR PERIOD, AN ALTERNATE CREW SHALL BE PROVIDED.

NO MORE THAN 54 PASSENGERS ARE ALLOWED ON THE UPPER DECK.

A CHILD SIZE LIFE PRESERVER SHALL BE PROVIDED FOR EACH CHILD ON BOARD.

SEE NEXT PAGE FOR ADDITIONAL CERTIFICATE INFORMATION

With this Inspection for Certification having been completed at Quincy, MA, the Officer in Charge, Marine Inspection, MSO BOSTON certified the vessel, in all respects, is in conformity with the applicable vessel inspection laws and the rules and regulations prescribed thereunder.

Annual/Periodic/Quarterly Reinspections

Date	Zone	A/P/Q	Signature
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

This certificate issued by:

B. M. SALERNO, CAPT, USCG
Officer in Charge, Marine Inspection

MSO BOSTON
Inspection Zone

U.S. Department of Transportation

Research and Special Programs Administration

ADA Access to Passenger Vessels: Finding Safety Equivalence Solutions for Weathertight Doors with Coamings

Phase 2: A Risk Management Approach to Reconfiguration Design Solutions

Prepared for:

Architectural and Transportation Barriers Compliance Board — Washington, D.C.

Prepared by:

U.S. Department of Transportation
Research and Innovative Technologies Administration
John A. Volpe National Transportation Systems Center — Cambridge, Massachusetts

March 2005

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Michael G. Dyer

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13. ABSTRACT

This report examines a risk management methodology to provide for both marine safety and disability access at weathertight doors into passenger accommodation spaces on U.S. passenger vessels. The Architectural and Transportation Barriers Compliance Board's ultimate objective is to assist designers and operators in improving disability access without compromising the vessel safety provisions of the coamings (sills) at these doorways. The methodology assigns numeric risk scores to several watertight integrity safety factors including door location and use, downflooding path, and vessel service. The aggregate risk score for a given door corresponds to a menu of possible access solutions. The methodology allows for the relocation of the door or other measures to lower the risk score and improve the access solution. The model is applied to several examples of doors on Subchapter T and K passenger boats.

14. KEY WORDS
Passenger vessel, ADA, ADAAG, access, coaming, weathertight door, Subchapter T, Subchapter K, watertight integrity, downflooding, load line.

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Several well-regarded naval architects contributed their knowledge and insight to review of the risk management methodology, affirming its credibility by a critical first review. Heartfelt gratitude is due Tim Graul of Timothy Graul Designs, John Hunter of Seaworthy Systems, and John Waterhouse of Elliott Bay Design Group. Pete Lauridsen of the Passenger Vessels Association (PVA) provided valuable technical guidance and was instrumental in setting up a peer review process by the PVA Partnership Action Team.

Finally, we must thank those who contributed the boat designs used as examples demonstrating application of the methodology. They were:

- Casco Bay Line and Seaworthy Systems;
- Timothy Graul Designs; and
- Gladding-Hearn Shipbuilding, Duclos Corporation and INCAT Designs

Table of Contents

Tables

Appendices

ACRONYMS

ADA	Americans with Disabilities Act, 1990
ADAAG	ADA Accessibility Guidelines for Buildings and Facilities (2002)
ATBCB	Architectural and Transportation Barriers Compliance Board
CFR	Code of Federal Regulations
COI	Certificate of Inspection
COTP	Captain of the Port
DOT	U.S. Department of Transportation
DF	Downflooding
ILLC	International Load Line Convention
IMO	International Maritime Organization
LLTM	Load Line Technical Manual
NVIC	Navigation and Vessel Inspection Circular
OCMI	Officer in Charge of Marine Inspection
PAT	Partnership Action Team
PAX	Passengers
PVA	Passengers Vessels Association
PVAAC	Passenger Vessel Access Advisory Committee
WL	Waterline

1 Introduction

1.1 Background

The aim of this project is to find possible approaches to provide for both marine safety and disability access at doors into passenger accommodation spaces on U.S. passenger vessels. The sponsoring organization is the Architectural and Transportation Barriers Compliance Board ("the Board", or ATBCB), an independent Federal agency, whose mission is to improve accessibility for people with disabilities. The Board's objective was to assist designers, operators, and inspectors in improving disability access without compromising the vessel safety provisions of the coamings at weathertight doors, whose purpose is to prevent the entry of water into the passenger spaces served.

"Phase 1" preceded this report, and examined the following:

1. The need for and application of the current governing safety regulations;
2. The application of access provisions in the Americans with Disabilities Act Accessibility Guidelines (ADAAG) to doors on passenger vessels; and
3. Brief technical case studies examining the design and regulatory review of existing weathertight doors on K and T boats.

The focus of this study is on two of the smaller sized classes of regulated U.S. passenger vessels, known as Subchapter T and Subchapter K boats, named after the relevant sections in Title 46 ("Shipping") of the Code of Federal Regulations (CFR). These boats generally are less than 100 gross tons and carry more than six passengers. T and K boats make up the overwhelming majority of passenger ferries and excursion vessels, such as dinner boats and whalewatchers, which are available to the general public.

1.2 Purpose

The purpose of Phase 2 was to develop new technical guidance and design solutions for weathertight doors meeting both the U.S. Coast Guard's ("Coast Guard") stability regulations and the Access Board's accessibility design standards. The Access Board specified development of two types of access solutions:

- Door design solution. Development of manual door design guidance templates to replace coaming equipped doors with doors complying with ADAAG threshold and maneuvering space requirements while providing an equivalent level of safety as achieved with coamings, which eliminate or minimize water entry.
- Reconfiguration solution. Development of guidance for designers, operators, and inspection personnel in the arrangement of doorways and accommodation spaces to reduce the need for coamings. The basis of the guidance is a characterization of the hazards and risks addressed by the coaming regulations, resulting in adjusted layouts that eliminate the coaming requirement for at least

one door, providing the desired access to passenger accommodation areas. This approach addresses manual doors only and does not include the access solutions suggested by the Passenger Vessel Access Advisory Committee (PVAAC).

1.3 Organization of Report

Chapter 2 describes the general approach to the problem. Chapter 3 presents the risk-based methodology in detail. Chapter 4 shows the results of applying the methodology to the reconfiguration of doors on three passenger boats. Chapter 5 is a summary of findings and recommendations.

2 Approach

It is useful at the outset to state the essential safety precepts in regard to watertight integrity, as expressed in national and international regulations and safety instruments. In the strict physical sense, the vessel consists of a watertight hull envelope and weathertight topside. The safety philosophy is to:

- Keep water off the decks, through assignment of freeboard, the height of the deck above the water
- Get water off the decks, via freeing ports and other drainage features, and transverse and longitudinal deck slopes, known as camber and sheer
- Keep water out of interior spaces by proper design of structures and closures
- Control any water that does get in through protection of downflooding paths, subdivision of compartments below, and pumping arrangements

2.1 "Door design solution"

The primary goal of the Access Board was the door design solution, meaning proper independent access through any weathertight door used by passengers. The desired outcome was a design or designs of coaming-less doors where the marine safety inspector would otherwise specify a coaming. The initial consideration of such solutions in the Phase 1 report included conceptual alternate water barrier arrangements and alternate deck drainage arrangements.

The difficulty in seeking an engineering solution lies in the fact that the Coast Guard cannot quantify the hazard that coamings are meant to protect against, that is, the volumes, heights, and velocities of water on deck, and the frequency and duration of exposure. The watertight integrity and coaming regulations include no preamble and have no supporting analysis characterizing the hazard. Therefore, development, and approval, of "equivalent" alternate designs on the basis of first principles would be fraught with technical uncertainty.

The Coast Guard's thinking on watertight integrity is grounded in the analogous regulations of the International Load Lines Convention, as expressed in the Load Line Technical Manual (USCG-M-1-90) and their regulations in 46 CFR, Subchapter E, Part 42. Doors and coamings are covered in the "conditions of assignment" (as described in the Phase 1 report), as are other topside structures, openings, and closures. Recent developments involving ocean-going ships covered by the Convention have tended towards strengthening conditions of assignment regulations rather than searching for alternate, equivalent solutions. The hazards addressed for such ships are likewise non-quantified, and the loss of many bulk carriers at sea, notably the *Derbyshire*, led to a re-examination and enhancement of regulations for the strength of closures, particularly cargo hatch covers.

These findings led to a decision to concentrate on the reconfiguration solution, rather than a pure engineering solution to a non-quantified problem.

2.2 "Reconfiguration solution"

The reconfiguration approach aims at access solutions by mitigating the hazard of water ingress and reducing risk, by protective placement of the door and minimization and control of water entry. The Phase 1 report showed in several cases that Coast Guard safety inspectors have *de facto* approved equivalences, based on common sense and without technical substantiation on the record. The risk management approach proposed here is a logical, risk-based guide to arrangement and design practice, building upon the *ad hoc* approaches developed in recent years among designers and Coast Guard inspectors. The outcome in past cases has been the elimination of coamings or the acceptance of other access designs based on several factors considered in an assessment of safety equivalency. This approach addresses manual doors only and does not include the access solutions suggested by the Passenger Vessel Access Advisory Committee (PVAAC).

The new approach assesses risk on a relative, quantitative scale, based upon several configuration and operations aspects. The results guide the designer to one or more intermediate design solutions or a finding that coamings must be included, as per the regulations. The intended result is a suggested solution or choice of solutions that must also be subject to sound judgment by the designer and safety inspector on a case-by-case basis.

The particulars of this approach are based upon several sources:

- The "Load Line Technical Manual" (USCG-M-1-90, 1990), for vessels with load lines, including those in ocean service. Chapter 4 addresses relaxation of some conditions of assignment in cases where the door is favorably located, e.g., when the vessel has increased freeboard relative to that required or extra deck height, the latter affecting doors located higher on the superstructure.
- Title 46 of the CFR, watertight integrity regulations of Subchapters K, T, and S. While the regulations do not explicitly address safety equivalences and the circumstances under which they are approved, they do provide insight into the relation of hazard and risk to the door's location. The regulations are discussed in detail in the Phase 1 Report.
- The "Phase 1" report for this project, which included:

  o Detailed presentation of the relevant doorway and coaming provisions U.S. regulations and the international code, including the hazards and risks addressed.

  o Case studies of Subchapter K and T vessels that have weathertight doors without coamings. These included visits to the boats, review of plans, Coast Guard Certificates of Inspection, and stability letters, and discussions with designers, operators, and Coast Guard inspection personnel.

  o Detailed presentation of the relevant access specifications and earlier efforts by industry and government experts to find mobility access solutions for weathertight doors with coamings.

- Discussion of the methodology with naval architects prominent in the passenger boat field, their review of the risk-based approach, and revision of the methodology in accordance with questions and comments received.

The Phase 1 work also revealed several ideas for intermediate access solutions, including doors with reduced height coamings and mitigating design features, such as removable coamings, double doors in sequence, and ADAAG-compliant short length ramps and platforms. These design features fit more aptly in the context of reconfiguration solutions, as improved doorway access options.

3 Risk Management Methodology

The main points of the risk-based approach are:

- Numerical risk scoring of each door by factors for service and route, door location, purpose and use, and downflooding potential;
- Correspondence of the aggregate risk score to a range of doorway access options, from full, no-coaming access to full compliance with the coaming regulations; and
- Reconfiguration to lower risk and improve access, through:
    - Relocation of the door
    - Mitigation of downflooding exposure
    - Protective structural and drainage features against exposure to water.

It is very important to properly characterize these risk-based guidelines as just that: a tool to be carefully applied, case by case, by the naval architect and the inspection authority, with sound technical judgment.

3.1 Terms of reference

The weathertight doors addressed herein are the following:

- Those doors providing access onto the boat, i.e., from the dock/gangway to passenger accommodation spaces
- Those doors providing access to/from passenger accommodation spaces from/to weather decks where passengers are allowed access (sun decks) or are required to have access (evacuation stations)

The reader should note that this methodology does not address interior doors, including fire zone doors, joiner doors, stairway access, and doors that are restricted to crew access. It may turn out, however, that this methodology can offer reconfiguration solutions that can be applied in these kinds of cases as well.

3.2 Characterization of risk factors

The proposed risk factors follow, with annotations showing the technical basis and supporting sources, for example, the Load Line Technical Manual or the Code of Federal Regulations:

- Purpose and use of the door. The type and frequency of use, such as evacuation, embarkation/disembarkation only, or passenger access to weather deck (e.g., “promenade deck”). There is no explicit reference to this factor in either the Load Line regulations or the CFR Title 46. However, the Coast Guard has in many cases considered the operational use, including restrictions on use, in assessing the safety of a particular door, for example, the Harbor Express boats *Flying Cloud* and *Lightning* (see case study in Phase 1 report). In that case, the bow passenger loading doors have no coamings and one of the

reasons for allowing that design is that the bow doors are closed at all times except for embarkation and disembarkation.

- Door's location. Its exposure to or protection from waves, spray, and precipitation.
    - Height above design waterline. The Load Line Technical Manual (LLTM) allows coaming height reductions for added height above the "freeboard deck", with increasing reductions allowed for increasing height; the allowances are presented in tabular format. The table is not prescriptive, and the reductions are allowed based upon the judgment of the inspector; the "Concept" discussion lists the factors to be taken into account. The reader should note that there is no case where the coamings are eliminated altogether.
    - Proximity to bow or stern. The LLTM identifies "Zones 1 and 2" as the forward 25% and the aft 75% of the ship, respectively. The table allows greater coaming height reductions in Zone 2.
    - Proximity to deck edge. The LLTM identifies "athwartships location" and "area of open deck around or adjacent to the opening" as mitigative factors to consider. These factors are not quantitatively addressed in the table.
    - "Exposure" of door. Protection from water by bulwarks, bulkheads, overhangs, and other structural barriers can reduce the hazard and risk.

      CFR antecedents include the Subchapter S ("Stability") regulation § 171.124 ("Watertight integrity above the margin line in a vessel less than 100 gross tons") requires a coaming for an "exposed location on a flush deck vessel". It requires interpretation by the designer and inspection authority to determine the extent to which the door's location is "exposed". In addition, Subchapters K (§ 114.400) and T (§ 175.400) both define "weather deck" in terms of exposure, specifying "partially or completely exposed from above or from at least two sides".
- Downflooding potential through the interior space accessed and protected by the door.
    - Downflooding path to lower deck spaces. The Load Line Manual height reduction table specifically differentiates between doors having "direct access below" ("Category A", 23.5" required standard height) and "no direct access below" ("Category B", 15" required standard height), with greater height reductions also allowed for the "no direct access below" case. The Title 46, Subchapter S "Watertight integrity…" regulation (§ 171.124) specifies coamings for doors that "Give access in to the hull" and allow for no coaming in the converse case. The Phase 1 report described the Incat/Gladding-Hearn catamaran with an allowed coaming-less door

into a large passenger accommodation space, in part, because there was no downflooding path to spaces below.

This methodology also allows for lowering the risk score based upon protective design features within the space, that is, interior doors and coamings, drainage arrangements, or other structural barriers interdicting flow to the downflooding point(s). Distance between the weather deck door and the downflooding point is also a consideration in the model. Neither the Load Line Manual nor the CFR address these matters directly.

The downflooding paths may be generally categorized as follows:

- Direct access to space below the "bulkhead", or main, deck, by an unprotected downflooding path, e.g., a stairway
- Indirect access to space below the bulkhead deck, that is, protective design features isolating the downflooding point(s)
- No access to lower deck

- o Size and configuration of the immediately affected space – The Load Line Manual cites the "type and volume of space the opening leads to" as a factor to be considered in the judgment of the inspector. Figure 75 of the LLTM shows two similar spaces with similarly oriented weathertight doors and indicates that the larger space requires a higher coaming. For these purposes, therefore, larger passenger spaces served carry more risk.

- Vessel's route. The Coast Guard Officer in Charge of Marine Inspection (OCMI) designation of waters in which the vessel may operate, as specified in the stability letter, that is, exposed, partially protected, or protected waters. These designations denote varied severity of wind and waves, as well as proximity to harbor safe refuge. The CFR watertight integrity and coaming regulations are closely tied to these designations. The LLTM does not address route and service. The presumption therein for ships with load lines is that they operate on oceanic voyages.

3.3 Numerical valuation of risk factors

The proposed risk categories and factors appear below, with numerical values in square brackets (i.e., subject to review and revision). Again, it is important to properly characterize the risk guidelines as just that: a guiding tool to be carefully applied, case by case, with sound technical judgment. The risk values appearing below increase in magnitude with increasing risk and are absolute pre-weighted numbers.

i. Purpose & use of door (scoring range: 0 - 2)

- [0] – Open only for embarkation/disembarkation, always closed during voyages
- [1] – Open during voyages for passenger access to weather deck, e.g., "promenade deck"
- [2] – Access to evacuation deck, required to be open in emergencies

ii. Door location (scoring range: 0 - 6)

Table 1. Door location risk scoring

	Height of deck at door < [8 feet] above waterline (WL)		**Height of deck at door >/= [8 feet] above WL**	
	Position 1	**Position 2**	**Position 1**	**Position 2**
Facing outboard *	[2]	[1]	[1]	[0]
Facing aft	[1]	[2], if < 0.25L from stern; [1], if >/= 0.25L from stern	[0]	[1], < 0.25L from stern
Facing forward	[6]	[4]	[3]	[2]
Note: "Position 1" is between the bow and the point 0.25L aft of the bow; "Position 2" is between the point 0.25L aft of the bow and the stern Per definition of International Load Line Convention and the LLTM				
* For doors facing outboard, multiply score by [1.5] if the door is within [4 feet] of the deck edge.				
** For doors with low exterior exposure to the elements due to protective structural elements, multiply score by [0.67]. Discussion in 2.1 cites Subchapter S, K, and T language describing "exposed" locations. Such barriers would need to be in close proximity to the door, and preferably "upstream" in terms of the deck's slope due to sheer and camber.				

iii. Downflooding Potential

- **Downflooding (DF) path (scoring range: 0 - 6)**

Table 2. Downflooding path risk scoring

	X < [20 feet]		X >/= [20 feet]	
	Y < [2 feet]	**Y >/= [2 feet]**	**Y < [2 feet]**	**Y >/= [2 feet]**
Manholes only	[1]	NA	[0.5]	NA
Protected	[2]	[1]	[1]	[0]
Unprotected	[6]	[4]	[4]	[2]
[0] – no pathway of any kind to watertight spaces below the passenger deck				
Manholes only. Watertight, bolted, flush manholes leading to void spaces, tanks, and unmanned spaces, closed during voyages.				
Protected: Watertight or weathertight closures (doors or hatchways) with coaming at downflooding point(s)				
Unprotected: Joiner doors, ventilation openings to spaces below				
X = distance from door to downflooding point Y = height of downflooding point above deck				

- **Size of accommodation space that the doorway leads to (scoring range: 0 - 2)**
    - [0] – less than [25%] of main deck area
    - [1] – between [25%] and [50%] of main deck area
    - [2] – more than [50%] of main deck area

iv. Area of operation

The aggregate scores for the above risk categories should be multiplied as follows for the OCMI designation of waters (that is, for the purposes of the stability regulations) in which the vessel is authorized to operate.

- Protected - [0.75]
- Partially protected - [1.0]
- Exposed - [1.5]

Total scoring range

The range of possible aggregate scores (“R”), before multiplying for the area of operation, is 0 – 16. The range of possible aggregate scores, after multiplying for the area of operation, is 0 – 24.

3.4 Doorway access solutions

The final step in the process is to identify the potential access solutions indicated by the total risk scores. In application, a solution may be selected for any risk score in or below its designated range. A high aggregate risk score may indicate the need to relocate the door and/or incorporate more protective features, to lower the score and consider the selection of a door with improved access.

The proposed menu of solutions follows:

- Weathertight door with no coaming - Aggregate risk score = [$0 \geq R \geq 4$]
- Weathertight door with no coaming with deck drainage arrangement or protective structural features against ingress of exterior water -

  Aggregate risk score = [$4 > R \geq 8$]

  Examples:

  - "Concept A" or B" exterior drains (see figures, Appendix A)
  - Gladding – Hearn exterior drainage detail on *Flying Cloud* (Appendix B, Figure 3)
  - Bulwarks, bulkheads, deck overhangs, etc. preventing passage of water to the door, especially from the direction of exposure, for example, from the bow for forward facing doors or from the stern for aft facing doors.
- Weathertight door with removable regulation height coaming -

  Aggregate risk score = [$8 > R \geq 12$]

  This solution is for embarkation access only, that is, where the crew operates the door at known times and places only.
- Reduced height coaming [50%] with sloped[1] deck ramp (grated) and landing at sill height -

  Aggregate risk score = [$8 > R \geq 16$]
- Regulation height coaming with sloped deck ramp and landing at sill height, -

  Aggregate risk score = [$16 > R \geq 20$]

[1] Guidance from ADAAG 4.1.6, as follows:
(i) A slope between 1:10 and 1:12 is allowed for a maximum rise of 6 inches.
(ii) A slope between 1:8 and 1:10 is allowed for a maximum rise of 3 inches. A slope steeper than 1:8 is not allowed.

- Regulation height coaming, no ramp or sloped deck due to water "runup" risk -

  Aggregate risk score = [$20 > R \geq 24$]

3.5 Other doorway solutions

It may be fruitful to explore the possibilities for substitution of a watertight door with a minimally sized coaming, allowed in both the Subchapter T and K regulations (46 CFR 116.1160 and 179.360, respectively; see discussion, Phase 1 report). The currently available interpretation from Coast Guard safety personnel is that such substitution is meant specifically for vessels with licensed crew and other capable personnel (e.g., offshore drilling rig workers) aboard, who know how to operate a watertight door and can do so in emergency egress situations. This interpretation may be ripe for re-examination.

The use of such doors would raise other accessibility questions (hardware configuration and opening force); however, the result of the inquiry could be a set of new design requirements for consideration by watertight door manufacturers.

3.6 Embarkation doors at the deck edge

Many passenger boats have embarkation doors in the deckhouse side, at or very close to the deck edge and offering no weather deck access. Coamings are not the access barrier in these cases, but poorly designed gangways are. The problem most commonly seen is the double slope of the gangway and a short interior ramp meeting in an apex at the coaming (there are non-specification variations like the "whaleback" arching over the coaming). Gangways designed to provide proper slopes on both sides of the doorway and a proper landing over the coaming are the access solution, not removal or reduction of the coaming. A concept design appears in Appendix A, Figure 3.

4 Application and examples

The risk methodology was first exercised and tuned with examples of weathertight doors in the as-built condition (section 4.1). The next step was the development of reconfiguration cases on several representative, and recent, designs. Summaries of the reconfiguration cases appear in section 4.2, and the full texts appear in Appendices B through D.

4.1 As built cases

Table 3 shows a sampling of the results applying the risk scoring methodology to doors serving passenger accommodation spaces on existing boats. All the particulars and scoring factors for each door appear, as well as the aggregate risk score. Descriptions of the existing door and the access solution indicated by the methodology appear in the rightmost column, for the purpose of comparison.

The risk methodology indicates solutions that are for the most part similar to the existing as-built doors, particularly those cases where alternate arrangements were approved in the inspection process. The exceptions are among the doors examined on larger and older vessels, the Subchapter H and K boats. In these cases, the risk-based solutions were less conservative than the as-built doors.

In the case of the Subchapter K overnight excursion boat, the main deck door giving access to the stern has a 6” high coaming in strict accordance with the regulations. The location and downflooding potential result in a moderate aggregate risk score of 8.0, indicating the need for protection from water ingress but allowing for an alternate design for improved access. The risk score is on the cusp between designated ranges for three different solutions. The conservative choice would be a weathertight door with a reduced height coaming, with sloped deck ramp (grated for drainage) and landing at sill height.

An “01 level” (one deck above the main deck) door on the same vessel scored quite low for risk (aggregate = 3.5). The indicated solution is nearly identical to the as-built door and both provide good access.

The 01 level door on the Subchapter K casino boat has a 6” high coaming, but scores for moderate risk only (aggregate = 7.0). The indicated solution is a weathertight door with no coaming and drainage/ water barrier protection. A more conservative option would be a door with reduced height coaming [50%] with sloped deck ramp (grated) and a level landing at the coaming height.

The doors examined for Subchapter K and T passenger-only catamaran ferries of recent construction had low to moderate aggregate risk scores. Notably, the indicated solutions were very similar to the as-built doors in all three cases.

Table 3. Risk scoring for as-built door examples

Pathway || To & From		Purpose and use of door ([0 – 2])	Door Location ([0 – 6])	DF Potential ([0 – 6])	Size of space doorway leads to ([0 - 2])	Area of Operation multiplier	Total risk ([0-24])	Existing Door and Solution(s)
Subchapter K overnight excursion boat, weather deck	Passenger accomm. space	Passenger access to weather deck, alternate access not available (**2**)	Main deck, aft, facing stern; deck at door < 8' above WL (**2**)	Unprotected pathway to spaces below with 20'+ separation; Y < [2'] (**4**)	Passage and passenger berths, less than 25% of main deck area (**0**)	Partially protected waters (**1.0**)	(2 + 2 + 4 + 0) * 1.0 = **8.0**	Existing door has 6" coaming. Indicated solutions are: 1) door with no coaming and protection for water; 2) door with removable regulation height coaming; or 3) reduced height coaming with sloped deck ramp (grated) and landing at sill height. 2 and 3 are the conservative choices.
	Passenger accomm. space	Passenger access to weather deck, alternate access available (**1**)	01 level, facing outboard, Pos. 1, less than 4' from deck edge (**1.5**)	Protected pathway:20'+ separation; Y < [2'] (**1**)	Passage and passenger berths, less than 25% of main deck area (**0**)	Partially protected waters (**1.0**)	(1 + 1.5 + 1 + 0) * 1.0 = **3.5**	Existing sliding door has no coaming. Indicated solution is a weathertight door with no coaming.
Subchapter K casino boat, forward weather deck	Passenger accomm. space	Passenger access to weather deck, no alternate access available, closed in bad weather (**1**)	01 level, facing forward, Pos. 1, more than 8' above waterline (**3**)	Protected pathway: 20'+ separation; Y < [2'] (**2**)	Gaming room, 30% - 50% of main deck area (**1**)	Partially protected waters (**1.0**)	(1 + 3 + 2 + 1) * 1.0 = **7.0**	Existing double doors have 6" coaming and nearby deck drain. Indicated solution is a weathertight door with no coaming and drainage/ water barrier protection.

Table 3 (continued)

Pathway || To & From		Purpose and use of door ([0 – 2])	Door Location ([0 – 6])	DF Potential ([0 – 6])	Size of space doorway leads to ([0 - 2])	Area of Operation multiplier	Total risk ([0-24])	Existing Door and Solution(s)
Subchapter H vehicle – passenger ferry, starboard weather deck	Passenger accomm. space	Passenger access to weather deck (**1**)	02 level, facing outboard, within 4' of deck edge (**0**)	No pathway to spaces below (**0**)	Passenger accomm. space, less than 25% of deck area (**0**)	Partially protected waters (**1.0**)	(1 + 0 + 0 + 0) * 1.0 = **1.0**	Existing door has 3" coaming with short ramps on either side. Indicated solution is a weathertight door with no coaming.
Subchapter K catamaran passenger ferry, starboard weather deck	Passenger accomm. space	Passenger access to weather deck (**1**)	Main deck aft, facing outboard, within 4' of deck edge (**1.5**)	No pathway to spaces below (**0**)	Passenger accomm. space, more than 50% of main deck area (**2**)	Partially protected waters (**1.0**)	(1 + 1.5 + 0 + 2) * 1.0 = **4.5**	Existing sliding door has 1" coaming. Indicated solution is weathertight door with no coaming, with drainage or barrier protection.
Subchapter T catamaran passenger ferry, forward weather deck	Passenger accomm. space	Passenger embarkation, closed during operations (**0**)	Main deck Position 1, facing forward (**6**)	No pathway to spaces below (**0**)	Passenger accomm. space, more than 50% of main deck area (**2**)	Partially protected waters (**1.0**)	(0 + 6 + 0 + 2) * 1.0 = **8.0**	Existing double doors have no coaming with drainage in adjacent deck. Indicated solution is no coaming, with drainage or barrier protection.
Subchapter T catamaran passenger ferry, aft starboard weather deck	Passenger accomm. space	Passenger access to weather deck (**1**)	Main deck Position 2, facing outboard, within 4' of shell (**1.5**)	No pathway to spaces below (**0**)	Passenger accomm. space, estimate more than 50% of main deck area (**2**)	Partially protected waters (**1.0**)	(1 + 1.5 + 0 + 2) * 1.0 = **4.5**	Existing sliding door has no coaming and protection of bulkheads forward. Indicated solution is weathertight door with no coaming, with drainage or barrier protection.

4.2 Reconfiguration examples

Risk scoring tables appear for each case, but the door access solution is discussed in detail in the accompanying text rather than specified in the table (as was presented in 4.1).

4.2.1 Gladding – Hearn INCAT Designs, 35 meter long Subchapter T catamaran

This case study was to ascertain whether access through the forward doors for this bow-loading boat could be improved, possibly by the elimination of the coamings, on the basis of the risk management approach. The case was instructive because it uses a "type" boat design wherein a number of options for design and operation may be selected, allowing for examination of several scenarios involving design options and hypothetical consideration of operation in protected or partially protected waters. The design options were:

- The passenger deck may "float", that is, be structurally separate from the catamaran hulls' watertight envelope and no direct downflooding path, or may be integral with the hull tops.
- Embarkation access may be via the bow to the forward deckhouse doors, or via bulwark gates near the stern to the aft deckhouse doors.

The design specifies weathertight doors, whether facing forward for bow loading, or aft for stern loading. Doors are presumed to have 3" coamings (designed per Subchapter S watertight integrity regulations for vessels less than 100 GT).

Tables 4 and 5 summarize the analytical framework for characterizing the design technical risk factors associated with the location and use of weathertight doors. The tables show four scenarios each for the forward and aft doors. Moving from the leftmost column rightward, the cells first divide to indicate the deck construction options, and then divide again for service in "protected" versus "partially protected" waters.

Table 4. 35-meter catamaran, risk scoring for forward door options

Pathway || To & From		Purpose and use of door ([0 – 2])	Door Location ([0 – 9])	Downflooding Potential		Area of Operation multiplier	Total risk "R" ([0-24])
				DF path ([0 – 6])	Size of space doorway leads to ([0 - 2])		
Forward doors, port and starboard	Weather || passenger accomm. space	Embark-ation only, closed otherwise (**0.0**)	Door sill less than [8 feet] above WL, facing forward in Position 2 (**4.0**)	Manholes only **(1.0)**	Passenger accomm. space, more than 50% of main deck area (**2.0**)	Protected waters (**0.75**)	**(0 + 4 + 1 + 2) * 0.75 = 5.25**
						Partially protected waters (**1.0**)	**(0 + 4 + 1 + 2) * 1.0 = 7.0**
				"Floating" deck, no DF pathway **(0.0**)		Protected waters (**0.75**)	**(0 + 4 + 0 + 2) * 0.75 = 4.5**
						Partially protected waters (**1.0**)	**(0 + 4 + 0 + 2) * 1.0 = 6.0**

Based strictly upon the aggregate risk scores, the aft doors would appear to be the better choice for passenger access. The scores in both cases are low, however, and an accessible pathway via the bow doors would also be appropriate for the right combination of design features and operation. Note that access through the aft doors to the aft weather deck is required whether or not the embarkation pathway includes those doors.

Forward doors

In the bow loader configuration with forward embarkation doors, the choice of a "floating" deck would reduce the risk scores from 5.25 and 7.0 to 4.5 and 6.0, for service in protected and partially protected waters, respectively. The benefit of the floating deck for either service choice is modest and does not substantively change the outcome, because the downflooding risk from the closed manholes in the passenger cabin is low to start with.

With or without the floating deck, in protected water service, the solution would be a coaming-less weathertight door. The risk for this design could be further reduced with protective drainage features against water on deck. It may be appropriate to replace the weathertight door with coaming with an improved access doorway, for example, a weathertight door with a coaming of reduced height, and protective drainage.

Table 5. 35-meter catamaran, risk scoring for aft door options

Pathway || To & From		Purpose and use of door ([0 – 2])	Door Location ([0 – 9])	Downflooding Potential		Area of Operation multiplier	Total risk "R" ([0-24])
				DF path ([0 – 6])	Size of space doorway leads to ([0 - 2])		
Aft doors, port and starboard	Weather || PAX accomm. space	Embark-ation, and passenger access to weather deck during voyage (**1.0**)	Door sill less than [8 feet] above WL, facing aft in Position 2 (**1.0**)	Manholes only **(1.0)**	PAX accomm. space, more than 50% of main deck area (**2.0**)	Protected waters (**0.75**)	**(1 + 1 + 1 + 2) * 0.75 = 3.75**
						Partially protected waters (**1.0**)	**(1 + 1 + 1 + 2) * 1.0 = 5.0**
				"Floating" deck, no DF pathway **(0.0**)		Protected waters (**0.75**)	**(1 + 1 + 0 + 2) * 0.75 = 3.0**
						Partially protected waters (**1.0**)	**(1 + 1 + 0 + 2) * 1.0 = 4.0**

Aft doors

Use of the aft doors for access to the weather deck is required whichever embarkation path is chosen. The floating deck results in scores of 3.0 and 4.0 for the protected and partially protected waters. A coaming-less door would be appropriate in either case. For partially protected waters, the score of 4.0 is on the cusp and it might be appropriate to include protective drainage or a reduced height coaming with ADA-compliant short ramps on either side.

Without the floating deck, the aggregate risk scores rise slightly. Protective drainage or a reduced height coaming with short ramps and a landing would be appropriate for service in partially protected waters.

Discussion

It is evident that the door location and the large size of the accommodation space drive the aggregate risk score in all the scenarios, especially for the forward doors. The floating deck eliminates downflooding paths, but the benefit is modest because the only potential downflooding points in this case are bolted manhole covers leading to tanks and voids; the likelihood of any of those manholes being open during a voyage is slight.

It turned out that the scoring bandwidth for all scenarios was relatively narrow at the low risk end of the range, but that there are several possible solutions.

This case shows there may be several design, operations, and economics decision points, of which mobility access is one. The operator and builder can consider accessible paths onboard in overall context of the desired operation for the boat (market served, waters served, and shoreside infrastructure and loading mode), and the added cost of mitigative safety features. An accessible pathway through either the forward or aft doors is feasible, given different design and operational choices.

4.2.2 Casco Bay Line monohull passenger only ferry, Subchapter K, 399 passengers, protected waters service

In this case, embarkation is via sliding weathertight doors on the main deck, port and starboard, forward (approximately 0.25L from the bow) at the deck edge. The doors have 3" coamings (per Subchapter S). The risk model exercise is to ascertain whether the coamings could be eliminated to improve embarkation access and simplify the design of the gangways from the shoreside piers.

Discussion

The embarkation doors, as designed, scored 4.5. The indication is that a weathertight door without coaming might be suitable. However, there would be no exterior drainage or water barrier protection available, given the deck edge location. The conservative approach would dictate retention of the coaming as structural protection and a strong gasketing surface against the unlikely event of waves impinging on the door.

Two possible reconfigurations would lower the risk score to below 4.0 and allow installation of a no coaming weathertight sliding door. First, the doors could remain in their forward position in a 48" recess, a protective bulkhead forward, and possibly a portable protective coaming at the deck edge while the door is closed. As shown in Table 6, the overall risk score would be 3.75 and the solution would be a sliding weathertight door with no coaming, with limited impact on the internal arrangement.

The second approach would be to move the doors aft to approximately amidships, resulting in a lowered aggregate risk score of 3.4 and a sliding coaming-less door. The internal space arrangement modification would be minimal. Bench space lost amidships would be regained forward at the former position of the door.

In this case, the two "downflooding" sub-factors, "distance to downflooding point" and "area of accommodation space", work against each other. Long distances to the downflooding point are more common in large accommodation spaces. At first blush, it seems that rethinking this contradictory linkage is necessary. However, the space area metric also protects against large volumes of entrapped water, should the worst

situation occur, that is, a failed door allowing ingress of large amounts of water from waves abeam or heavy spray.

Table 6. Subchapter K monohull ferry, risk scoring for embarkation door options

Pathway || To & From		Purpose and use of door ([0 – 2])	Door Location ([0 – 9])	Downflooding Potential		Area of Operation multiplier	Total risk "R" ([0-24])
				DF path ([0 – 6])	Size of space doorway leads to ([0 - 3])		
As designed configuration							
Forward embark-ation doors, port and starboard, as designed	PAX accomm. space || Weather	Embark-ation only, closed otherwise (**0.0**)	Less than [8 feet] above waterline, on deck edge, facing outboard in Position 1 (**2.0 X 1.5 = 3.0**)	Protected DF pathway: DF point at least [20 feet] from the door; Y < [2 feet] (**1.0**)	More than 50% of main deck area **(2.0)**	Protected waters (**0.75**)	(0 + 3 + 1 + 2) * 0.75 = **4.5**
Reconfigurations							
Forward embark-ation doors, port and starboard, recessed inboard	PAX accomm. space || Weather	Embark-ation only, closed otherwise (**0.0**)	Door sill less than [8 feet] above the main deck, inboard of deck edge, facing outboard in Position 1 (**2.0**)	Protected DF pathway; DF point at least [20 feet] from the door; Y < [2 feet] (**1.0**)	More than 50% of main deck area **(2.0)**	Protected waters (**0.75**)	(0 + 2 + 1 + 2) * 0.75 = **3.75**
Amidship embark-ation doors, port and starboard, at deck edge	PAX accomm. space || Weather	Embark-ation only, closed otherwise (**0.0**)	Door sill less than [8 feet] above main deck, on deck edge, facing outboard in Position 2 (**1.0 X 1.5 = 1.5**)	Protected DF pathway; DF point at least [20 feet] from the door; Y < [2 feet] (**1.0**)	More than 50% of main deck area **(2.0)**	Protected waters (**0.75**)	**(0 + 1.5 + 1 + 2) * 0.75 = 3.4**

4.2.3 Graul monohull dinner boat, Subchapter K, 127' long, 368 passengers, protected or partially protected waters service

This is to ascertain whether the coamings could be eliminated or reduced on a risk management basis. The main deck passenger cabin has weathertight doors with 6" coamings, forward for weather deck access, and aft for embarkation and weather deck access. In this case, the reconfiguration will be to better protect downflooding points.

Table 7. Subchapter K dinner boat, risk scoring for embarkation door options

Pathway || To & From		Purpose and use of door ([0 – 2])	Door Location ([0 – 9])	Downflooding Potential		Area of Operation multiplier	Total risk "R" ([0-24])
				DF path ([0 – 6])	Size of space doorway leads to ([0 - 3])		
As designed configuration							
Forward weather deck door	PAX cabin || weather deck	Weather deck access and embark-ation (**1**)	Door sill less than [8'] above WL, facing forward, in Position 2 (**4**)	Unprotected pathway, separation of DF point more than [20 feet] from the door, less than [2 feet] above the deck. **(4)**	More than 50% of main deck area **(2)**	Protected waters (**0.75**)	**(1 + 4 + 4 + 2) * 0.75 = 11 * 0.75 =8.25**
						Partially protected waters **(1.0)**	**11.0 * 1.0 = 11.0**
Aft weather deck door	PAX cabin || weather deck	Ditto **(1)**	Door sill less than [8'] above WL, facing aft, < 0.25L from stern, with struct. protection from water (**1.33**)	Ditto, except DF point is less than [20 feet] from the door **(6)**	Ditto **(2)**	Protected waters (**0.75**)	**(1 + 1.33 + 6 + 2) * 0.75 = 10.3 * 0.75 = 7.75**
						Partially protected waters **(1.0)**	**10.3 * 1.0 = 10.3**
Reconfigurations							
Forward weather deck door	Ditto above	Ditto above **(1)**	Ditto above **(4)**	Protected DF path, same horiz./vert. separations **(1.0)**	Ditto above **(2)**	Protected (**0.75**)	**6.0**
						Part. Prot. **(1.0)**	**8.0**
Aft weather deck door	Ditto above	Ditto above **(1)**	Ditto above **(1.33)**	Ditto **(2.0)**	Ditto above **(2)**	Protected **(0.75)**	**4.75**
						Part. Prot. (**1.0**)	**6.3**

The aggregate risk scores in Table 7 indicate that some form of weathertight protection is appropriate both for forward and aft doors, especially for partially protected waters service, for which the doors are designed. The deck arrangement precludes relocation or reconfiguration of the doors without serious impact. The reasonable approach is to examine reconfiguration of other risk elements, and the best accessible pathway.

The best way to reduce risk is better protection of the downflooding point. Replacing the non-weathertight door at the downflooding point with a weathertight door with a coaming would significantly reduce the risk. The downflooding path score for both the forward and aft doors would drop from 4 to 1 and from 6 to 2, respectively, as per Table 8.

Table 8. Downflooding paths, Graul dinner boat, revised scores

Risk scores for downflooding path	**X < [20 feet]**		**X >/= [20 feet]**	
	Y < [2 feet]	**Y >/= [2 feet]**	**Y < [2 feet]**	**Y >/= [2 feet]**
Manholes only	[1]	NA	[0.5]	NA
Protected	Aft door: [2]	[1]	Forward door: [1]	[0]
Unprotected	~~[6]~~	[4]	~~[4]~~	[2]

The aggregate risk scores for the aft door drop considerably, and a weathertight, accessible coaming-less door aft with a protective drainage arrangement appears to be appropriate for both protected waters and partially protected waters service.

The forward door has significantly lowered scores, but remains in need of protection against water entry. The conservative approach for safety might dictate retention of at least a reduced height (3”) coaming and designation of the aft door only as accessible for the mobility-impaired. This would provide the embarkation pathway and the accommodation of access to the weather deck. The fore deck would remain available to other passengers for embarkation and access during voyages. There would be benefit to the operator here as well in the reduction of the barrier for able-bodied passengers.

5 Summary and Actions

5.1 Findings

- The investigation into safety regulations and access standards for weathertight doors revealed the nature and details of the fundamental conflict between the two: coamings keep water out and provide structure for weathertight doors, but raise a barrier to access for the mobility-impaired.
- Designers, shipbuilders and the Coast Guard have in some cases found alternative solutions providing improved access, but these have not been formally recorded as “equivalents” meeting the intent of the watertight integrity regulations.
- The Coast Guard’s inspectors have in those cases been using a common sense risk management approach without the use of a formalized methodology.
- Naval architects and operators have welcomed the idea of the risk management methodology.
- Several naval architects have reviewed and agreed with the particulars of the methodology.
- Applying the methodology to as built designs produces largely similar door design and access results, with some noted exceptions for larger vessels.
- Applying the methodology to reconfigure doors and other design elements can work effectively to provide improved access between the passenger cabin and weather decks.

5.2 Course of Action

The Passenger Vessels Association (PVA) and the Coast Guard’s "Partnership Action Team" (PAT) expressed support for the risk methodology at its January 2005 meeting, and agreed to undertake a formal peer review process, offering technical and operational insights to improve the tool. The PAT intends to put the risk methodology reports into the current Department of Transportation (DOT) docket for the rulemaking “Nondiscrimination on the Basis of Disability: Passenger Vessels”, docket number OST-2004-19700. At the time of this report’s completion, the PAT had agreed to prepare a charter identifying the course of action and had asked PVA members to help by providing:

- Examples where alternative doorway designs give enhanced access from the weather decks to passenger accommodation spaces; and
- Comments on the practicality of the proposed methodology and the particulars of the risk scoring regime; and

- Knowledge of vessel casualties where weathertight doors and coamings (or lack of same) were contributing factors.

5.3 Issues

There are several significant questions at the time of this report's completion. The first concerns the technical particulars as they may be affected by the future PAT review and the public's response after the report is placed in the DOT docket.

The second question is the eventual disposition of the risk-based methodology. The Coast Guard, industry, and the author agree that it should not become part of the Coast Guard's or the Access Board's regulations. One possible outcome is its publication as a Coast Guard "Navigation and Vessel Inspection Circular" (NVIC). NVICs function as technical guidance to industry and have proven a very useful tool for many safety and environmental protection matters in the past.

Finally, there is a set of questions concerning the prospective designs of weathertight and watertight doors providing enhanced access, that is, in conjunction with reduced height coamings and short ramps. These address the enhanced access solutions offered in the risk-based methodology and the extent to which marine door manufacturers can respond to the need for accessible doors. The questions are:

- Are there manual weathertight and watertight doors currently in the market that comply with 4.13, "Doors, Doorways, and Gates", of the ADAAG? For doors required to be accessible, do any of the provisions in 4.13 add space or features or present design challenges of providing conforming doors?
- On the subject of proper sealing of door gaskets:
    - Can manual weathertight doors properly seal against a sloped surface or do they require a vertical surface at the top of the sloped surface? If such doors cannot be properly sealed, would interior deck drains satisfy any leakage concerns and does the installation of such drains create a design challenge or cost concern?
    - Can manual watertight doors properly seal against a ¼ inch vertical surface or a ½ inch vertical rise sloped surface? If not, what is the minimum height required for proper sealing and are such doors commercially available?

REFERENCES

Access for Persons with Disabilities to Passenger Vessels and Shore Facilities, The Impact of the Americans with Disabilities Act of 1990, prepared by the Volpe National Transportation Systems Center for the Office of Secretary of Transportation, July 1996

Americans with Disabilities Act Accessibility Guidelines, United States Access Board, 2002

Coast Guard Maine Safety Manual Chapter 3: Documentation of Vessel Inspections.

Code of Federal Regulations, Title 46 “Shipping”, Subchapters C, H, K, S, and T

Passenger Vessel Access Advisory Committee, “Recommendations for Accessibility Guidelines for Passenger Vessels: Final Report”, December 2000.

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FIGURE 1. SUMP AND DRAIN ADJACENT TO THE DOOR

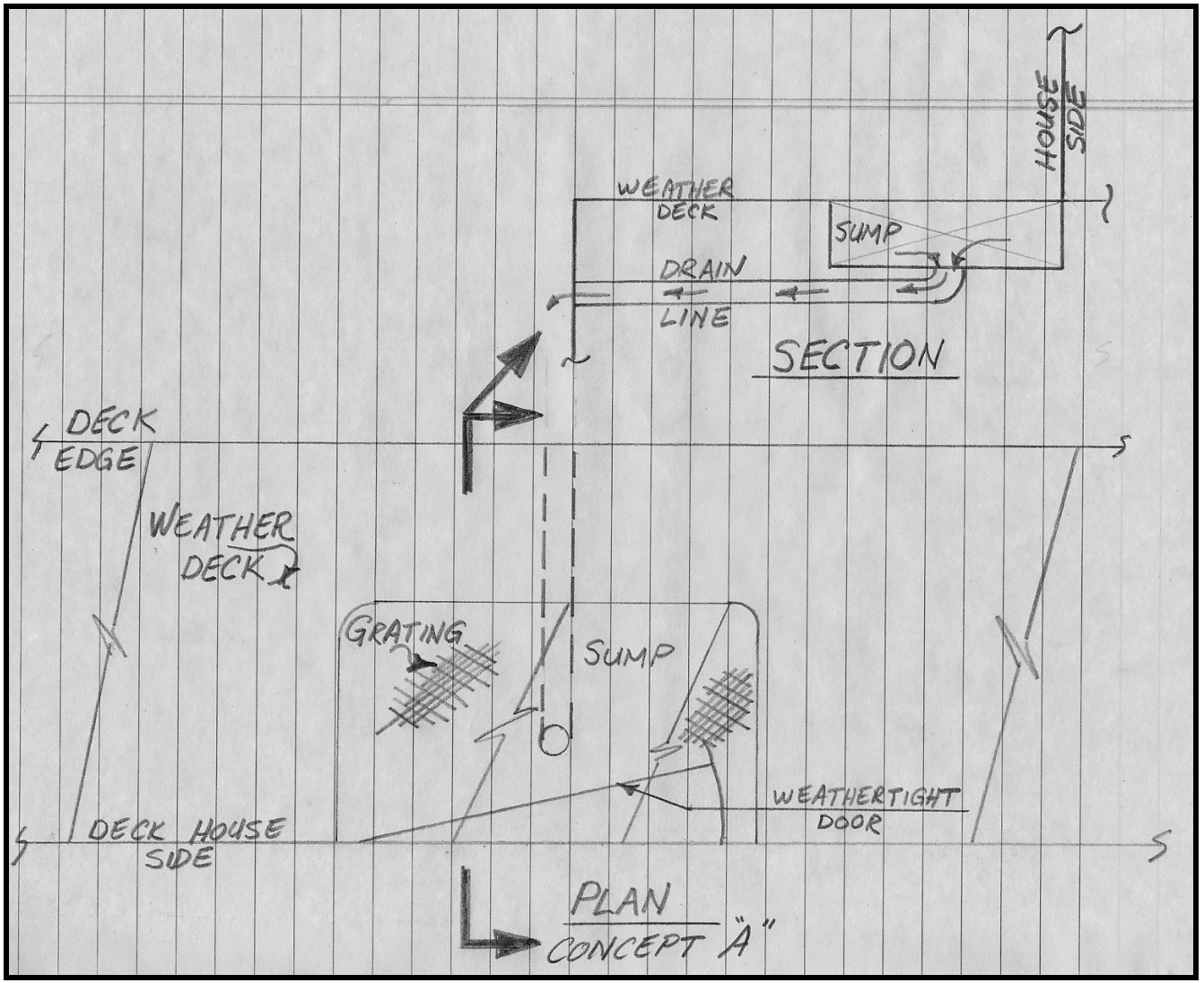


FIGURE 2. DRAINAGE SLUICES ADJACENT TO THE DOOR

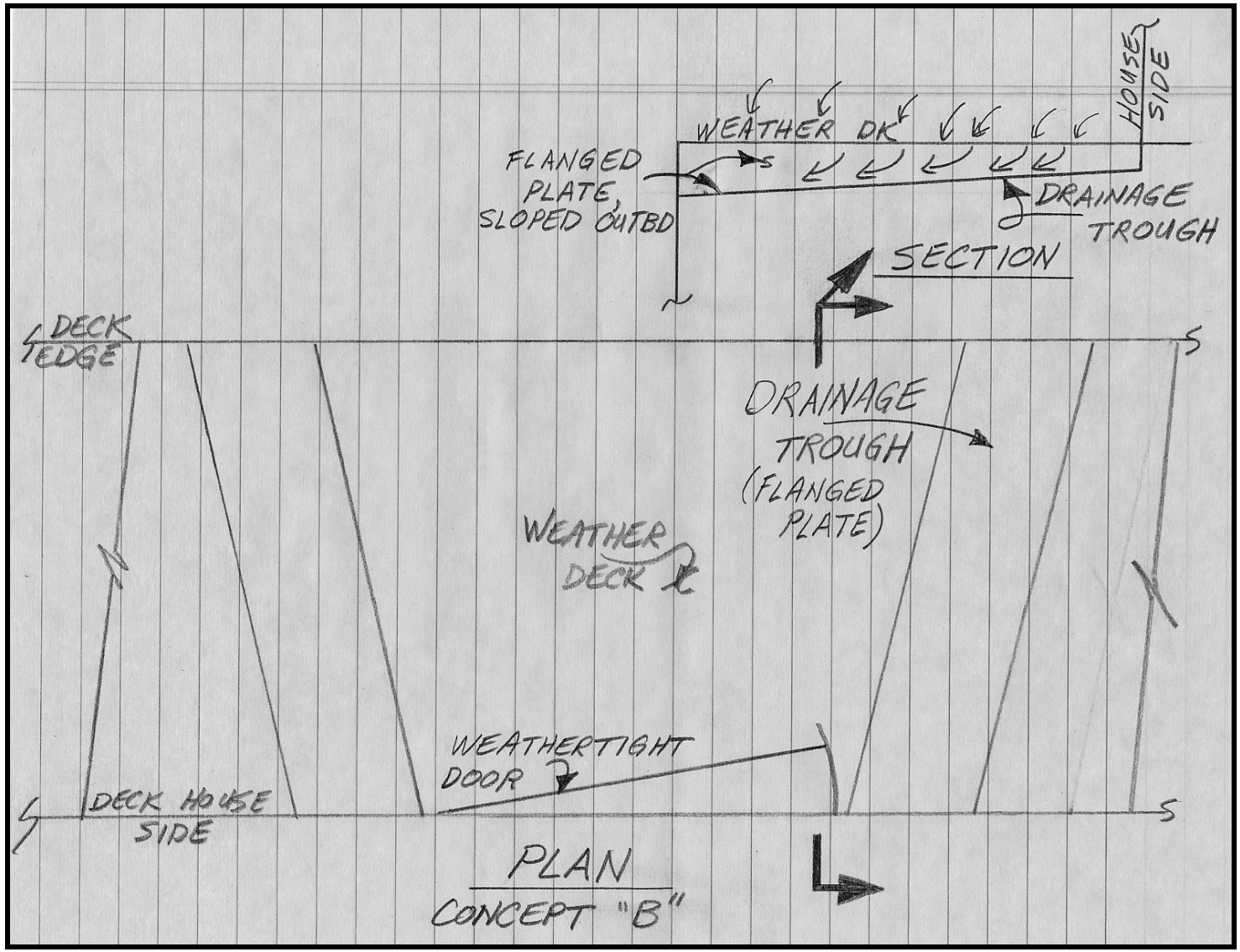
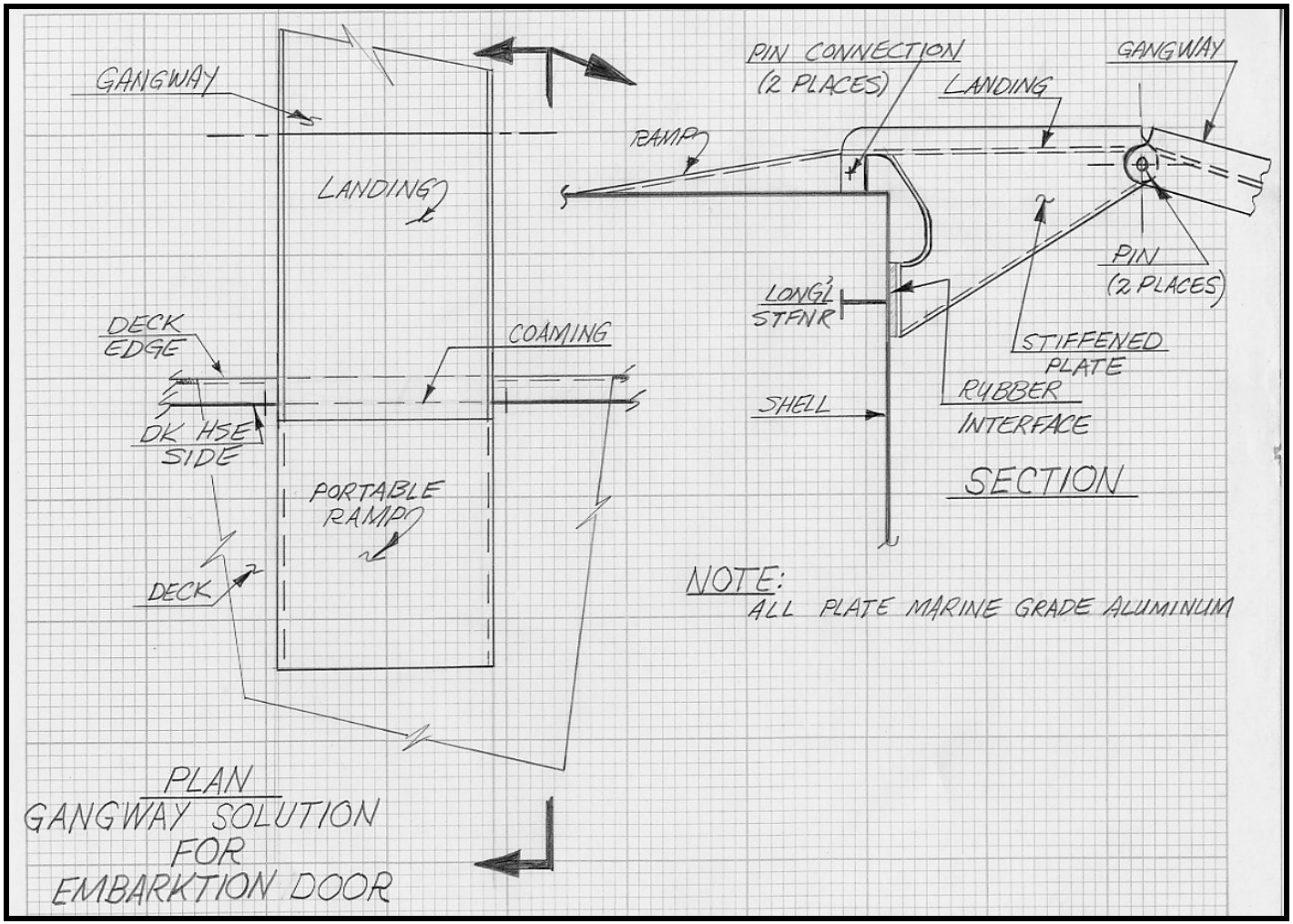


FIGURE 3. GANGWAY SOLUTION FOR EMBARKATION DOOR



Numerical risk evaluation, main deck doors
35 meter long catamaran 149 passengers
Gladding-Hearn Shipbuilding and INCAT Designs - Sydney

INTRODUCTION

This paper shows an application of the proposed use of risk indices leading to enhanced doorway access solutions for people with mobility impairments. It is important to note that the risk guidelines are to be carefully applied, on a case by case basis, with sound technical judgment.

The particulars of the case for this Gladding-Hearn and INCAT Designs (GH-ICD) boat (deck plan, Figure 1) are:

- This is a design type for a Subchapter T boat, capacity of 149 passengers, intended for operation in protected waters. According to the builder, two important design features are optional depending on the particular service and client:
    - The deck may or may not "float". The floating deck is structurally separate from the catamaran hulls' watertight envelope and affords no direct access or downflooding through the passenger cabin deck; otherwise the passenger cabin deck is integral with the hull tops.
    - Embarkation access may be via the bow to the forward deckhouse doors, or via bulwark gates near the stern to the aft deckhouse doors. Figure 2 shows GH-ICD boats of similar, but not identical, design to the 35-meter boat considered herein, one each with the bow and stern embarkation access points.
- GH-ICD specifies watertight or weathertight doors, facing forward from the deckhouse forward bulkhead, port and starboard (0.35L aft of bow); and weathertight doors facing aft, port and starboard, from the aft deckhouse bulkhead, all on the main deck.
- Doors are presumed to have 3" coamings (designed per Subchapter S watertight integrity regulations for vessels less than 100 GT).

This case study is to ascertain whether access through the doors could be improved, possibly by the elimination of the coamings, on the basis of the risk management approach. This example is instructive because it uses a "type" boat design wherein a number of options for design and operation may be selected. This allows for examination of several scenarios involving the two design options shown above, deck structure types and bow vs. stern embarkation. The study includes hypothetical consideration of operation in partially protected waters as well, recognizing that the builder intends the design for protected water operations.

Figure 1. General plans, Gladding –Hearn/INCAT 35 meter catamaran

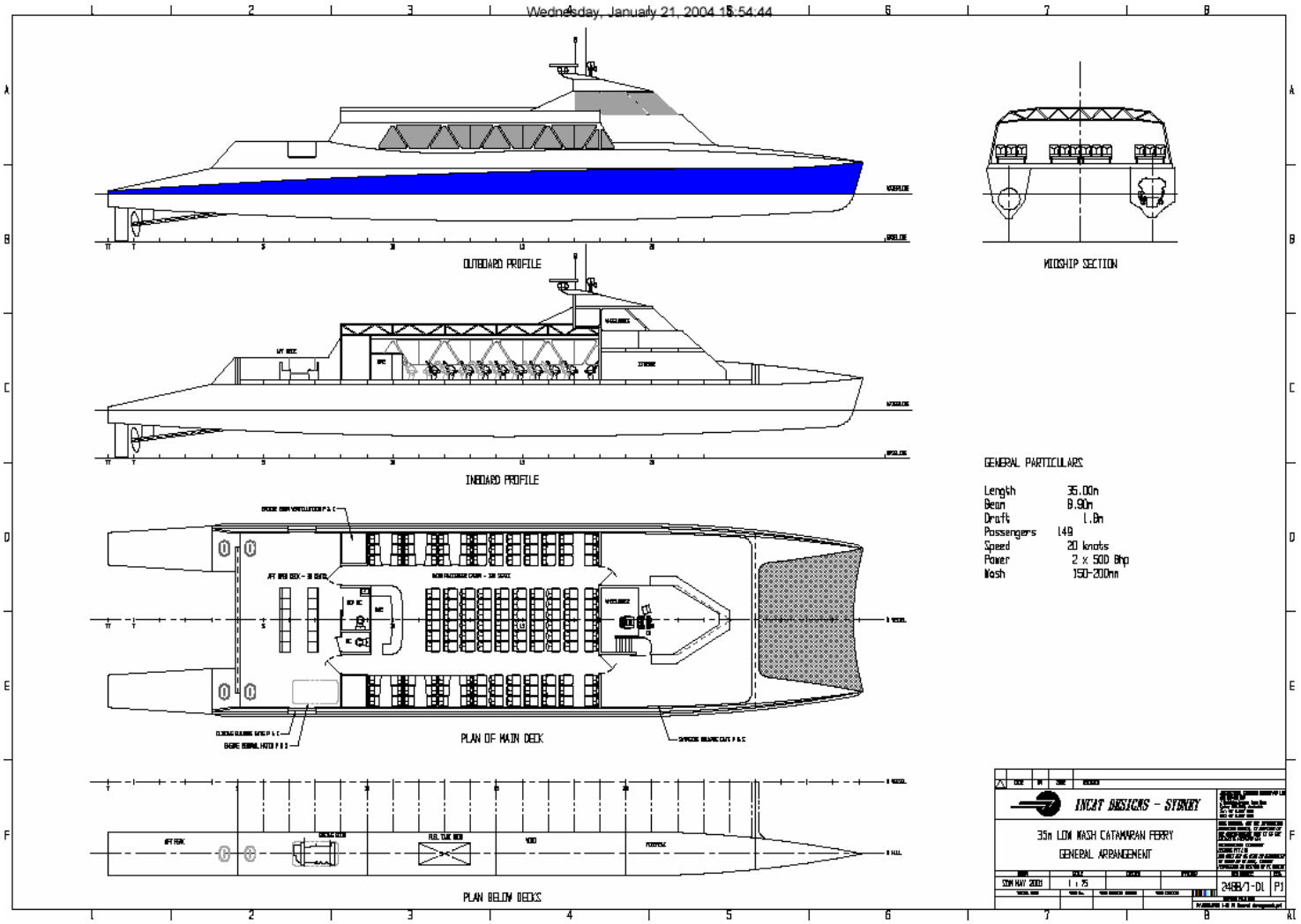


Figure 2. Gladding-Hearn INCAT Design boats 331 and 332 at dock.

NOTE: These boats are not identical to the design chosen for this example and shown in Figure 1. The photograph shows how bow doors and bow loading reconfigure the design (boat at bottom of photograph) of the passenger cabin. The configuration of the side loader (at top) has different doors into aft area of the passenger cabin, which are not part of the configuration for this example, as shown in Figure 1.

APPENDIX B

APPLICATION

The descriptive language for the risk factors developed in the Volpe Center report appears verbatim. The risk values appearing below increase in magnitude with increasing risk and are absolute un-weighted numbers.

The forward doors and aft doors are treated separately (sub-headings i and ii), each with scenarios for the two deck construction techniques. Gray text shading of text show the particulars for the subject case, with annotations added where appropriate. Annotations show differences between the cases of the separate floating deck and the structurally integral deck..

The risk summation for all scenarios follows the detailed scoring for the forward and aft doors, appearing in Table 5, and with a discussion of possible doorway access solutions.

1. FORWARD DOORS

i. Purpose & use of door

- [0] – Open only for embarkation/disembarkation, always closed during voyages. NOTE: GH-ICB state that there is no passenger access to the forward weather deck during voyages.
- [1] – Open during voyages for passenger access to weather deck, e.g., "promenade deck", alternate access available
- [2] – Access to evacuation deck, required to be open in emergencies

ii. Door location

Risk scores for door position	**Sill < 8 feet above WL**		**Sill >/= [8 feet] above WL**	
	Position 1	**Position 2**	**Position 1**	**Position 2**
Facing outboard *	[2]	[1]	[1]	[0]
Facing aft	[1]	[2], if < 0.25L from stern; [1], if >/= 0.25L	[0]	[1], < 0.25L from stern
Facing forward	[6]	[4]	[3]	[2]

Note: ***"Position 1" is between the bow and the point 0.25L aft of the bow;***

"Position 2" is between the point 0.25L aft of the bow and the stern

Per definition of International Load Line Convention and the LL Technical Manual

* For doors facing outboard, multiply score by [1.5] if the door is within [4 feet] of the deck edge.

** For doors with low exterior exposure to the elements due to protective structural elements, multiply score by [0.67]. Discussion in 2.1 cites Subchapter S, K, and T language describing "exposed" locations. Such barriers would need to be in close proximity to the door, and preferably "upstream" in terms of the deck's slope due to sheer and camber. NOTE: There is no reduction credited here because the protective features forward of the door are relatively short in height and are about 8 meters away.

iii. Downflooding potential

- **Downflooding path**

The plan provided shows no downflooding path in the passenger accommodation space. Manholes giving access to engine room spaces appear aft of the deckhouse on the weather deck. The engine rooms' air supply plenums (frames 9 – 10, port and starboard) are in the aft corners of the passenger accommodation space; the intake ducts would be in the aft or outboard bulkheads of the plenum, NOT in the passenger space. However, it is assumed that there are bolted manhole covers elsewhere in the space giving access to fuel tanks and void spaces. The conservative view would be that there is a "protected" downflooding path in the space for integral deck construction. Such is not the case for the "floating" deck construction, where there is no downflooding path.

Risk scores for downflooding path	**X < [20 feet]**		**X >/= [20 feet]**	
	Y < [2 feet]	**Y >/= [2 feet]**	**Y < [2 feet]**	**Y >/= [2 feet]**
Manholes only	[1], structurally integrated deck	NA	[0.5]	NA
Protected	[2]	[1]	[1]	[0]
Unprotected	[6]	[4]	[4]	[2]
[0] – no pathway of any kind to watertight spaces below the passenger deck, for "floating deck"				
Manholes only. Watertight, bolted, flush manholes leading to void spaces, tanks, and unmanned spaces, closed during voyages.				
Protected: Watertight or weathertight closures (doors or hatchways) with coaming at downflooding point(s)				
Unprotected: Joiner doors, ventilation openings to spaces below				
X = distance from door to downflooding point Y = height of downflooding point above deck				

- **Size of accommodation space that the doorway leads to**

- [0.0] – less than [25%] of main deck area
- [1.0] – between [25%] and [50%] of main deck area
- [2.0] – more than [50%] of main deck area (nearly exactly 50% in this case)

iv. Area of operation

The aggregate scores for the above risk categories should be multiplied as follows for the OCMI designation of waters (that is, for the purposes of the stability regulations) in which the vessel is authorized to operate.

- Protected :: [0.75]
- Partially protected :: [1.0] (both areas of operation considered)
- Exposed :: [1.5]

2. AFT DOORS

i. Purpose & use of door

- [1] – Open during voyages for passenger access to weather deck, e.g., "promenade deck", alternate access available. NOTE: Access through these doors to the aft weather deck is required whether the forward or aft doors are the chosen embarkation path.

ii. Door location

Note: ***"Position 1" is between the bow and the point 0.25L aft of the bow;***

"Position 2" is between the point 0.25L aft of the bow and the stern

(Per definition of International Load Line Convention and the Load Line Technical Manual)

Risk scores for door position	Sill < 8 feet above WL		Sill >/= [8 feet] above WL	
	Position 1	Position 2	Position 1	Position 2
Facing aft	[1]	[2], if < 0.25L from stern; [1], if >/= 0.25L from stern	[0]	[1], < 0.25L from stern
** For doors with low exterior exposure to the elements due to protective structural elements, multiply score by [0.67]. NOTE: There is no reduction credited here because there are very limited protective structural features nearby.				

iii. Downflooding potential

- **Downflooding path**

See discussion for forward doors. Score is 1.0.

- **Size of accommodation space that the doorway leads to**

o [2.0] – more than [50%] of main deck area

iv. Area of operation

o Protected :: [0.75]
o Partially protected :: [1.0]

3. Risk summary and solutions

Table 1 summarizes the analytical framework for characterizing the design technical risk factors associated with the location and use of weathertight doors. The first two columns describe the pathway served by the door, and its purpose and operational function. The next four are individual risk factors, which are to be scored as specified above, with ranges defined by relative severity of the hazard. Aggregated risk scores are in the seventh column.

The table shows four scenarios for both the forward and aft doors. Moving from the leftmost column rightward, the cells first divide to indicate the deck construction options, and then divide again for service in "protected" versus "partially protected" waters.

Table 1 (forward doors)

Pathway || To & From		Purpose and use of door (score [0 – 2])	Door Location (score [0 – 9])	Downflooding Potential		Area of Operation multiplier	Total risk "R" (score [0-30])	Solution(s)
				Downflooding path (score [0 – 6])	Size of space doorway leads to (score [0 - 2])			
Forward doors								
Forward doors, port and starboard	Weather || passenger accomm. space	Embarkation only, closed otherwise (**0.0**)	Door sill less than [8 feet] above WL, facing forward in Position 2 (**4.0**)	Manholes only **(1.0)**	Passenger accomm. space, more than 50% of main deck area **(2.0)**	Protected waters (**0.75**)	**(0 + 4 + 1 + 2) * 0.75 = 5.25**	Passenger embarkation only for a "bow loader": The 4 scores are in the low range. "Floating" deck yields modestly lower risk scores because of DF through manholes is low risk. Additional protective features against water on deck would improve the case for an accessible doorway solution, especially for partially protected water service.
						Partially protected waters (**1.0**)	**(0 + 4 + 1 + 2) * 1.0 = 7.0**	
				"Floating" deck, no DF pathway **(0.0**)		Protected waters (**0.75**)	**(0 + 4 + 0 + 2) * 0.75 = 4.5**	
						Partially protected waters (**1.0**)	**(0 + 4 + 0 + 2) * 1.0 = 6.0**	

Table 1, continued (aft doors)

Pathway || To & From		Purpose and use of door (score [0 – 2])	Door Location (score [0 – 9])	Downflooding Potential		Area of Operation multiplier	Total risk "R" (score [0-30])	Solution(s)
				Downflooding path (score [0 – 6])	Size of space doorway leads to (score [0 - 2])			
Aft doors								
Aft doors, port and starboard	Weather || passenger accomm. space	Embarkation and passenger access to weather deck during voyage (**1.0**)	Door sill less than [8 feet] above WL, facing aft in Position 2 (**1.0**)	Manholes only **(1.0)**	Passenger accomm. space, more than 50% of main deck area (**2.0**)	Protected waters (**0.75**)	**(1 + 1 + 1 + 2) * 0.75 = 3.75**	Accessible embarkation and deck access via the aft doors are appropriate for all scenarios. The low scores in protected waters indicate that with or without a "floating" deck a coaming-less door would be appropriate. For service in partially protected waters, scores are low as well. Without the floating deck, more protection would be needed for an accessible door solution.
						Partially protected waters (**1.0**)	**(1 + 1 + 1 + 2) * 1.0 = 5.0**	
				"Floating" deck, no DF pathway **(0.0**)		Protected waters (**0.75**)	**(1 + 1 + 0 + 2) * 0.75 = 3.0**	
						Partially protected waters (**1.0**)	**(1 + 1 + 0 + 2) * 1.0 = 4.0**	

Doorway Solutions

The roster of possible access enhancement solutions appears below, tied to sub-ranges of total risk scores as shown:

- Weathertight door with no coaming - Aggregate risk score = [0 ≥ R ≥ 4]
- Weathertight door with no coaming with deck drainage arrangement or protective structural features against ingress of exterior water - Aggregate risk score = [4 > R ≥ 8]
- Weathertight door with removable regulation height coaming - Aggregate risk score = [8 > R ≥ 12]
- Reduced height coaming [50%] with sloped[1] deck ramp (grated) and landing at sill height - Aggregate risk score = [8 > R ≥ 16]
- Regulation height coaming with sloped deck ramp and landing at sill height - Aggregate risk score = [16 > R ≥ 20]
- Regulation height coaming, no sloped deck due to water "runup" risk :: Aggregate risk score = [20 > R ≥ 24]

NOTE: Subchapters K and T (46 CFR 116.1160 and 179.360, respectively) allow for substituting a watertight door with a minimal height sill for a weathertight door with a coaming. Such would be appropriate for a door with any risk score, if operation of the door is by crew only (as currently interpreted by Coast Guard) as for use in embarkation/disembarkation only, or if industry develops a watertight door appropriate for operation by passengers.

Based strictly upon the risk scores, the aft doors would appear to be the better choice for passenger access. The scores in both cases are low, however, and an accessible pathway via the bow doors would also be appropriate for the right combination of design features and operation. Note that access through the aft doors to the aft weather deck is required wherever the embarkation point and pathway are sited.

Forward doors

If the desired configuration were a "bow loader" with the forward deckhouse doors used for embarkation only, the choice of a "floating" deck would reduce the risk scores by 0.75 and 1.0 to 4.5 and 6.0, for protected and partially protected waters, respectively. The benefit is modest and does not substantively change the outcome, because the downflooding risk from the closed manholes in the passenger cabin is low to start with.

With or without the floating deck, in protected water service, the solution indicated would be a coaming-less weathertight door (possibly similar to the GH-ICB sliding doors found on the *Flying Cloud*) or a watertight door with minimal height sill, as allowed by the CFR for operation by able-bodied crew. The risk for this design could be further reduced with protective drainage features against water on deck (e.g., the GH-ICB drainage detail for Flying Cloud, Figure 3).

Similarly for partially protected water service, the risk reduction due to the floating deck does not significantly change the outcome. It may be appropriate to replace the weathertight door with coaming with an improved access doorway, for example, a weathertight door with a coaming of reduced height,

[1] Guidance from ADAAG 4.1.6, as follows:
(i) A slope between 1:10 and 1:12 is allowed for a maximum rise of 6 inches.
(ii) A slope between 1:8 and 1:10 is allowed for a maximum rise of 3 inches. A slope steeper than 1:8 is not allowed.

and the *Flying Cloud* drainage detail. Addition of protective structure forward of the door (against water on deck) to reduce the risk appears infeasible because of the access route from bow doors to the deckhouse.

In this example case, the operator and builder would have to consider accessible paths onboard in overall context of the desired operation for the boat (market served, waters served, and shoreside infrastructure and loading mode), the added cost of the floating deck and drainage features. An accessible pathway through the forward doors appears to be feasible, given the correct operational procedures and protective features forward of the doors.

Alternatively, the desired approach in this case may be retaining the forward weathertight doors as designed and providing passenger access via the aft bulwark gates and aft deckhouse doors. In this scenario, the boat would be configured for aft loading and the forward doors would be for crew only access. An improved access doorway could still be installed for future operational flexibility, or the conservative approach taken, that is, a weathertight door with 3" coaming, as designed.

Aft doors

Use of the aft doors for access to the weather deck is required whichever embarkation path is chosen. The floating deck results in scores of 3.0 and 4.0 for the protected and partially protected waters. A coaming-less door would be appropriate in either case, possibly similar to the aft sliding doors on the *Flying Cloud*. For partially protected waters, the score of 5.0 is on the cusp and it might be appropriate to include a protective drainage feature to be on the safe side or a reduced height coaming with ADA-compliant short ramps on either side.

Without the floating deck, the protective drainage feature or a reduced height coaming with ADA-compliant short ramps on either side would be appropriate, especially for partially protected waters.

Scoring methodology comments

The case shows how the builder and operator may have several design and operations decision points in which mobility access is one element in the consideration of cost. In this case, it turns out that the scoring bandwidth for all scenarios is relatively narrow at the low risk end of the range, but that there are several possible solutions.

As for the particulars of the scoring, it is evident that the door location and the size of the accommodation space drive the aggregate score in all scenarios, especially for the forward doors. The floating deck eliminates downflooding paths, but the benefit is modest because the only potential downflooding points in this case are bolted manhole covers leading to tanks and voids; the likelihood of any of those manholes being open during a voyage is slight. The scoring methodology now includes an added field "bolted manholes closed during voyages", scored as [1.0] in this case study. The risk is lower than for a tight door leading to a workspace below but does not equate to the "no pathway" score of [0].

The exposure of the forward doors and the size of the passenger space alone raise the risk score above the lowest category, even for protected water service. The hazard of the forward door location is clear in the science and the regulations. The affected space area metric may bear more scrutiny, but the idea is that it protects against large volumes of entrapped water, should the worst situation occur, that is, a failed door allowing ingress of large amounts of water from waves or heavy spray.

FIGURE 3. DRAINAGE DETAIL, GH-ICB BOAT *FLYING CLOUD*, FORWARD EMBARKATION DOORS

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Numerical risk evaluation, main deck doors, 399 passenger ferry, Casco Bay Line

INTRODUCTION

This paper shows an application of the proposed use of risk indices leading to enhanced doorway access solutions for people with mobility impairments. It is important to note that the risk guidelines are to be carefully applied, on a case by case basis, with sound technical judgment.

The risk values appearing below increase in magnitude with increasing risk and are absolute pre-weighted numbers. The particulars of the case are:

- This is a new design for a Subchapter K boat, capacity of 399 passengers, operating in protected waters (Figure 1: Profile, and Figure 2: Main Deck Plan).
- Sliding weathertight doors on the main deck, port and starboard, for embarkation access, located forward (approximately 0.25L from the bow) at the deck edge.
- Doors have 3" coamings (designed per Subchapter S watertight integrity regulations for vessels less than 100 GT).
- This exercise is to ascertain whether the coamings could be eliminated on a risk management basis as suggested by the Phase 2 report (footnote #1). The designer states that elimination of the coamings at those points would improve embarkation access and simplify the design of the gangways from the shoreside piers used by Casco Bay Line.

APPLICATION

The descriptive language for the risk factors appears verbatim, with gray shading showing the particulars for the subject case and annotations where needed. The risk summation appears in Table 1, followed by a discussion of the possible solutions.

i. Purpose & use of door

- [0] – Open only for embarkation/disembarkation, always closed during voyages
- [1] – Open during voyages for passenger access to weather deck, e.g., "promenade deck", alternate access available
- [2] – Access to evacuation deck, required to be open in emergencies

Figure 1. Casco Bay Line boat –Profile

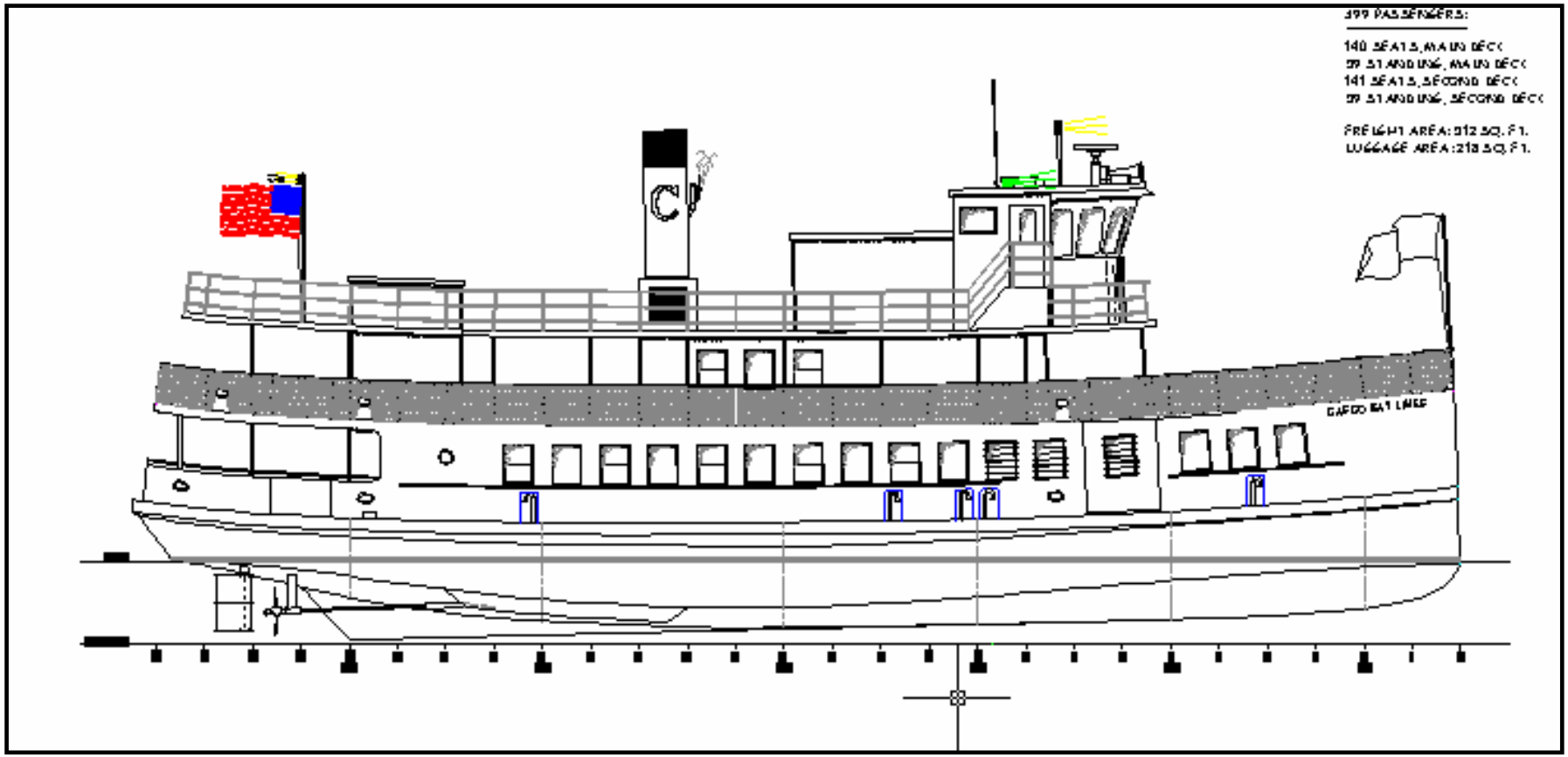
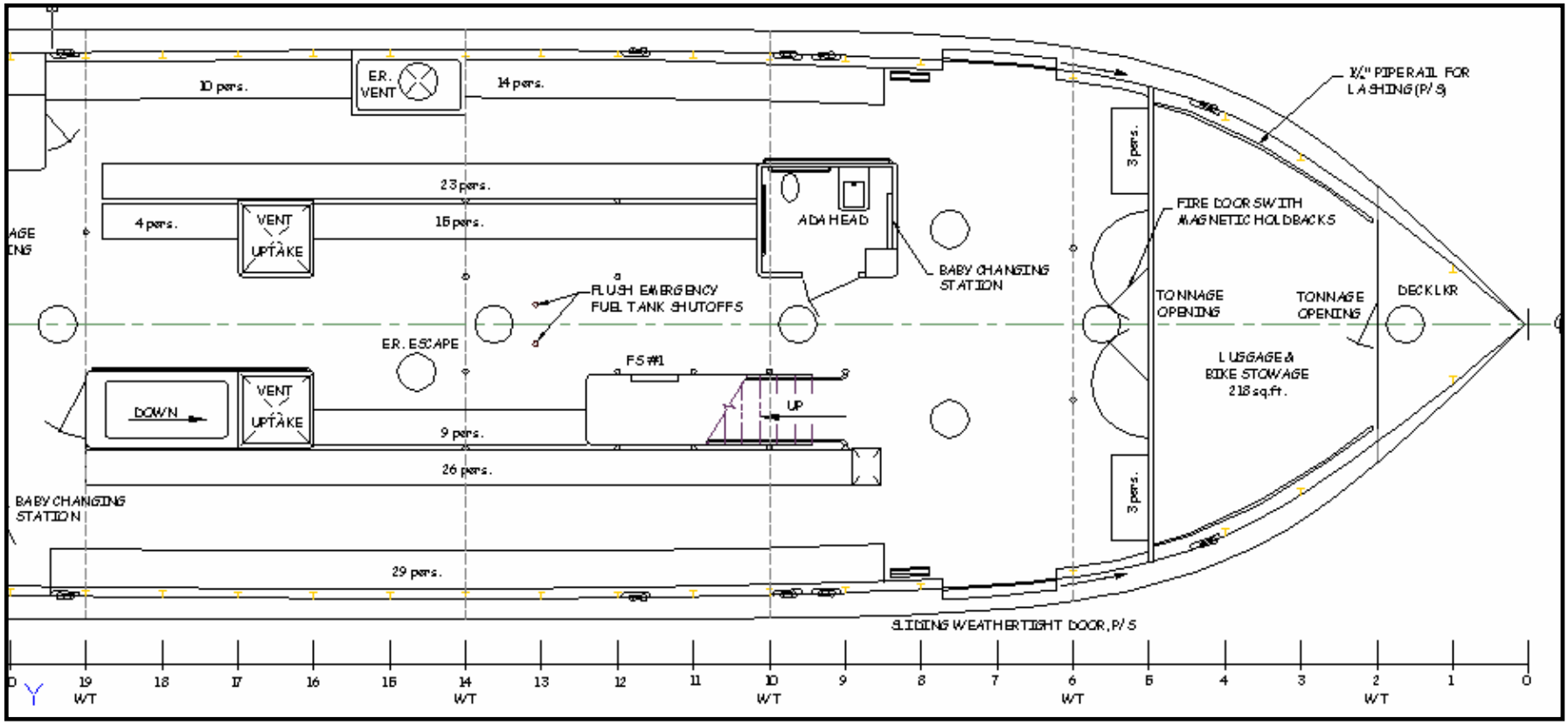


Figure 2. Casco Bay Line boat – Main Deck Plan



ii. Door location

Note: ***"Position 1" is between the bow and the point 0.25L aft of the bow;***

"Position 2" is between the point 0.25L aft of the bow and the stern

Per definition of International Load Line Convention and the Load Line Technical Manual

Risk scores for door position	**Sill < 8 feet above WL**		**Sill >/= [8 feet] above WL**	
	Position 1	**Position 2**	**Position 1**	**Position 2**
Facing outboard *	[2] X [1.5]	[1]	[1]	[0]
* For doors facing outboard, multiply score by [1.5] if the door is within [4 feet] of the deck edge.				
** For doors with low exterior exposure to the elements due to protective structural elements, multiply score by [0.67].				
NOTE: Doors are at 0.25L point. The Position 1 score is assigned as the conservative choice.				

iii. Downflooding potential

- **Downflooding path to lower deck spaces**

Risk scores for downflooding path	**X < [20 feet]**		**X >/= [20 feet]**	
	Y < [2 feet]	**Y >/= [2 feet]**	**Y < [2 feet]**	**Y >/= [2 feet]**
Manholes only	[1]	NA	[0.5]	NA
Protected	[2]	[1]	[1]	[0]
Unprotected	[6]	[4]	[4]	[2]
[0] – no pathway of any kind to watertight spaces below the passenger deck				
Manholes only. Watertight, bolted, flush manholes leading to void spaces, tanks, and unmanned spaces, closed during voyages.				
Protected: Watertight or weathertight closures (doors or hatchways) with coaming at downflooding point(s)				
Unprotected: Joiner doors, ventilation openings to spaces below				
X = distance from door to downflooding point Y = height of downflooding point above deck				

- **Size of accommodation space that the doorway leads to**

  - [0] – less than [25%] of main deck area
  - [1] – between [25%] and [50%] of main deck area
  - [2] – more than [50%] of main deck area

iv. Area of operation

The aggregate scores for the above risk categories should be multiplied as follows for the OCMI designation of waters (that is, for the purposes of the stability regulations) in which the vessel is authorized to operate.

- Protected :: [0.75]
- Partially protected :: [1.0]
- Exposed :: [1.5]

Table 1 summarizes the analytical framework for characterizing the design technical risk factors associated with the location and use of weathertight doors. The first two columns describe the pathway served by the door, and its purpose and operational function. The next four are individual risk factors, which are to be scored as specified above, with ranges defined by relative severity of the hazard.

Table 1's first row shows the door as designed, in its forward position at the deck edge. The second and third rows show the scoring for alternate door arrangements. Discussion of the solutions for these cases appear following Table 1.

Table 1

Pathway || To & From		Purpose and use of door (score [0 – 2])	Door Location (score [0 – 9])	Downflooding Potential		Area of Operation multiplier	Total risk "R" (score [0-30])	Solution(s)
				Downflooding path (score [0 – 6])	Size of space doorway leads to (score [0 - 3])			
Current configuration								
Forward embarkation doors, port and starboard, as designed	Passenger accomm. space	Embarkation only, closed otherwise (**0.0**)	Door sill less than [8 feet] above the main deck, on deck edge, facing outboard in Position 1 (**2.0 X 1.5 = 3.0**)	Protected DF pathway; separation of downflooding point of at least [20 feet] from the door (**1.0**)	Passenger accommodation space, more than 50% of main deck area **(2.0)**	Protected waters (**0.75**)	**(0 + 3 + 1 + 2) * 0.75 = 4.5**	Conservative approach: door with 3" coaming, as designed.
Reconfigurations								
Forward embarkation doors, port and starboard, recessed inboard	Passenger accomm. Space	Embarkation only, closed otherwise (**0.0**)	Door sill less than [8 feet] above the main deck, inboard of deck edge, facing outboard in Position 1 (**2.0**)	Protected DF pathway; separation of downflooding point of at least [20 feet] from the door (**1.0**)	Passenger accommodation space, more than 50% of main deck area (**2.0**)	Protected waters (**0.75**)	**(0 + 2 + 1 + 2) * 0.75 = 3.75**	**Sliding weathertight door with no coaming**
Amidship embarkation doors, port and starboard, at deck edge	Passenger accomm. space	Embarkation only, closed otherwise (**0.0**)	Door sill less than [8 feet] above main deck, on deck edge, facing outbd in Position 2 **(1.0 X 1.5 = 1.5)**	Protected DF pathway; separation of downflooding point of at least [20 feet] from the door (**1.0**)	Passenger accommodation space, more than 50% of main deck area (**2.0**)	Protected waters (**0.75**)	**(0 + 1.5 + 1 + 2) * 0.75 = 3.4**	**Sliding weathertight door with no coaming**

SOLUTIONS

The roster of possible access enhancement solutions appears below, tied to total risk scores as shown:

- Weathertight door with no coaming - Aggregate risk score = [0 ≥ R ≥ 4]
- Weathertight door with no coaming with deck drainage arrangement or protective structural features against ingress of exterior water - Aggregate risk score = [4 > R ≥ 8]
- Weathertight door with removable regulation height coaming - Aggregate risk score = [8 > R ≥ 12]
- Reduced height coaming [50%] with sloped[1] deck ramp (grated) and landing at sill height - Aggregate risk score = [8 > R ≥ 16]
- Regulation height coaming with sloped deck ramp and landing at sill height - Aggregate risk score = [16 > R ≥ 20]
- Regulation height coaming, no sloped deck due to water "runup" risk :: Aggregate risk score = [20 > R ≥ 24]

NOTE: Subchapters K and T (46 CFR 116.1160 and 179.360, respectively) allow for substituting a watertight door with a minimal height sill for a weathertight door with a coaming. Such would be appropriate for a door with any risk score, if operation of the door is by crew only (as currently interpreted by Coast Guard) as for use in embarkation/disembarkation only, or if industry develops a watertight door appropriate for operation by passengers.

Doors as located

The embarkation doors, as designed, scored 4.5, identical for the port and starboard doors. The indication is that a weathertight door without coaming (similar to the type found on the Gladding-Hearn/Incat/Harbor Express boats) would be a suitable solution. However, there would be no exterior drainage or water barrier protection available, given the deck edge location. The conservative approach (or a very conservative OCMI's approach) might dictate retention of the 3" coaming as structural protection and a strong gasketing surface against the unlikely event of wave slapping loads on the door.

Alternately, a very well designed sliding weathertight door with no coaming might avail, if it had the confidence of the designer, inspector, and operator. This prospect is brightened by the facts that 1) the score is close to 0 – 4 threshold, and 2) the doors are in fact AT the 0.25L longitudinal point and therefore at the safer, aft end of the forward, exposed zone.

Door reconfiguration

[1] Guidance from ADAAG 4.1.6, as follows:
(i) A slope between 1:10 and 1:12 is allowed for a maximum rise of 6 inches.
(ii) A slope between 1:8 and 1:10 is allowed for a maximum rise of 3 inches. A slope steeper than 1:8 is not allowed.

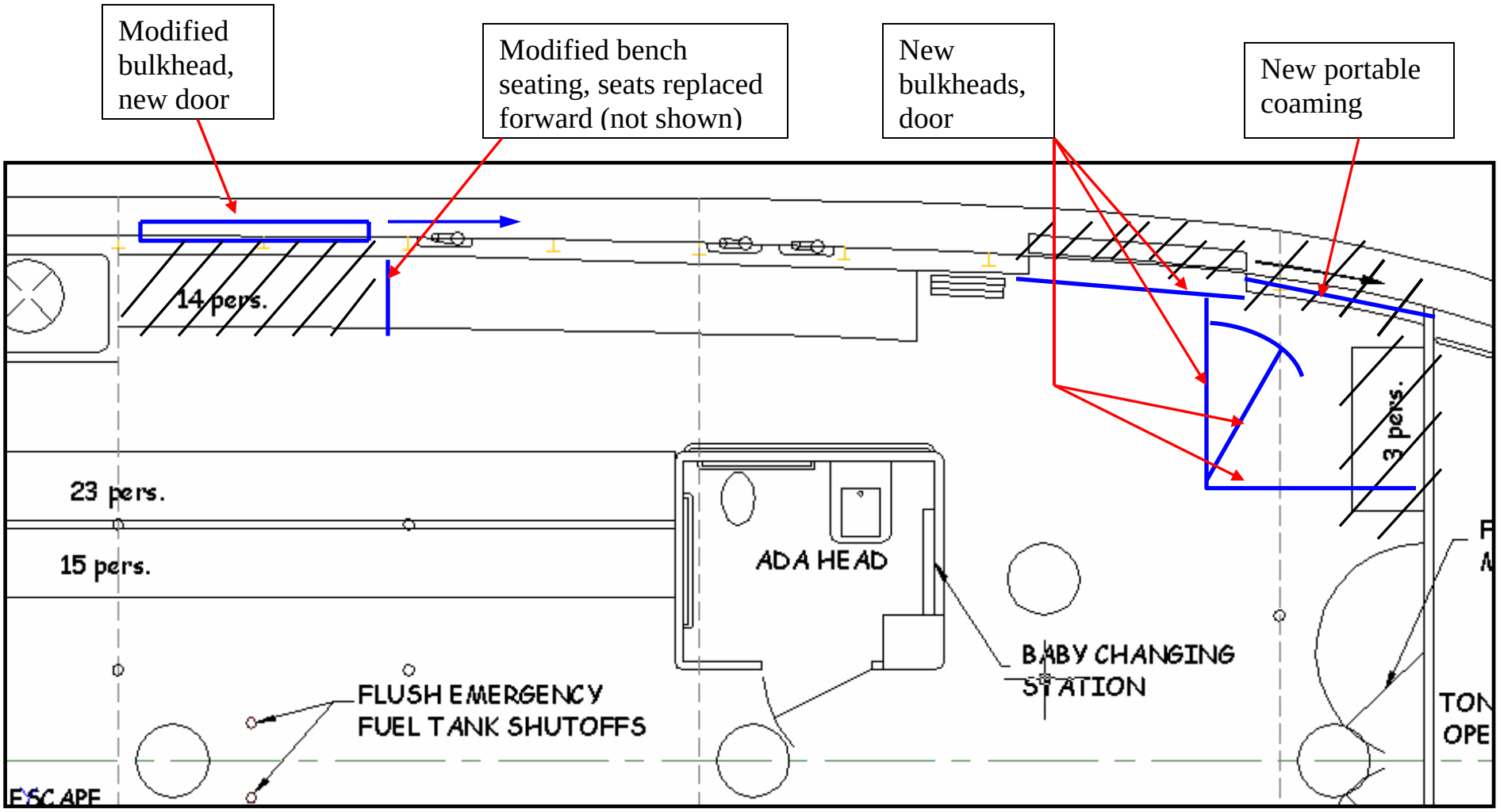
Two possible reconfigurations would lower the risk score to below 4.0 and allow installation of a no coaming weathertight sliding door. In the first case, the doors would remain at Frame 7 with a 48" recess, protective bulkhead forward, and possibly a portable protective coaming at the deck edge while the door is closed. As shown in Table 1, the overall risk score would be 3.75 and the solution would be a weathertight door with no coaming, and the added safety of protective structural features against ingress of exterior water. The impact on the internal arrangement would be the loss of a small bench seat on the aft side of the bulkhead at Frame 5 (6 seats total) and approximately 30 square feet of interior space on each side.

The second would be to move the doors aft, to Frame 13 or so (forward of the engine room vent on the port side), resulting in a score of 3.4, due to the doors' locations further aft. The internal space arrangement modification would be minimal. Bench space lost amidships would be regained forward at the former position of the door.

SCORING METHODOLOGY COMMENTS

The case illustrates how the two "downflooding" subfactors, "distance to downflooding point" and "area of accommodation space", work against each other. Long distances to the downflooding point are more common in large accommodation spaces. At first blush, it seems that rethinking this contradictory linkage is necessary. However, the space area metric also protects against large volumes of entrapped water, should the worst situation occur, that is, a failed door allowing ingress of large amounts of water from waves abeam or heavy spray.

Figure 2. Door reconfigurations.



Numerical risk evaluation, main deck doors, 127'/368 Passenger Dinner Boat, Graul Design

INTRODUCTION

This paper shows an application of the proposed use of risk indices leading to enhanced doorway access solutions for people with mobility impairments, similar to previous cases studies for a Casco Bay Line monohull by Seaworthy Systems and a Gladding Hearn/INCAT Designs catamaran. It is important to note that the risk guidelines are to be carefully applied, on a case-by-case basis, with sound technical judgment.

The particulars of the case are:

- This is a new design for a Subchapter K boat, capacity of 368 passengers, operating in protected waters but designed for partially protected waters (Figures 1 and 2).
- Hinged weathertight doors in the passenger cabin on the main deck, forward to starboard for weather deck access, and aft to port for embarkation and weather deck access.
- Doors have 6" coamings, designed for partially protected waters service per 46 CFR Subchapters K and S watertight integrity regulations for vessels less than 100 GT (Parts 116.1160 and 171.124, respectively).
- This exercise is to ascertain whether the coamings could be eliminated or reduced on a risk management basis as suggested by the proposed approach.

Figure 1. 127’/368 passenger dinner boat, outboard profile

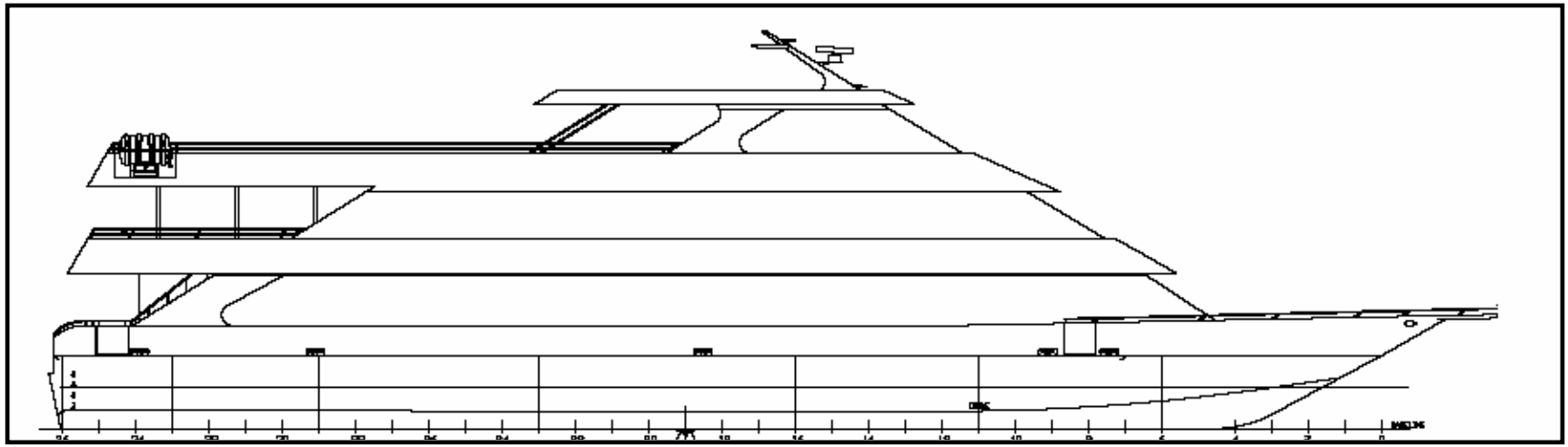
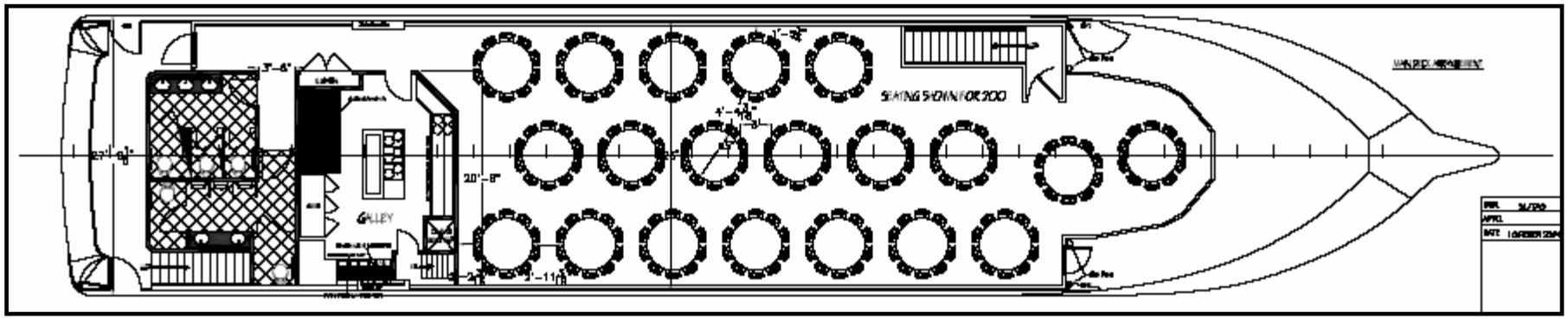


Figure 2. 127’/368 passenger dinner boat, main deck plan



APPLICATION

The selections for the risk factors appear below, shaded gray for the subject case and annotated where needed. The risk summation appears in Table 1, followed by a discussion of the possible solutions.

1. FORWARD DOOR

i. Purpose & use of door

- [0] – Open only for embarkation/disembarkation, always closed during voyages
- [1] – Open during voyages for passenger access to weather deck, e.g., "promenade deck", alternate access available
- [2] – Access to evacuation deck, required to be open in emergencies

ii. Door location

Note: ***"Position 1" is between the bow and the point 0.25L aft of the bow;***
"Position 2" is between the point 0.25L aft of the bow and the stern

Risk scores for door position	**Sill < 8 feet above WL**		**Sill >/= [8 feet] above WL**	
	Position 1	**Position 2**	**Position 1**	**Position 2**
Facing outboard *	[2]	[1]	[1]	[0]
Facing aft	[1]	[2], if < 0.25L from stern; [1], if >/= 0.25L from stern	[0]	[1], < 0.25L from stern
Facing forward	[6]	[4]	[3]	[2]

* For doors facing outboard, multiply score by [1.5] if the door is within [4 feet] of the deck edge.

** For doors with low exterior exposure to the elements due to protective structural elements, multiply score by [0.67]. Discussion in 2.1 cites Subchapter S, K, and T language describing "exposed" locations. Such barriers would need to be in close proximity to the door, and preferably "upstream" in terms of the deck's slope due to sheer and camber.

iii. Downflooding Potential

- **Downflooding path to lower deck spaces**:

Risk scores for downflooding path	**X < [20 feet]**		**X >/= [20 feet]**	
	Y < [2 feet]	**Y >/= [2 feet]**	**Y < [2 feet]**	**Y >/= [2 feet]**
Manholes only	[1]	NA	[0.5]	NA
Protected	[2]	[1]	[1]	[0]
Unprotected	[6]	[4]	[4]	[2]

[0] – no pathway of any kind to watertight spaces below the passenger deck

Manholes only. Watertight, bolted, flush manholes leading to void spaces, tanks, and unmanned spaces, closed during voyages.

Protected: Watertight or weathertight closures (doors or hatchways) with coaming at downflooding point(s)

Unprotected: Joiner doors, ventilation openings to spaces below

X = distance from door to downflooding point

Y = height of downflooding point above deck

- **Size of accommodation space that the doorway leads to**
  - [2] – more than [50%] of main deck area

iv. Area of operation

The aggregate scores for the above risk categories should be multiplied as follows for the OCMI designation of waters (that is, for the purposes of the stability regulations) in which the vessel is authorized to operate. Two cases are considered: 1) protected waters as for current operation; and 2) partially protected, per the weathertight door design in place.

- Protected :: [0.75]
- Partially protected :: [1.0]

2. AFT DOOR

i. Purpose & use of door

- [1] – Open during voyages for passenger access to weather deck, e.g., "promenade deck", alternate access available

ii. Door location

Risk scores for door position	Sill < 8 feet above WL		Sill >/= [8 feet] above WL	
	Position 1	**Position 2**	**Position 1**	**Position 2**
Facing aft	[1]	[2], if < 0.25L from stern; [1], if >/= 0.25L from stern	[0]	[1], < 0.25L from stern
** For doors with low exterior exposure to the elements due to protective structural elements, multiply score by [0.67]. This door is protected overhead by the upper deck's overhang, and from the outboard and aft directions by bulwarks at the deck edge. Use of the multiplier is appropriate. The score for the aft door is therefore: 2.0 X 0.67 = 1.33.				

iii. Downflooding Potential

- Downflooding path to lower deck spaces

Risk scores for downflooding path	X < [20 feet]		X >/= [20 feet]	
	Y < [2 feet]	**Y >/= [2 feet]**	**Y < [2 feet]**	**Y >/= [2 feet]**
Manholes only	[1]	NA	[0.5]	NA
Protected	[2]	[1]	[1]	[0]
Unprotected	[6]	[4]	[4]	[2]
[0] – no pathway of any kind to watertight spaces below the passenger deck				
Manholes only. Watertight, bolted, flush manholes leading to void spaces, tanks, and unmanned spaces, closed during voyages.				
Protected: Watertight or weathertight closures (doors or hatchways) with coaming at downflooding point(s)				
Unprotected: Joiner doors, ventilation openings to spaces below				
X = distance from door to downflooding point Y = height of downflooding point above deck				

- **Size of accommodation space that the doorway leads to**
  - [2] – more than [50%] of main deck area

iv. Area of operation (two cases)

- Protected :: [0.75]
- Partially protected :: [1.0]

Table 1 summarizes the analytical framework for characterizing the design technical risk factors associated with the location and use of weathertight doors. The first two columns describe the pathway served by the door, and its purpose and operational function. The next four are individual risk factors, which are to be scored as specified above, with ranges defined by relative severity of the hazard.

Table 1's first two rows show the doors as designed. The third and fourth rows show the scoring for alternate door arrangements. Discussion of the solutions for these cases follows Table 1.

SOLUTIONS

The roster of possible access enhancement solutions appears below, tied to total risk scores as shown:

- Weathertight door with no coaming :: Aggregate risk score = [$0 \geq R \geq 4$]
- Weathertight door with no coaming with deck drainage arrangement (e.g., "Concept A" or "Concept B" (Appendix A), or Gladding – Hearn drainage detail on *Flying Cloud*), or with exterior water barrier protection :: Aggregate risk score = [$4 > R \geq 8$]
- Removable regulation height coaming, similar to American-Canadian-Caribbean Line boats :: Aggregate risk score = [$8 > R \geq 12$]
- Reduced height coaming [50%] with sloped[1] deck ramp (grated) and landing at sill height :: Aggregate risk score = [$8 > R \geq 16$]
- Regulation height coaming with sloped deck ramp and landing at sill height :: Aggregate risk score = [$16 > R \geq 20$]
- Regulation height coaming, no sloped deck due to water "runup" risk :: Aggregate risk score = [$20 > R \geq 24$]

[1] Guidance from ADAAG 4.1.6, as follows:
(i) A slope between 1:10 and 1:12 is allowed for a maximum rise of 6 inches.
(ii) A slope between 1:8 and 1:10 is allowed for a maximum rise of 3 inches. A slope steeper than 1:8 is not allowed.

Table 1

Current configuration (doors as designed)								
Pathway || To & From		**Purpose and use of door (score [0 – 2])**	**Door Location (score [0 – 9])**	**Downflooding Potential**		**Area of Operation multiplier**	**Total risk "R" (score [0-30])**	**Comments**
				Downflooding path (score [0 – 6])	**Size of space doorway leads to (score [0 - 3])**			
Forward weather deck door, starboard, as designed	Passenger accomm. space	Weather deck access and embarkation (**1.0**)	Door sill less than [8 feet] above the waterline, facing forward, in Position 2 (**4.0**)	Unprotected pathway to watertight spaces below, separation of DF point more than [20 feet] from the door, less than [2 feet] above the deck. **(4.0)**	Passenger accommodation space, more than 50% of main deck area (**2**)	Protected waters (**0.75**)	**(1 + 4 + 4 + 2) * 0.75 = 11 * 0.75 =8.25**	Scores are very close for the two doors. The lower score for the aft location is nearly offset by its proximity to the downflooding point. Scores are of course higher for partially protected waters. Weathertight protection for these doors as designed is appropriate according to the model.
						Partially protected waters **(1.0)**	**11.0 * 1.0 = 11.0**	
Aft weather deck door, port, as designed	Passenger accomm. space	Weather deck access and embarkation (**1.0**)	Door sill less than [8 feet] above the waterline, facing aft, within 0.25L from the stern, with structural protection from water (**1.33**)	Ditto, except DF point is less than [20 feet] from the door **(6.0)**	Passenger accommodation space, more than 50% of main deck area (**2**)	Protected waters (**0.75**)	**(1 + 1.33 + 6 + 2) * 0.75 = 10.3 * 0.75 = 7.75**	
						Partially protected waters **(1.0)**	**10.3 * 1.0 = 10.3**	

Doors as designed

The forward doors, as designed, score 8.25 and 11.0, for protected and partially protected waters service, respectively. The aft door likewise scores 7.75 and 10.3. The indication from the model is that some form of weathertight protection is appropriate especially for partially protected waters service, for which the doors are designed. The deck arrangement precludes relocation or reconfiguration of the doors without serious impact. The reasonable approach must then be to examine reconfiguration or modification of use of other features contributing to the risk score, and perhaps identifying the single best accessible pathway of the two.

Reconfiguration

The best candidate is better protection of the downflooding point and reduction of the score for that risk factor. Replacing the non-weathertight door with a weathertight door with a coaming would significantly reduce the risk. The score for each door would drop from 6.0 to 2.0, as per the revised table below:

Downflooding Path, Revised				
Risk scores for downflooding path	**X < [20 feet]**		**X >/= [20 feet]**	
	Y < [2 feet]	**Y >/= [2 feet]**	**Y < [2 feet]**	**Y >/= [2 feet]**
Manholes only	[1]	NA	[0.5]	NA
Protected	Aft door: [2]	[1]	Forward door: [1]	[0]
Unprotected	~~[6]~~	[4]	~~[4]~~	[2]

See Table 2 for resulting calculations (modified cells are highlighted gray). The aggregate risk scores for the aft door are lowered considerably (4.75 and 6.3), and a weathertight, accessible coaming-less door aft with a protective drainage arrangement appears to be appropriate for both protected waters and partially protected waters service.

The forward door has significantly lowered scores (6.0 and 8.0), but remains in need of protection against water entry. The conservative approach for safety might dictate retention of at least a reduced height (3") coaming as structural protection and designation of the aft door only as accessible for the mobility-impaired. This would provide the embarkation pathway and the accommodation of access to the weather deck. The fore deck would remain available to other passengers for embarkation and access during voyages. There would be benefit to the operator here as well in the reduction of the barrier for able-bodied passengers.

Table 2

Reconfiguration								
Pathway || To & From		**Purpose and use of door (score [0 – 2])**	**Door Location (score [0 – 9])**	**Downflooding Potential**		**Area of Operation multiplier**	**Total risk "R" (score [0-30])**	**Comments**
				Downflooding path (score [0 – 6])	**Size of space doorway leads to (score [0 - 3])**			
Forward weather deck door, starboard, as designed	Passenger accomm. space	Weather deck access and embarkation (**1.0**)	(**4.0**)	Protected pathway to watertight spaces below, separation of DF point more than [20 feet] from the door, less than [2 feet] above the deck **(1.0)**	Passenger accommodation space, more than 50% of main deck area (**2**)	Protected waters (**0.75**)	**(1 + 4 + 1 + 2) * 0.75 = 8 * 0.75 = 6.0**	Scores are very close for the two doors. The lower score for the aft location is nearly offset by its proximity to the downflooding point. Scores are of course higher for partially protected waters. Weathertight protection for these doors as designed is appropriate according to the model.
						Partially protected waters **(1.0)**	**8.0 * 1.0 = 8.0**	
Aft weather deck door, port, as designed	Passenger accomm. space	Weather deck access and embarkation (**1.0**)	(**1.33**)	Ditto, except DF point is less than [20 feet] from the door. **(2.0)**	Passenger accommodation space, more than 50% of main deck area (**2**)	Protected waters (**0.75**)	**(1 + 1.33 + 2 + 2) * 0.75 = 6.3 * 0.75 = 4.75**	
						Partially protected waters **(1.0)**	**6.3 * 1.0 = 6.3**	