ANALYSIS OF THE CHALLENGES ASSOCIATED WITH THE CONDUCT OF MARITIME MASS RESCUE OPERATIONS

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OFFICE OF SEARCH & RESCUE (CG-SAR)
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RICK BUTTON
CHIEF, COORDINATION DIVISION (CG-SAR -2)
OFFICE OF SEARCH AND RESCUE
U.S. COAST GUARD HEADQUARTERS

HAROLD HUNT
MASS RESCUE PROGRAM ANALYST (CG-SAR -2)
OFFICE OF SEARCH AND RESCUE
U.S. COAST GUARD HEADQUARTERS

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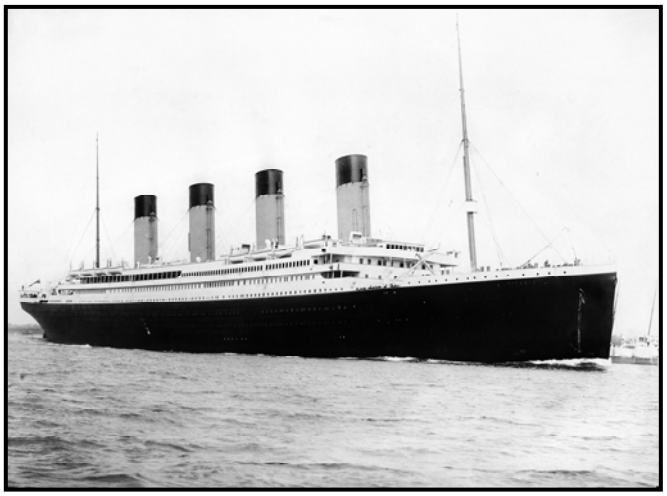
EXECUTIVE SUMMARY

The magnitude of disasters decreases to the extent that people believe that they are possible, and plan to prevent them, or to minimize their effects.

Kenneth E.F. Watt, The Titanic Effect

There has been considerable work accomplished nationally and internationally in improving the safety of passenger ships and aircraft in order to *prevent* maritime disasters. However, disasters still continue to occur every year.

The mass rescue challenge has never been greater, with the continuing increase in the size and number of passenger ships, as well as daily transoceanic passenger aircraft flights. While most disasters have occurred near shore and within range of available Search and Rescue (SAR) facilities, it is the offshore mass rescue risk that continues to be the planning and response challenge in the U.S. maritime SAR regions.



Titanic departing Southampton on its maiden voyage, April 10, 1912. *Titanic* sank after colliding with an iceberg on April 15, 1912, with a loss of 1,502 passengers and crew.
Photo: F.G.O. Stuart

It is true that in most cases a *"passenger ship is its own best lifeboat."* However, there will be disasters in the future in which large numbers of survivors must be rescued. The January, 2012, *Costa Concordia* disaster is an unfortunate example in which thousands of passengers and crew had to abandon ship. What if a *Costa Concordia* type disaster occurred hundreds of miles offshore?

This concern also applies to passenger aircraft. While most passenger aircraft accidents occur during takeoff or landing, there have been instances in which passenger aircraft have had to ditch at sea. Aircraft statistics indicate that when an aircraft must ditch, more than half of the passengers and crew will survive and require rescue. With passenger aircraft now capable of carrying up to 850 passengers, on daily transoceanic flights, there will be incidents in the future in which an aircraft will ditch at sea requiring the rescue of hundreds of survivors.

Search and Rescue (SAR) authorities must be ever vigilant in understanding the risks and planning for the conduct of a Mass Rescue Operation (MRO). While significant planning and preparation continues to be accomplished for responding to a MRO that occurs near the coast and available SAR facilities, it is the *offshore* MRO challenge, a low probability, high consequence disaster, where there are limited available SAR facilities, that SAR authorities must understand, plan for, and effectively *respond* to when it does occur again in the future.

MRO planning relies heavily on available merchant ships to divert and assist in any MRO response, especially a MRO that occurs offshore. However, there are significant challenges

associated with merchant ships conducting rescue operations that must be thoroughly understood by the SAR Mission Coordinator (SMC).

Three recommendations are provided that will contribute to mitigating and potentially reducing the loss of life associated with response to a maritime MRO.

> ***Recommendation #1****: Research, procure and maintain high-capacity MRO lifesaving appliances for rapid air or sea-based deployment to MRO survivors.*
>
> ***Recommendation #2****: Support a multi-year MRO exercise program that includes full scale, table-top and seminar-based MRO exercises on a recurring basis, that incorporates both near and offshore MRO scenarios.*
>
> ***Recommendation #3****: SAR authorities must ensure effective planning is conducted for responding when a maritime disaster occurs offshore requiring a MRO, with other response stakeholders. Personnel in other agencies, as well as industry representatives change over time. MRO coordination and planning must continue to be conducted on a recurring basis.*

INTRODUCTION

"The thing I constantly think about – we were so, so very lucky. The difference between our ship and the Titanic is we weren't caught in the middle of the ocean," said Kajian…. "If we had been caught in the middle of the ocean, most of these people wouldn't have survived."

Mike Kajian, passenger on board Costa Concordia[1]

Offshore maritime Mass Rescue Operations (MROs).

Regardless of the sophistication of passenger ship and aircraft design, regulations, inspections, policies and procedures, SAR authorities and the maritime community continue to respond to disasters at sea where large numbers of people in distress must be rescued. With passenger ships sailing worldwide, and passenger aircraft on daily transoceanic flights, there will always be the risk of a maritime disaster and a MRO occurring. In these maritime disasters, the challenge will be to mount an effective rescue of a large number of survivors in the water or survival craft, a response compounded by weather and sea conditions, hypothermia, as well as the distance from available search and rescue resources.

Despite all the improvements to aeronautical and maritime passenger transportation safety, every year people are lost at sea worldwide.

Through the International Maritime Organization (IMO)[2] and International Civil Aviation Organization (ICAO),[3] the international community continues to work towards improving aeronautical and maritime passenger transportation safety in order to minimize these horrific disasters. Lessons learned from disasters are collected and analyzed. New safety regulations and procedures are adopted and implemented.

Rescue of the passengers and crew from the Passenger Ship *Prinsendam*; October 11, 1980
Photo: U.S. Coast Guard

While these measures are critical in *preventing* or minimizing the impact of a maritime disaster, they still continue to occur.

Responding to a disaster at sea with a large number of survivors and subsequent MRO is a difficult and complex challenge. With the increase in the capacity of passenger ships and aircraft,[4] the challenge has never been greater, especially if a disaster occurs hundreds of miles offshore from the nearest coastal State that can coordinate the response and provide search and rescue resources.

Even if SAR resources are available, is any coastal State really prepared to mount an effective response to a disaster at sea, with possibly *hundreds or thousands* of survivors in the water?

The U.S. Coast Guard has a distinguished 232-year legacy of saving lives at sea, which includes the response to several MROs.[5] Today, the U.S. Coast Guard's lifesaving challenge and

responsibility remains the same concerning MROs: to effectively coordinate and respond when large numbers of persons are in distress. The risk and complexity of the challenge has continued to increase as the number of passenger ships and aircraft used in the transportation of passengers, or in transoceanic flights, as well as the number of passengers carried by these transportation systems, has continued to increase over the years.

Because of the potential, significant loss of life associated with a maritime disaster and subsequent MRO, this paper was developed for two reasons.

First, while considerable work has been accomplished towards *preventing* maritime disasters, the purpose of this analysis is to draw attention to the challenges associated with *conducting* a MRO – *offshore* – the worst case scenario. If SAR authorities can effectively plan, prepare and respond when this low probability, high risk disaster occurs in the maritime environment, then the loss of life can be minimized.

Second, this paper provides SAR authorities and planners an awareness of the challenges that must be considered in planning and responding to a maritime MRO.

It is for these reasons the alarm is being sounded.

In 2012, the U.S. Coast Guard saved over 4,000 lives

A single passenger ship disaster could result in a MRO with over 6,000 survivors. What if this disaster occurred offshore?

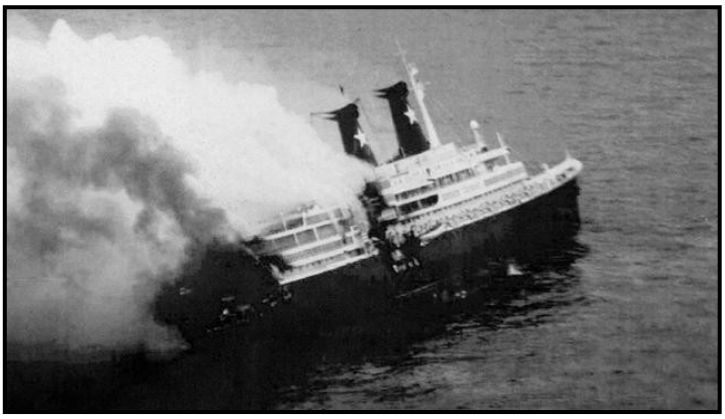
MASS RESCUE OPERATION (MRO)

The IMO/ICAO *International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual* defines a MRO:

> *A mass rescue operation (MRO) is one that involves a need for immediate assistance to large numbers of persons in distress such that capabilities normally available to SAR authorities are inadequate.*[6, 7]

The IAMSAR Manual goes on to describe the worst case MRO scenario:

> *Such incidents might involve hundreds or thousands of persons in distress in remote and hostile environments. A large passenger ship collision, for example, could call for the rescue of thousands of passengers and crew in poor weather and sea conditions, with many of the survivors having little ability to help themselves. Preparedness to mount a large and rapid response would be critical to preventing large-scale loss of lives.*[8]



Aerial view of Italian cruise ship *Achille Lauro*, on fire in the Indian Ocean off the coast of Somalia, taken from a US Navy helicopter, on November 30, 1994
Photo: AFP/Getty Images

In addition, the IAMSAR Manual explains well the scope of the challenge SAR Coordinators[9] have in planning for and responding to a maritime MRO. The key challenges include the following:

1. *MROs are a low-probability, high-consequence event that might result in a large-scale loss of life or serious injury to a large number of people.* If a maritime disaster and subsequent MRO has not occurred in several years, then this type of event can become marginalized in planning. MRO response processes and procedures may take a back seat to other types of events that may occur more often. The consequence to lowering the priority of MRO response planning could be disastrous if and when such an event does occur and SAR authorities are unable to mount an effective response, possibly increasing the number of lives lost.

2. *Capabilities normally available to the SMC would be inadequate in a maritime MRO scenario.* In many SAR operations, merchant ships can be diverted to assist vessels in distress. While these operations are extremely difficult when only a small number of persons may be in distress, the rescue of a large number of persons in distress can be an overwhelming and a nearly impossible challenge for one, or even several merchant ships.[10]

3. *Success often depends on immediate, well planned, and closely coordinated large-scale actions, and the use of resources from multiple volunteers and organizations, both national and international*. In many SAR regions[11] the SAR authorities must rely on other SAR resources, such as Amver[12] to assist persons in distress. These other resources will be critical in the overall response to an offshore MRO. SAR authorities must continue to work together, as well as with other SAR and industry stakeholders and volunteers in planning for and preparing to respond to a maritime disaster and subsequent MRO.

4. *A maritime MRO may require activation of other missions in addition to SAR* (e.g., environmental response, law enforcement, maritime security, etc.).

5. *A maritime MRO will generate intense media interest and scrutiny by the general public*. Information should be provided to the media and public with minimal delay.

MARITIME MROS IN CONTEXT

In order to properly plan and respond to a maritime MRO, the uniqueness of this type of event must be appreciated. Two principles identified below provide a basis for putting in context why it is important to understand the risk, and prepare for and effectively respond to such a disaster.

THE *TITANIC* EFFECT

In 1974, author Kenneth E. F. Watt wrote, *The Titanic Effect: Planning for the Unthinkable*, in which he described possible future economic and energy consumption challenges. Relevant in this analysis of MRO planning and response challenges is Mr. Watt's description of the "Titanic effect" principle:

> *History abounds with parallels of imminent disaster. Public warnings have been ignored when they were outside the range of past experience. Consequently, the appropriate countermeasures were not taken. The Titanic and other "unsinkable" ships that nevertheless went down; the cities built on flood plains; Pearl Harbor and other military "surprises"; hospitals and schools destroyed with great loss of life after repeated warnings of what fire or earthquake might do; these are some examples.*
>
> *There appears to be a basic human tendency to ignore warnings about such possible enormous disasters as "unthinkable." We must understand this tendency and guard against it…. Yet if we examine history, an important generalization, which might be called the "Titanic effect," can be discerned:*
>
> > *THE MAGNITUDE OF DISASTERS DECREASES TO THE EXTENT THAT PEOPLE BELIEVE THAT THEY ARE POSSIBLE, AND PLAN TO PREVENT THEM, OR TO MINIMIZE THEIR EFFECTS.*[13]

Uniquely, Mr. Watt captured the foundational principle for maritime disaster prevention and MRO planning and response. Despite regulatory, safety, training, and shipboard design improvements, the primary premise is that a maritime disaster will occur again and SAR authorities must be prepared to coordinate as well as respond to a subsequent MRO.

This is especially important with the continued increase in the size of passenger ships and aircraft and the locations in which these transportation systems are used in North America.

For example, consider the volume of passengers that take North American cruises. In the fourth quarter of 2011 alone, a record 18.9 million passenger nights were booked on North American cruise ships, up 3.3 percent from a year earlier. For 2011, a total of 71.8 million passenger nights were booked, up 2.8 percent from 2010. In addition, over the last five years, the average size of ships (per cruise) based on passenger occupancy increased by 9.8 percent to 2,301 passengers.[14]

From a maritime MRO response perspective, it is also important to note that passengers traveling on cruises are not limited to a particular geographic location in North America (Table 1 on the next page):

TABLE 1: NORTH AMERICAN CRUISE PASSENGERS BY DESTINATION[15] (THOUSANDS)						
	2011 (QUARTERS)				YEAR	
DESTINATION	1	2	3	4	2009	2011
ALASKA	0	336	548	0	872	884
BAHAMAS	547	575	580	616	1,972	2,318
BERMUDA	0	117	170	50	269	338
CA/NEW ENGLAND	0	41	163	65	276	269
CARIBBEAN	1,973	1,185	903	1,662	5,741	5,722
EASTERN	487	295	227	400	1,656	1,409
SOUTHERN	411	149	75	324	820	958
WESTERN	1,076	741	601	938	3,264	3,355
HAWAII	68	42	34	71	188	215
MEXICO (PACIFIC)	229	156	127	185	878	697
NOWHERE	3	3	0	8	17	14
PACIFIC COAST	0	25	23	4	44	51
S. AMERICA	13	0	0	4	19	17
S. PACIFIC/FAR EAST	4	5	11	6	25	27
TRANSATLANTIC	8	74	43	72	158	197
TRANS-PANAMA CANAL	43	40	15	41	168	139
TOTAL	**2,887**	**2,599**	**2,616**	**2,785**	**10,627**	**10,887**

Even though the maritime community will never be able to completely eliminate the risk of future maritime disasters, IMO and ICAO, SAR authorities, as well as the industry stakeholders will continue to work towards improving safety and preventing these disasters from occurring. Mitigating potential ways that disasters can occur is the essence of the *Titanic* effect.

But this can never limit a SAR authority's requirement for effective planning and the *response* to a future maritime MRO. Just because disasters may be occurring less frequently, or with less extreme impact as the sinking of the *Titanic* or other large passenger ship or aircraft disaster, does not allow for a reduced maritime MRO response posture.

In addition, Mr. Watt provided an important recommendation in preparing for the response to disasters in general, and for this analysis, a maritime MRO in particular:

> *In general, it is worth taking action in advance to deal with disasters. The reason is that the costs of doing so are so typically inconsequential as measured against the losses that would ensue if no such action were taken.*[16]

Mr. Watt is correct when you consider the impact a maritime disaster and subsequent MRO will have if a SAR authority is unprepared or ineffective in conducting a rescue operation. Regardless of how a maritime MRO occurs (i.e., aircraft ditching, fire, collision, grounding, terrorist attack, etc.), the SAR authority will be responsible for implementing plans to coordinate and rescue survivors, regardless of where the disaster occurs in their respective SAR region, or will support of other international SAR authorities.

SAR authorities must develop appropriate regional and risk specific plans and procedures, as well as foster support and response relationships with other SAR organizations and industry stakeholders, so that when a maritime disaster occurs, we can "minimize their effects."

BLACK SWAN

More than three decades after the publication of *The Titanic Effect*, in 2007, author Nassim Taleb wrote the New York Times best seller, *The Black Swan: The Impact of the Highly Improbable*.[17] Mr. Taleb's work was extremely important in describing how history generally moves forward, not in a gradual incline, but in singular events that are outside the expected; unpredictable events with massive impact that make history. These unpredictable events are known as "Black Swans" – events that are unforeseen and point to the limits of human knowledge:

> *Before the discovery of Australia, people in the Old World were convinced that all swans were white, an unassailable belief as it seemed completely confirmed by empirical evidence. The sighting of the first black swan might have been an interesting surprise for a few ornithologists (and others extremely concerned with the coloring of birds), but that is not where the significance of the story lies. It illustrates a severe limitation to our learning from observations or experience and the fragility of our knowledge. One single observation can invalidate a general statement derived from millennia of confirmatory sightings of millions of white swans. All you need is a single… black bird.*[18]

Maritime MRO disasters are examples of Black Swan events.

Mr. Taleb describes three criteria that define a Black Swan:

1. BLACK SWANS ARE OUTLIER EVENTS.

In statistical probability, an outlier is a data point that significantly deviates from the rest of the data;[19] a rare event that "lies outside the realm of regular expectations."[20]

Maritime disasters that result in a MRO can be statistically considered outlier events: low-probability, high-consequence disasters that infrequently occur. However, even with the work accomplished in developing new international and national safety regulations and shipboard system improvements, maritime disasters will still continue to occur.

As a result, effectively planning the *response* to maritime MROs, even though considered an outlier event, is critical. The consequences of unpreparedness in the SAR response to a maritime MRO can be exacerbated by the lack of planning. Preparation and planning, in particular for maritime disaster that may occur offshore, must be a priority in any maritime MRO analysis.

2. BLACK SWANS WILL HAVE A MAJOR IMPACT.

Maritime disasters that include a significant loss of life, historically, have been the impetus for changing both national and international maritime regulations. Table 2 below details maritime disasters and the response to improve safety after the disaster occurred.

TABLE 2: EXAMPLES OF THE IMPACT OF MARITIME DISASTERS[21, 22]

DATE	DISASTER	OUTCOME
15 Apr 12	*Titanic*: Ocean liner sunk after striking an iceberg	1914: International Convention for the Safety of Life at Sea (SOLAS) was established. Required ships to carry enough lifeboats for all persons on board.
29 May 14	*Empress of Ireland*: Struck another vessel and sank; 1,012 people died.	Disaster led to widespread changes to the design of ships bows ("raked" bows) to reduce the amount of damage cause in the event of a collision.
08 Sep 34	Morro Castle: Fire resulted in the death of 137 people.	Merchant Marine Act was passed in 1936; U.S. Merchant Marine Academy was established in 1942.
06 Mar 87	*Herald of Free Enterprise*: Capsized with 193 deaths.	Led to development of SOLAS amendments regarding ships transporting passengers and vehicles; accelerated the adoption of provisions aimed at further improving passenger ship stability.
28 Sep 94	*Estonia*: Capsized with 852 deaths.	In 1997, passenger ships carrying 400 persons or more had to comply with the requirements initially only imposed on ferries to avoid capsizing even when the main compartments flood.
23 Mar 06	*Star Princess*: Fire damage 150 cabins with 1 death and 13 injured.	In 2010, new SOLAS regulations were introduced to prohibit the use of combustible materials in new cruise ships.

As demonstrated in Table 2 above, new regulations based on previous maritime disasters will never completely ensure that maritime disasters will not occur again. Reviewing historical trends does help to isolate where new regulations and requirements can target specific safety gaps, but will not predict if and when the next maritime disaster will again occur.

3. BLACK SWAN EVENTS BECOME EXPLAINABLE AND PREDICTABLE… AFTER THE FACT.

Analysis of any disaster will provide conclusions and implementation of new safety regulations, development of new, mandated safety equipment, improved design and construction, etc. All of these efforts will be beneficial.

However, even as attempts are made to understand how an accident occurred and what can be done to prevent disasters in the future, disasters will continue to occur because of *human error*:

Over the last 40 years or so, the shipping industry has focused on improving ship structure and the reliability of ship systems in order to reduce casualties and increase efficiency and productivity. We've seen improvements in hull design, stability systems, propulsion systems, and navigational equipment. Today's ship systems are technologically advanced and highly reliable.

Yet the maritime casualty rate is still high. Why? Why is it, with all these improvements, we have not significantly reduced the risk of accidents? It is because ship structure and system reliability are a relatively small part of the safety equation. The maritime system is a people system, and human errors figure prominently in casualty situations. About 75-96% of maritime casualties are caused, at least in part, by some form of human error.[23]

Just moments after leaving port in Zeebrugge, Belgium, enroute to Dover, England, the *Herald of Free Enterprise* roll-on, roll-off car and passenger ferry capsized on March 6, 1987, killing 193 people. The ferry sank because the inner and outer bow doors were left open on departure, due to a combination of factors and decisions, which could have been avoided.[24]
Photo: Rousseau/Keystone/Hulton Archive/Getty Images.

Even though Black Swan events may be explainable after the fact, and lead to needed improvements to continue preventing these disasters in the future, they will still occur. This is because passenger ships and aircraft are "people operated and maintained" transportation systems. So long as people continue to be an integral component of complex ship and aircraft systems, errors will occur that can lead to future maritime disasters requiring a MRO response.

This is the essence of a Black Swan event: outlier, significant impact, explainable after the fact.

In summary:

- The *Titanic* effect provides an important principle in MRO planning: Anticipate that a maritime disaster that will require a MRO will occur again in the future. SAR authorities must plan for the event to minimize the effect.

- The Black Swan criterion provides SAR authorities with a framework for understanding the MRO challenge.

FRAMING THE MRO ISSUE

SAR authorities must be prepared to respond to a maritime disaster and MRO offshore – the worst case scenario, in which there may be a large number of survivors in the water, or survival craft that must be rescued and delivered to a place of safety.[25]

This analysis was developed from reviewing previous MROs worldwide, examining response activities and reviewing requirements of potential response interventions. The authors reviewed incident records, lessons learned, MRO scenario-response exercises with information about incidents, persons affected, persons rescued, rescue resources, rescue activity and the degree of success, and rescue gaps and successes.

ASSUMPTIONS

For this analysis, the following assumptions are made concerning maritime MROs:

1. For the United States, a MRO involving a large passenger ship or aircraft will again occur in the Atlantic and/or Pacific maritime SRRs and will require the rescue of a large number of survivors.[26]

2. In the U.S. SAR regions, the U.S. Coast Guard will most likely assume SAR Mission Coordinator (SMC) of the disaster and be responsible for the coordination of the response.[27]

3. A MRO that occurs potentially hundreds of miles offshore will severely limit the number of SAR facilities[28] available to respond to a large scale rescue operation.[29]

Survivors from the sinking of the Passenger Ferry
Rabaul Queen
February 2, 2012

4. It is not likely that a SAR authority will independently have the necessary resources to rescue possibly thousands of survivors that may be in the water or survival craft and must rely on assistance from other available SAR facilities from other SAR authorities, commercial ships and other volunteers in the vicinity.

5. Multiple survivors with life threatening injuries may require immediate medical attention or transportation to medical facilities.

6. MRO survivor retrieval to any height above water is difficult.[30]

QUANTIFYING MRO RISK

U.S. Coast Guard, other SAR authorities, local communities and industry stakeholders face different maritime MRO challenges based on passenger ships and aircraft traffic, environmental considerations, distance event occurs from shore, etc. Every maritime SAR Region differs in the capabilities available to respond to a MRO. In order to better understand the associated MRO risks in U.S. maritime SAR regions, in 2006, the U.S. Coast Guard Research and Development Center (RDC), in coordination with the U.S. Coast Guard Office of Search and Rescue, began to identify potential gaps in MRO planning. As a result this effort, in 2007, the RDC completed a *Mass Rescue Operations Scoping Study* (MROSS).[31] This scoping effort included a historical review of past MRO incidents, as well as an assessment and analysis workshop attended by safety, response, and transportation professionals. The historical review identified past MRO incidents, and provided data on the frequency and consequences of these incidents, as well as on the effectiveness of U.S. Coast Guard response efforts. As stated in the Executive Summary, the MROSS concluded in part that:

> *"…the MRO scenarios of greatest interest to the USCG are those that involve vessels carrying a large number of passengers. In these scenarios, the condition of the vessel, the distance from shore, and the severity of the environment are key factors in determining the level of difficulty of the response. Primary areas of concern are: Adequacy of evacuation equipment and procedures aboard the distressed vessel (especially a non-SOLAS passenger vessel subject to less-stringent regulations); ability to provide survival platforms when the survival capability aboard the vessel is compromised; ability to retrieve a large number of people from the water; and ability to evacuate a large number of people from the vessel."*[32]

The MROSS recommended development of equipment or techniques to effect rapid evacuation and rescue of multiple survivors.

In 2012, the U.S. Coast Guard conducted a review of the 2007 MROSS. An informal risk assessment utilizing the same scenarios from the 2007 MRO Scoping Study was conducted to draw a comparison and examine the risk posed, but more importantly to see if any changes had occurred.

After five years, the 2012 analysis revealed that the greatest concern and the number one risk posed to the U.S. Coast Guard, industry and community stakeholders remained the same as identified in the 2007 MROSS: *a domestic passenger vessel requires evacuation*. In all likelihood, this was due to the three major reasons cited in the original study being:

- Limited numbers of crewmembers trained in vessel evacuation;
- Limited evacuation information provided to passengers; and
- Less-stringent requirements for safety equipment aboard smaller vessels and vessels not required to comply with the Safety of Life at Sea (SOLAS) Convention.

Table 3 on the next page shows the 2007/2012 resulting risk based ranking of mass rescue incident scenarios.

TABLE 3: MASS RESCUE OPERATIONS SCOPING STUDY (2007/2012)		
SCENARIO	**2007 RANKING**	**2012 RANKING**
Domestic passenger vessel requires evacuation	1 (tie)	1
Large vessel sinks, passengers and crew must be located and rescued	1 (tie)	4
Natural disaster requiring air, land, sea rescue	3	2 (tie)
Major casualty aboard cruise ship requires evacuation	4 (tie)	6
Rescue and interdiction of large number of refugees/illegal immigrants	4 (tie)	7 (tie)
Airliner crash requiring passenger extrication and water rescue	6	5
Rescue of people from collapsed or burning waterfront building or facility	7	10
Rescue of individuals necessitated by bridge collapse or train derailment	8 (tie)	11
Small MRO (above local capability)	8 (tie)	2 (tie)
Rig sinks; crew must be located and rescued	10	12
Waterborne evacuation necessitated by large-scale terrorist action, industrial accident, natural disaster, or nuclear/biological incident	11	9
Rescue of individuals stranded on an ice floe or on a ship beset in ice	12	13
Rescue of large number of people from flooded (or flooding) tunnel or other need for rescue	13	7 (tie)

The following observations can be made from the comparison of the 2007 and 2012 MROSS information:

- The three scenarios: 1) *"Airliner crash requiring passenger extrication and water rescue;"* 2) *"Major casualty aboard cruise ship requires evacuation;"* and 3) *"Large vessel sinks, passengers and crew must be located and rescued,"* remained in the top six MRO challenges to be faced by the U.S. Coast Guard, which is in alignment with the issues that must be addressed in an MRO that occurs offshore. This was consistent both in 2007 and in 2012.

- In 2007 the two MRO scenarios: 1) *"Large vessel sinks, passengers and crew who must be located and rescued;"* and 2) *"Domestic passenger vessel requires evacuation,"* were both considered number one (tied), and in 2012 were ranked number 4. While still considered the fourth most important MRO challenge, it is the least understood and planned for, especially in an offshore situation with limited U.S. Coast Guard SAR facilities available to assist in the rescue operation.

- What the 2007 MROSS and 2012 review did *not* specifically consider, is the *distance* offshore any of these events could occur. Regardless of the type of MRO, the farther offshore from available SAR facilities the incident occurs and the more adverse the environmental conditions (i.e., sea water temperature, sea state, wind, etc.), the greater

the challenge the U.S. Coast Guard will have in coordinating the response and conducting a mass lifesaving operation, *regardless of the MRO type*.

While the other MROSS scenarios identified should be considered in U.S. Coast Guard MRO planning (as well as considered in planning by other SAR authorities) the purpose of this analysis will be to focus on passenger ship and aircraft MROs that may occur offshore.[33]

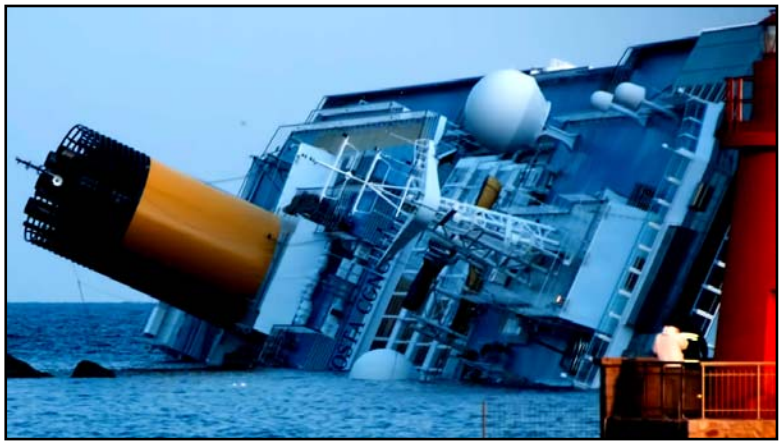
MRO PLANNING FACTOR: LOCATION

From a response perspective, in addition to the number of persons in distress, environmental considerations and other factors to be considered in the planning and conduct of a MRO, the distance from available shore-based SAR facilities must be considered one of the most critical.

MROS NEAR SHORE

While this analysis' emphasis is on the challenges in responding to an "offshore" maritime disaster and MRO, planning using the Territorial Sea can be an effective guide for MRO near shore planning. [34] Within 12 miles of shore, additional SAR facilities from other SAR authorities, commercial shipping and volunteers can be utilized in the MRO response, especially if the incident occurs in well traveled sea lanes, traffic separation schemes, or in the vicinity of a major port. Depending on the location of the incident and the time required for SAR facilities to arrive on scene, the loss of life in a near-shore MRO can be minimized. While weather and sea state will also be critical factors,[35] how close to shore a maritime disaster occurs is a critical factor in a successful multi-agency response with multiple SAR organizations, volunteers and industry partners.[36]

The January 13, 2012, grounding of the cruise ship *Costa Concordia* is a recent example of a near-shore MRO that occurred in near ideal environmental circumstances.[37]



Cruise Ship *Costa Concordia* – Aground
January 14, 2012
Photo: Roberto Vongher

Although the grounding occurred at approximately 9:45 PM, most of the 4,252 passengers and crew on board were able to abandon ship in survival craft, or were rescued by responding vessels and the Italian Coast Guard. Those that were in the water were able to swim ashore. While the *Costa Concordia* disaster did tragically end with loss of life, when the large number of passengers and crew on board are considered, the outcome could have been much worse if the ship had to be abandoned offshore, where thousands of survivors would be in the water or survival craft requiring rescue.

MROs Offshore

If a maritime disaster and MRO occurred further offshore (e.g., international waters[38]), SAR facilities that could have assisted in a near shore MRO may be unavailable to assist in the offshore response. Add any inclement weather and sea state challenges to an incident and the pool of available SAR resources, again as in the case of a near-shore MRO, shrinks considerably.

Prinsendam lifeboat with survivors; October 11, 1980
Photo: U.S. Coast Guard

Aeronautical SAR facilities, both fixed and rotary wing, will be critical in any near shore or offshore MRO response. Helicopters, in particular, have greater speed, but have different weather constraints as vessels.[39] However, helicopters are limited by the duration they can remain on scene and by the number of survivors that can be rescued. In an offshore MRO with potentially thousands of survivors, *relying* on helicopters as the primary means of rescue will significantly extend the length of the response and could potentially increase the number of fatalities.[40]

Depending on geographical location, other aeronautical SAR resources (i.e., long range refuelable SAR helicopters) may be available to assist in an offshore MRO as well.

Fixed wing SAR facilities will be critical in an offshore MRO response. Fixed wing aircraft, while not being able to rescue survivors, can assist as On Scene Coordinator (OSC),[41] deploy rafts, data marker buoys (DMBs), and coordinate on scene communications.

In addition, any vessels that can assist in the response, whether belonging to a SAR authority, military, commercial ships or recreational vessel, all will be critical in saving lives in both near and offshore MROs.

Location is an important element in planning and responding to a maritime disaster and subsequent MRO.

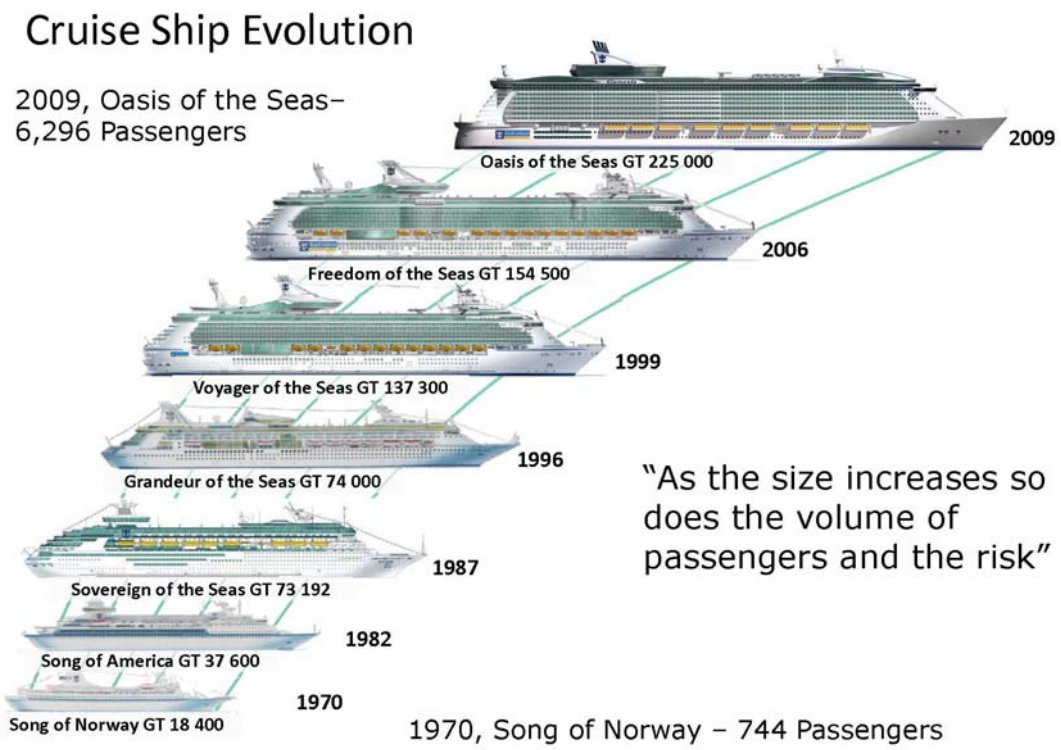
PASSENGER SHIPS

Most of the information and lessons learned obtained from previous MROs and MRO exercises is based on incidents that occurred *near shore* – the MRO *best case* scenario – where SAR resources can quickly arrive on scene and conduct the rescue operation. The emphasis of this analysis is to discuss the challenges associated with responding to a large passenger ship or aircraft MRO *offshore*.

HISTORY AND OVERVIEW

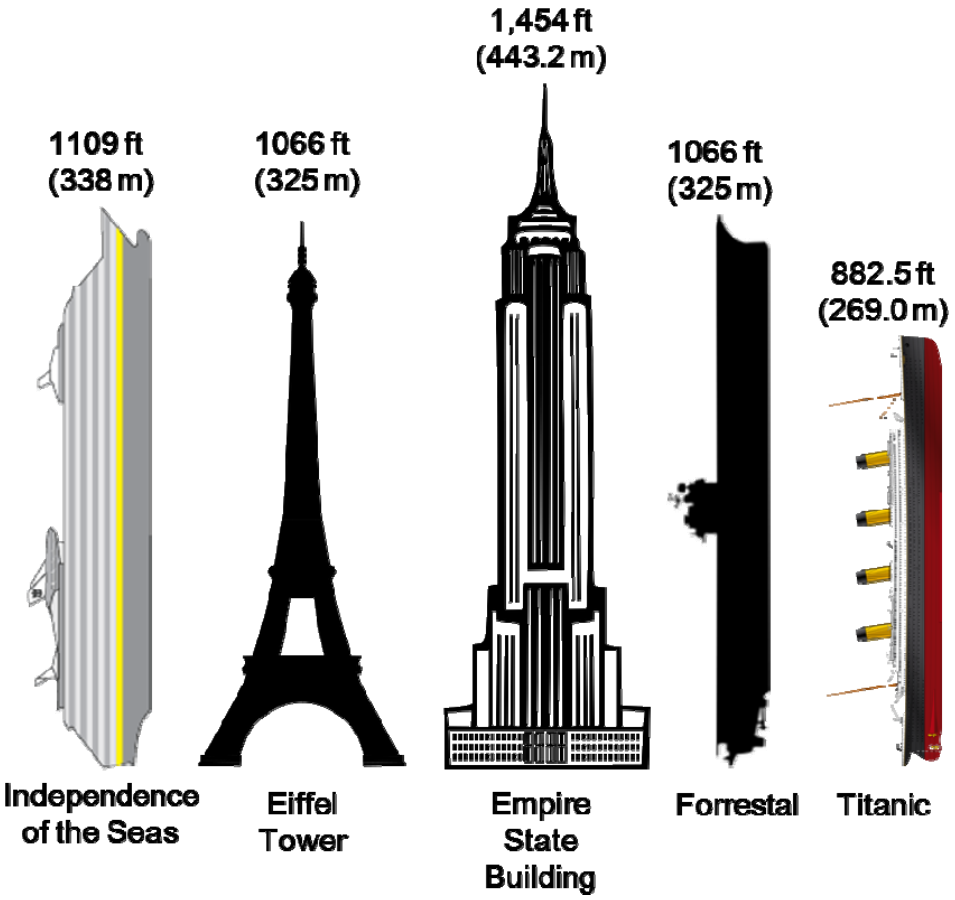
Since the earliest commercial cruises offered in the 1840s, passenger ships have changed beyond recognition and evolved into one of the world's most sophisticated, specialized, complex, and expensive type of vessel.

Many modern passenger ships exceed 100,000 tons and carry thousands of passengers and crew.[42] The challenge for SAR authorities is to consider the types and sizes of passenger ships that transit the U.S. SAR regions and in planning for a maritime MRO.



Cruise Ship Evolution
Photo: U.S. Coast Guard

The number of passenger ships has continued to rise with more new ships built and planned, carrying more passengers than ever before.[43] For example, in 2013, it is anticipated that five new passenger ships will be delivered, each capable of carrying from 516 to 3,600 passengers.[44]



Cruise Ship Size Comparison
Photo: U.S. Coast Guard

When discussing MROs and the challenges associated with the response to large scale disasters at sea, the significance of the continued increase in size of large passenger ships cannot be overstated. While the passenger ship industry is extremely safe, with millions of passengers taking cruises every year, the implications for SAR authorities if a passenger ship must be abandoned at sea are enormous. While the industry is safe, disasters have occurred and will occur again (Table 4). SAR authorities must understand the risks and develop response plans for when this disaster does occur.

WHAT ABOUT PASSENGER FERRIES?

In the U.S., passenger ferries are legally defined two ways:

1. 46 United States Code (USC) § 2101:

…a vessel that is used on a regular schedule – a) to provide transportation only between places that are not more than 300 miles apart; and b) to transport only – i. Passengers; or ii. Vehicles, or railroad cars, that are being used, or have been used, in transporting passengers or goods.

2. 46 Code of Federal Regulations (CFR) 175.400:

   …a vessel that 1) operates in other than ocean or coastwise service; 2) has provisions only for deck passengers or vehicles, or both; 3) Operates on a short run on a frequent schedule between two ports over the most direct water route; and 4) offers a public service of a type normally attributed to a bridge or tunnel.

Passenger Ferry *Andrew J. Barberi*
Photo: Troels Jepsen.

According to the *National Census of Ferry Operators 2008*, in 2007 a typical ferry in the U.S. territorial sea had a median passenger capacity of 149; however, individual ferry capacity ranged from 2 to nearly 6,000 passengers as carried by the Staten Island Ferry, *Andrew J. Barberi*. In 2007, there were almost 700 ferries transporting an estimated 106 million passengers every year. It is significant that the annual number of ferry passengers exceeds the number of cruise ship passengers by almost 10 to 1.[45]

As can be demonstrated from Table 4, passenger ferry disasters worldwide cause significant numbers of deaths, requiring SCs to assess the risk and plan for a MRO response when these maritime disasters do occur. Regulations preventing overcrowding and ensuring the proper safety equipment is on board and usable must become a priority.

In the U.S., there will always be a risk of a ferry disaster that will require the planning and conduct of a MRO response. Local plans and coordination between U.S. Coast Guard Districts and Sectors with other Federal Agencies, as well as State and local SAR authorities and industry stakeholders must continue to be developed and improved.

Passenger Ferry *M. V. Taqwa* with thousands of passengers.
Photo: HNC Ferries

TABLE 4: PASSENGER SHIP AND FERRY INCIDENTS (1980-PRESENT)					
DATE	SHIP'S NAME	TYPE OF SHIP	LIVES ONBOARD	LIVES LOST	SUMMARY
04 Oct 80	*Prinsendam*	Passenger Ship	525	0	Sank following a fire in the Gulf of Alaska. All passengers and crew were rescued.
31 Aug 86	*Admiral Nakhimov*	Passenger Ship	1,234	448	Collided with merchant ship in the Black Sea, both ships sank.
20 Dec 87	*Doña Paz*	Passenger Ferry	>4,000	4,341 (est.)	The world's worst peacetime ferry disaster. While traveling from Leyte island to Manila, Philippines; collided with *M/V Vector*; resulted in a fire and sinking of the Doña Paz.
07 Apr 90	*Scandinavian Star*	Pass/Car Ferry	UNK	159	Fire on board.
04 Aug 91	*Oceanos*	Passenger Ship	571	0	Sank off South Africa's eastern coast. All persons on board were evacuated by helicopter.
17 Feb 93	*Neptune*	Passenger Ferry	1,200 (est.)	900 (est.)	Overloaded vessel sank in a storm while transiting to Port-au-Prince, Haiti.
28 Sep 94	*Estonia*	Pass/Car Ferry	989	852	Sank during a storm in the Baltic Sea.
30 Nov 94	*Achille Lauro*	Passenger Ship	1,090	2	Fire off the coast of Somalia; ship was abandoned and sank on 02 Dec 94.
21 May 96	*Bukoba*	Passenger Ferry	UNK	>800	Sank in Lake Victoria killing more than 800 people.
26 Sep 02	*Le Joola*	Passenger Ferry	UNK	1,863 (est.)	Capsized off Gambia in a storm while carrying more than three times its capacity of 580 passengers.
03 Feb 06	*al-Salam Boccaccio 98*	Pass/Car Ferry	1,408 (est.)	>1,000	Sank in the Red Sea enroute southern Egypt from Duba, Saudi Arabia.
23 Mar 06	*Star Princess*	Passenger Ship	3,813	1	Fire caused damage to 150 cabins, killing 1 person and injuring 13 others.
05 Apr 07	*Sea Diamond*	Passenger Ship	1,558	2	Sank after running aground near the Greek island of Santorini the previous day; of the 1,195 passengers on board, two were missing and presumed dead.
23 Nov 07	*Explorer*	Passenger Ship	154	0	Sank near the South Shetland Islands after striking an iceberg; all 154 persons on board were evacuated.
21 Jun 08	*Princess of the Stars*	Passenger Ferry	747 (est.)	800 (est.)	Capsized off the coast of San Fernando, Romblon, at the height of Typhoon Fengshen.
08 Nov 10	*Carnival Splendor*	Passenger Ship	4,500 (est.)	0	Engine room fire resulting in a complete power loss; towed to San Diego.
15 Apr 11	*Ocean Star Pacific*	Passenger Ship	748	0	Engine room fire; All persons on board were evacuated off the ship.
15 Sep 11	*Nordlys*	Passenger Ship	252	2	Engine room explosion and fire killed two; ship was evacuated at Hurtigruten, Norway
13 Jan 12	*Costa Concordia*	Passenger Ship	4,252 (est.)	30	Partially sank, ran aground at Isola del Giglio, Tuscany
NOTE: LIST DOES NOT INCLUDE ALL INCIDENTS IN THE SAME TIMEFRAME, BUT ONLY A REPRESENTATIVE SAMPLE.					

However, for this analysis, the emphasis is on an *offshore* MRO, where by definition passenger ferries normally do not transit. As a result, this report will focus on both passenger ships (e.g., cruise ships) and aircraft that transport passengers in and over international waters.

PASSENGER SHIP MRO CHALLENGE

> *Evacuating thousands of passengers at sea is everybody's worst nightmare. Maybe we need to rethink our approaches to evacuation. Will we ever reach a point at which passenger safety is no longer facilitated by having more lifeboats lining longer rails ever higher above the waterline? Are better lifeboats and stronger davits really the answer? How else could people be evacuated? I can tell you right now that the Coast Guard doesn't have the platforms to do the job, but we do have to figure something out.*
>
> *Admiral James M. Loy, Commandant, U.S. Coast Guard*
> *Speech given at SeaTrade Cruise Ship Conference, Miami, Florida, March 6, 2001*

Other than the maritime disaster and subsequent MRO risk from the increase in the number of passenger ships, the increase in the number of passengers and crew carried on passenger ships and the locations passenger ships transit globally, has anything really changed since 2001 when Admiral Loy delivered the above speech?

A maritime disaster that requires evacuation of a large passenger ship (or passenger aircraft) with a large number of survivors would almost certainly overwhelm available SAR resources anywhere. While the probability of such a disaster is low, the magnitude of the potential consequences is great. A SAR authorities obligations under IMO's SOLAS[46] and Maritime SAR[47] Conventions dictate that adequate SAR arrangements are developed to coordinate an effective response to such a disaster within a respective SAR authorities maritime SAR region(s).

While it is true that in most cases a *"passenger ship is its own best lifeboat,"*[48] there will be disasters in which large numbers of survivors must be rescued.[49] The greater challenge is when the survivors must immediately abandon ship into the water, or clinging to floating wreckage, and getting them out of the water. These survivors are less able to help themselves than if they were in a survival craft; nor will they survive long.[50]

The question is: How will a SAR authority coordinate and respond to a maritime disaster and MRO with a large number of persons in the water or survival craft?

Sinking of the Passenger Ship *Explorer*; all 154 persons on board were evacuated to another cruise ship in the vicinity.
November 23, 2007
Photo: Reinhard Jahn

PASSENGER AIRCRAFT

The year 2012 was an extremely safe year for civil aviation… In fact, 2012 was the safest year since 1945 by number of accidents. The number of accidents involving passenger flights was the lowest since 1945: 11 accidents, as compared to the ten-year average of 16 accidents.

Aviation Safety Network

The airplane has revolutionized the way travel is conducted. For thousands of years, humans have wished to fly, and finally, in the last century, the dream became a reality.

In the United States, the first passenger airline was started by Mr. P. E. Fansler with Mr. Tom Benoist of the Benoist Aircraft Company. The first scheduled airline flight took place on January 1, 1914, from St. Petersburg, Florida, across the waterway to Tampa, Florida. The flight was 21 miles and lasted 23 minutes.[51] From this first step, the passenger airline industry has continued to grow over the decades. With advances in technology, combined with improving transatlantic service, airline passengers are now able to arrive and spend more time at their destination. This was one of many factors that brought about a steady decline in the demand for passengers wanting to make transoceanic voyages via ocean liner (the predecessor to today's cruise ship), as more and more passengers were flying and airplanes were becoming larger and faster to accommodate this new transportation industry.

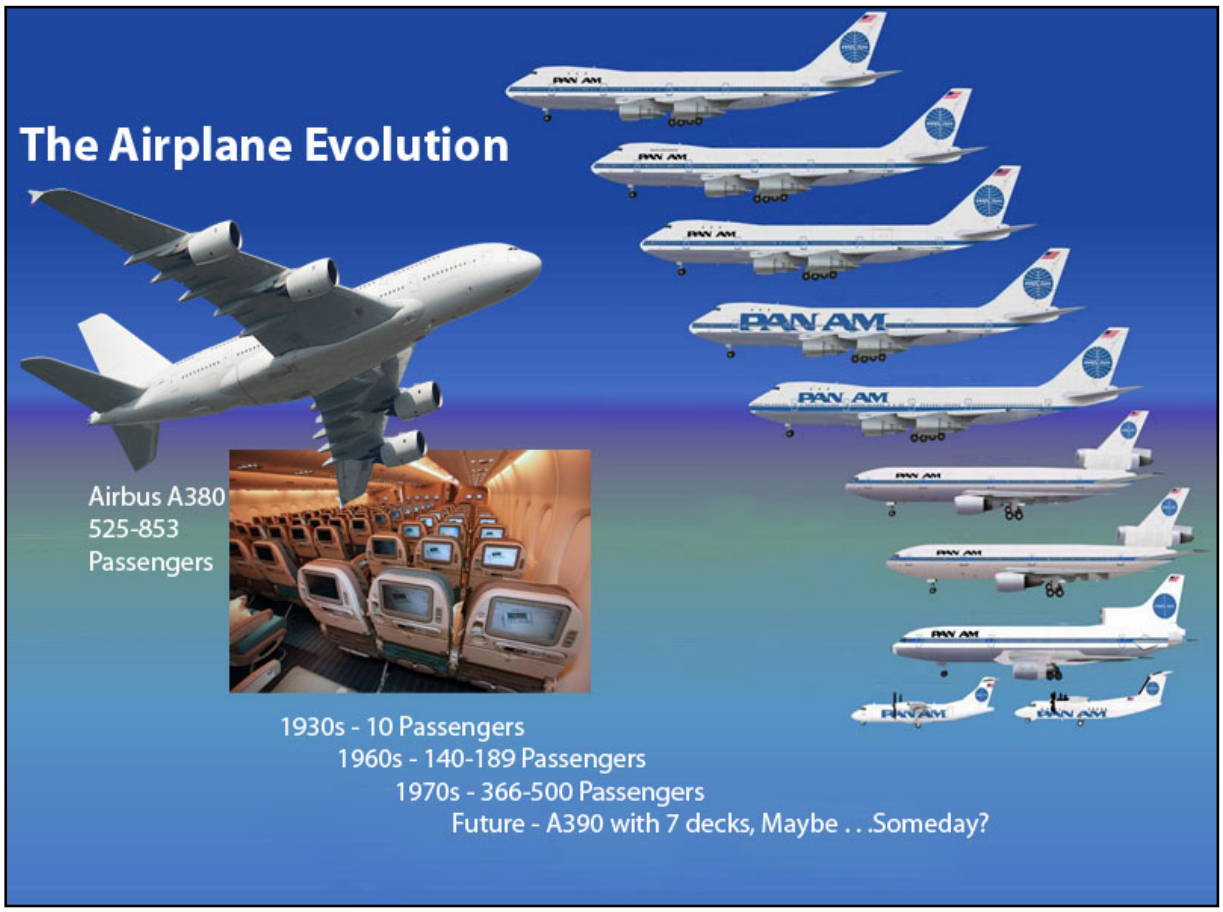
Another major milestone took place on August 15, 1958, when Pan Am took delivery of the first U.S. commercial jet airliner, the Boeing 707-120. On October 26, 1958, Pan Am and the Boeing 707 made history by inaugurating the first daily transatlantic jet service from New York to Paris with 12 crew and 111 passengers.[52]

In 1970, the Boeing 707 was replaced by the Boeing 747. The Boeing 747 revolutionized long-distance air travel by carrying more than twice as many passengers as the Boeing 707[53] and offered significantly lower passenger costs. Future 747 generations increased passenger capacity to 467 passengers with a flying distance of 9,200 miles.

Today, the largest passenger aircraft in service is the Airbus A380, which can carry up to 853 passengers with a flying distance of 8,500 miles.

Even with the large number of passenger aircraft that fly everyday worldwide, the industry is considered the safest form of transportation. More people die in auto accidents in three months in the United States than have lost their lives in the entire history of commercial flight. It is far safer to fly than it is to get to the airport. Because air travel is so safe and accidents so rare, when an incident does occur it is often highly publicized, which heightens the unwarranted perception of danger.

For the U.S. Coast Guard, involvement in maritime aircraft response began as early as 1921 as part of the weather observation program. However, it wasn't until January, 1940, when President Roosevelt directed the establishment of the "Atlantic Weather Observation Service," using cutters and U.S. Weather Bureau observers that the U.S. Coast Guard became involved in aircraft tracking response and communications relay.[54]



Passenger Aircraft Evolution
Photo: Harold Hunt/U.S. Coast Guard

PASSENGER AIRCRAFT STATISTICS

The passenger vessel industry claims that a *"passenger ship is its own best lifeboat,"* and in many cases during a disaster at sea, this may very well be true. However, this would obviously not apply for passenger aircraft disasters, requiring a large number of passengers to evacuate after ditching an aircraft at sea.[55]

According to accident statistics, the level of risk in aviation varies depending on the nature of the flying. In particular, commercial airline transportation is at least ten times safer than driving an automobile, thus placing aircraft accidents in the low probability/high consequence category.[56] In fact, the odds of a passenger being on an airline flight which results in at least one fatality is 1

in 11.4 million among the top 30 airlines. However, when an aviation incident in a maritime scenario does occur it is more likely to be a mass casualty versus a MRO.

Table 2 below provides an aircraft incidents statistical summary.

TABLE 2: AIRCRAFT INCIDENT STATISTICS (1919-PRESENT)						
	ALL AIRPLANE INCIDENTS			AIRCRAFT DISASTERS OVER WATER		
	#	SURVIVED	DIED	#	SURVIVED	DIED
1919-1938	37	121	505	4	6	74
1939-1958	121	589	3,442	17	127	593
1959-1978	276	3,476	16,218	23	148	1,316
1979-1998	253	6,849	18,081	15	61	1,397
1999-2008	139	4,784	9,807	8	45	925
2009-PRESENT	84	3,022	2,431	7	200	371
TOTAL	**913**	**18,841**	**50,484**	**74**	**587**	**4676**

Source: Aviation Safety Network, Revised October 2011

From a SAR/MRO perspective, the challenge SAR authorities is aircraft disasters in a maritime scenario. In 1930, Captain A.G. Lamplugh, British Aviation Insurance Group, London, succinctly stated the issue:

> *Aviation in itself is not inherently dangerous. But to an even greater degree than sea, it is terribly unforgiving of any carelessness, incapacity or neglect.*

For many, it is assumed that if a passenger aircraft "crashes" in the maritime environment there will be no survivors.

Statistically, this is not the case.

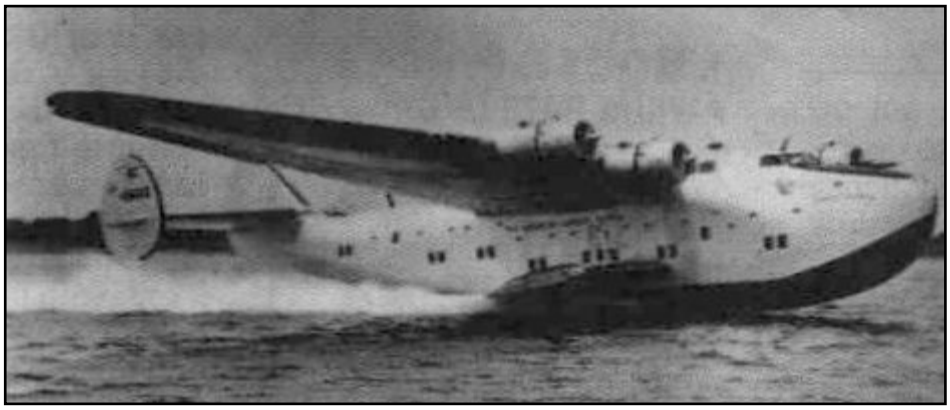
What is important for this analysis is that the statistical survival rate of passengers on aircraft in maritime environment ("ditching") during controlled flight is 53 percent.[57] While this may seem to be a low survival rate, this implies that if, for example, an Airbus A380 with 850 persons on board ditched in the maritime environment, that statically, there could be 450 survivors requiring rescue.

Life rafts pull away from the *Sovereign of the Skies* just before the broken craft settles to her grave in the Pacific Ocean.
October 16, 1956
Photo: William Simpson
U.S. Coast Guard

PASSENGER AIRCRAFT MRO EXAMPLES[58]

Below are examples of passenger aircraft MROs in the maritime environment. As is the case for passenger ships, passenger aircraft MROs closer to shore will normally allow for the opportunity to utilize other SAR facilities to assist in the response, in addition to the U.S. Coast Guard (e.g., military, other SAR authorities, commercial ships, volunteers, etc.).

BERMUDA SKY QUEEN (OCTOBER 14, 1947)[59]



Bermuda Sky Queen

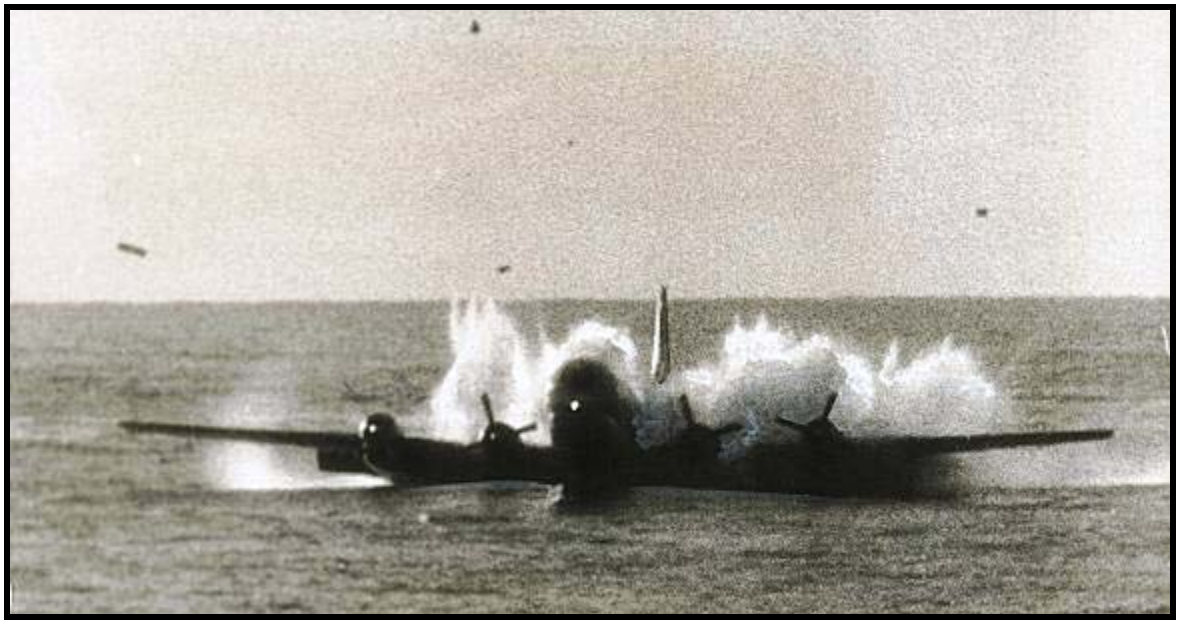
The American-owned Boeing 314 flying boat, *Bermuda Sky Queen*, carrying 69 passengers, was flying from Foynes, Ireland, to Gander, Newfoundland. Gale-force winds had slowed its progress, and it was running low on fuel. Too far from Newfoundland and unable to make it back to Ireland, the captain decided to fly toward the U.S. Coast Guard cutter *Bibb* which was on patrol in the North Atlantic. The plane's captain decided to ditch and have his passengers and crew picked up by the *Bibb*.

In 30-foot seas, the transfer was both difficult and dangerous. Initially, the *Bibb*'s captain tried to pass a line to the plane which taxied to the lee side of the cutter. A collision with the cutter ended this attempt to save the passengers. With worsening weather, a 15-man rubber raft and a small boat were deployed from the ship. The raft was guided to the escape door of the aircraft. Passengers jumped into the raft, which was then pulled to the boat. After rescuing 47 of the crew, worsening conditions and the approach of darkness forced the rescue's suspension. By dawn, improved weather allowed the rescue to resume, and the remaining passengers and crew were transferred to the *Bibb*.

SOVEREIGN OF THE SKIES (OCTOBER 16, 1956)[60]

On October 16, 1956, a Boeing 377, *Sovereign of the Skies* (Pan Am Flight 943), departed San Francisco at 8:30 P.M. with 31 passengers on a flight over the Pacific Ocean. On October 17, at approximately 3:30 A.M., the aircraft was midway through the flight when the No. 4 engine failed. Shortly after, the No. 1 engine began sputtering; leaving the plane with just two engines and as a result the aircraft began losing altitude. Fortunately, the U.S. Coast Guard cutter *Pontchartrain* was in the vicinity. For the next four hours the aircraft circled the cutter burning off fuel until daylight was on the horizon and seas were calmer. On October 17, shortly before 8 A.M., the passenger aircraft ditched only one mile from *Pontchartrain*. When *Pontchartrain* arrived on scene, they could see the passengers walking on the aircraft's wings. All the survivors

were transferred to *Pontchartrain* and the aircraft sank. The entire MRO took only 21 minutes from the time of ditching until rescue of the survivors before the aircraft sank.



Sovereign of the Skies Ditching.
Photo: William Simpson/U.S. Coast Guard

ROMANCE OF THE SKIES (NOVEMBER 9, 1957)[61]

On November 9, 1957, on the same route as the *Clipper Sovereign of the Skies*, a Boeing 377, *Romance of the Skies* (Pan Am Flight 7), disappeared at or near the same position, which was on the first leg of a round-the-world flight that began earlier that day in San Francisco. The *Romance of the Skies* next stop was Honolulu, Hawaii. The aircraft never arrived, crashing in the Pacific, killing all 44 passengers and crew. Immediately following the disappearance of *Romance of the Skies* the search commenced for survivors. The search ended four days later with the discovery of 19 bodies of the 44 passengers and crew and floating wreckage about 1,000 miles northeast of Honolulu. The other 25 missing persons were never found.

Romance of the Skies.
Photo: San Francisco International Airport Museum

Other aircraft debris was eventually found 90 miles north of the flight's intended track, suggesting that the airplane continued to fly for some time after the unknown incident occurred. 14 of the 19 bodies recovered were wearing life vests but no shoes, indicating that some preparations had been made prior to attempting to ditch the aircraft in the ocean.

OVERSEAS NATIONAL AIRWAYS, INC., FLIGHT 980 (MAY 2, 1970)[62]

On May 2, 1970, an Overseas National Airways, Inc., DC-9 Flight ALM 980, on a flight from New York City, New York, to St. Maarten, ditched approximately 30 miles east-northeast of St. Croix, Virgin Islands. 40 persons (35 passengers and 5 crewmembers) survived. The remaining 23 persons on board (including two infants and a stewardess) did not survive. The aircraft sank in 5,000 feet of water and was not recovered.

What is important about this tragic incident is that none of the five 25-man rafts on board the aircraft deployed. However, several rafts were air-dropped at the ditching site. The U.S. Coast Guard HU-16 amphibian aircraft dropped two rafts but both fell too far away to be reached. A second aircraft also dropped two rafts in the area. The captain swam to one raft and the navigator reached the other, but neither was able to maneuver their respective rafts back to the main group.

Recovery of the survivors by helicopter began approximately 90 minutes after ditching, and the last survivor, the first officer, was rescued one hour later. In summary, 11 survivors were picked up by two U.S. Coast Guard HH-52 helicopters, 26 survivors by a U.S. Navy SH-3A helicopter, and the remaining three survivors were rescued by a U.S. Marine Corps CH-46 helicopter.

"MIRACLE ON THE HUDSON"[63]

On January 15, 2009, U.S. Airways Flight 1549, an Airbus A320-214 on a scheduled commercial flight from LaGuardia Airport, New York City, New York, to Charlotte-Douglas International Airport in Charlotte, North Carolina, experienced an almost complete loss of thrust

in both engines after encountering a flock of birds. When the aircraft crew determined they would be unable to reliably reach any airfield, they turned southbound and glided over the Hudson River, finally ditching the aircraft near the *USS Intrepid* museum about three minutes after losing power. At approximately 3:40 p.m., the controller was advised by a nearby helicopter pilot that the airplane was in the water. The U.S. Coast Guard, the New York Police Department, and various other search and rescue authorities were immediately notified. All 155 passengers and crew safely evacuated the aircraft, which was still virtually intact though partially submerged and slowly sinking, and were quickly rescued by nearby passenger ferries and other vessels.

Forty-five passengers and all 5 crewmembers were transported to shore after the accident. Two passengers and a flight attendant sustained serious injuries.

PASSENGER AIRCRAFT MRO CONSIDERATIONS

What is the Risk to Passenger Aircraft?

According to the National Air Traffic Controllers Association (NATCA):

> *On an average day, air traffic controllers handle 28,537 commercial flights (major and regional airlines), 27,178 general aviation flights (private planes), 24,548 air taxi flights (planes for hire), 5,260 military flights and 2,148 air cargo flights (Federal Express, UPS, etc.). At any given moment, roughly 5,000 planes are in the skies above the United States. In one year, controllers handle an average of 64 million takeoffs and landings.*[64]

With this large volume of air traffic, in 2011 for example, there were only 36 airplane accidents, none of which involved a maritime scenario.[65] For SAR authorities, a passenger aircraft MRO in the maritime environment should be considered a "Black Swan" low probability/high consequence event.

PASSENGER AIRCRAFT MROS: DITCHING OF FLIGHT 1549 AS A CASE STUDY

With limited examples of passenger aircraft ditching in the maritime environment and the subsequent MRO, the ditching of Flight 1549 on the Hudson River provides an opportunity to use a recent, passenger aircraft MRO to discuss MRO response considerations.

Modern safety requirements for passenger aircraft over water have improved significantly over the last 50 years. For example, U.S. Airways Flight 1549 was equipped so that crewmember life vests were at every jump seat location, passenger life vests at every seat for primary passenger flotation and seat cushions could be used for auxiliary passenger flotation. In addition, Flight 1549 was equipped with ten infant life vests (stowed in a bag in the last overhead bin), two emergency locater transmitters (ELTs), 4 slide/rafts located at each exit, four survival kits, and four life lines.

Within seconds after ditching, the crewmembers and passengers initiated the evacuation of the airplane.

> ***Consideration #1****: If a passenger aircraft ditches on the water, SAR authorities must assume there will be survivors that must be rescued.*

Fortunately, Flight 1549 was able to ditch on the Hudson River in the vicinity of SAR facilities that were immediately available to rescue the passengers and crew.

How important is a community response to the ditching of Flight 1549? When Flight 1549 ditched on the Hudson River, it was in close proximity to shore and near the Port Imperial Ferry Terminal in Weehawken, New Jersey. Many ferries were operating over established routes in the local waterway, and the ferry captains either witnessed the accident or were notified about it by the director of ferry operations. *Seven* vessels responded to the accident and recovered the occupants. The first vessel arrived on scene at approximately 3:34 P.M. (Approximately *three minutes* after Flight 1549 ditched), and the six other ferries arrived on scene just a few minutes later. The incident log also indicated that one NYFD fire rescue boat and two U.S. Coast Guard boats arrived on scene just a few minutes later. As a result of the immediate response by vessels in the vicinity, all of Flight 1549's passengers and crew were rescued within approximately 20 minutes of the ditching.

> ***Consideration #2****: What if this same MRO scenario occurred, not on the Hudson River, in the vicinity of other ships and boats that were able to conduct an immediate MRO operation, but 200 miles offshore? Most MRO scenarios planned, and exercises conducted, involve passenger aircraft that ditch during takeoff or landing in the vicinity of the airport. While a low probability, high consequence event, a passenger aircraft MRO offshore must be considered and planned for as well.*

In the case of Flight 1549, the water temperature was 41° F, with a wind chill of 2° F. In addition, there was a lack of sufficient slide/rafts that resulted from water entering the aft fuselage. These on scene factors posed an immediate threat to the survivors. Although the airplane continued to float for some time after ditching, many of the passengers who evacuated onto the wings were exposed to water up to their waists within 2 minutes. The passengers who jumped or fell into the water (and the passengers on the wings who would have had to eventually enter the water if the emergency response had not been so timely) were at the most risk. Medical literature indicates that cold-water immersion causes cold shock, which can kill a person within 3 to 5 minutes, and swimming failure, which can kill a person within 5 to 30 minutes. Therefore, if the rescue vessels had not been near the accident site, or if conditions or procedures caused additional survivors to enter the water, it is likely that some of the airplane occupants would have succumbed to cold shock or hypothermia-related swimming failure.[66]

> ***Consideration #3****: Cold water immersion is a critical, life-threatening consideration in any MRO response.*

***Consideration #4**: Safety and survival equipment (e.g., rafts) on passenger aircraft may be unavailable or not operate due to the impact of ditching at sea. As was the case with the 1970 Overseas National Airways, Inc., DC-9 ditching, none of the five survival rafts provided on the aircraft were available for use by the survivors.*

***Consideration #5**: While the position of most passenger ship disasters may be reasonably well known and would require minimal searching prior to the commencement of rescue operations, there may be no prior warning if a passenger aircraft ditches in the marine environment, requiring a search for survivors.*

***Consideration #6**: In the maritime environment, passenger aircraft have a very limited capability to float and will normally sink quite rapidly, limiting receipt of the aircraft's emergency locating transmitter (ELT). As a result, SAR authorities and the responding SAR facilities may have a very difficult time determining the position of possible survivors.*

Is the response community prepared for a maritime MRO involving a passenger aircraft? In the United States for example, for near-shore MROs involving passenger aircraft, airports must conduct MRO exercises as a regular component of each airport's emergency response plan. The U.S. Federal Aviation Administration (FAA) requires all airports to conduct a full-scale exercise every three years.[67] Many of these airport exercises include SAR authorities such as the U.S. Coast Guard, which also has a requirement to conduct periodic MRO exercises with their local response community and stakeholders.[68]

As is the case with any maritime MRO, a passenger aircraft ditching offshore presents an incredibly difficult challenge for any SAR authority. With limited available SAR facilities, the response will in all likelihood take much more time. SAR planners must consider both near-shore and offshore scenarios in the unlikely event that a passenger aircraft must ditch in the maritime environment.

RESCUER'S MRO CHALLENGE[69]

One of the most difficult and least thought through challenges that SAR responders will encounter in any maritime disaster and MRO is the actual rescue of the survivors. Merchant ships that divert to assist persons in distress face difficult challenges in rescuing just one person from a survival craft or from the water. If hundreds or thousands of people must be rescued, or if conditions on scene are less than ideal, the difficulties and risk will significantly increase. Even if the MRO occurs within range of shore-based SAR facilities, SAR responders on scene can quickly become overwhelmed.[70]

An unfortunate example of this problem occurred during the response to the 1994 sinking of the passenger ferry *Estonia*:

> *In 1994, the worst civilian ship disaster in modern European history occurred. Although there were 22 ships in the close proximity when the M/S Estonia sank, only 137 persons survived out of the approximately 1,000 persons on board. Ships that arrived at the scene were forced to improvise. They had neither the equipment nor the routines to participate effectively in such a rescue operation. Instead, in spite of all their efforts, they mostly became witnesses to the tragedy.*[71]

One of *Estonia's* liferafts.
Photo: Accident Investigation Board Finland

The following considerations are provided to help SAR authorities, as well as ships and shipping companies understand the challenges in conducting a maritime MRO.[72]

SAR FACILITY CONSIDERATIONS

1. In many instances, when conducting MRO planning, an implied assumption is that there will be sufficient dedicated SAR facilities available to rescue large numbers of survivors in an MRO. Most SAR authorities do *not* have the dedicated SAR facilities available to respond to a MRO with possibly several thousand survivors requiring rescue and will need to rely on additional SAR facilities (e.g., merchant ships in the vicinity) that can divert to render assistance. However, it should be anticipated that ships on scene will encounter difficulties in rescuing potentially large numbers of survivors.

2. While critical to any MRO response, SAR helicopters are dependent on the disaster location and fuel usage. In addition, helicopters do present challenges in the rescue of large numbers of persons that must be considered.[73]

    a. All on-scene SAR assets will need to coordinate their operations closely during the response to a MRO. Surface assets may not be familiar with working around a helicopter and the associated downwash and noise they produce. Helicopter pilots

will need to be cognizant of their aircraft affects and ensure they minimize disruptions within their vicinity.

b. Each helicopter hoist takes time and helicopters are limited to the number of people they can rescue at one time. A MRO could easily over tax the capability of helicopters in both numbers and time required to effect a rescue of each survivor.

c. Each MRO brings a different scenario for the SAR facilities to assess and respond to. For example, partially submerged vessels with cranes and rigging can challenge or limit the hoisting opportunities of helicopters. Survival craft with canopies designed for rescue by vessels may be difficult to hoist from, adding further time delay in rescuing all the survivors by a helicopter.[74]

d. Helicopter crew endurance limits or mandatory maintenance may be reached during a prolonged MRO response. Additional crews may be required or maintenance may need to be performed during the response.

e. U.S. Coast Guard helicopters, for example, are not equipped with an in-flight refueling capability. Currently, the only such aircraft and helicopters with this specific design capability are U.S. Department of Defense (DoD) assets which may or may not be available due to time, mission requirements and rescue location. When landing on a ship is not an option, U.S. Coast Guard and U.S. Navy helicopters can utilize In-Flight Refueling (HIFR) from certified U.S. Navy and U.S. Coast Guard ships, which allows the helicopter to receive fuel through the cabin while hovering. However, the ship and helicopter will be removed from rescue operations while HIFR is being conducted.

f. Regardless of the type of helicopter, the key issues involving a MRO is the number of passengers that must be rescued, incident location and environmental conditions.

3. Assisting ships will often be other than another passenger ship. Cargo ships, fishing vessels and other craft that divert to assist as SAR facilities, are generally ill-equipped to locate and retrieve survivors in large numbers from the water or survival craft, and to care for the survivors once onboard. SAR authorities must coordinate any support required by ships assisting in the response.

4. Maneuvering a large ship in a seaway to come alongside, and then remain alongside a small target like a survival craft or a survivor in the water will be difficult. The critical issue is running over and/or crushing the survival craft/survivor.[75]

5. An assisting ship mooring alongside a large passenger ship in distress in anything but near-ideal circumstances is regarded as potentially dangerous and of questionable benefit. It cannot be relied upon as a solution to the survivor transfer/evacuation challenge.

6. Assisting ships that are not passenger ships have unique challenges when a large number of rescued survivors are brought on board. Most ships (especially cargo ships) have a relatively small crew and have little capability to manage large numbers of survivors. In particular, most ships:

a. Lack covered public spaces which provide protection from weather;

b. Lack sanitary facilities, blankets and clothing, food and water;

c. Have insufficient numbers of crew to control and assist survivors, and lack training on how to do so; and

d. Lack medical staff and facilities.

7. Masters of assisting ships will likely require substantial help both on board and ashore in handling communications functions during a MRO involving thousands of survivors.

8. Training of ship crews that respond to a MRO is also an issue. Difficulties with using shipboard recovery systems in recovering large numbers of survivors will be exacerbated if ships' crews are insufficiently experienced and trained in using these systems.

9. Not all shipping companies have the capability to quickly stand up and sustain a 24-hour emergency response center with substantial equipment, staffing, information management and communications capabilities, nor is such capability currently required.

10. Who will assume On Scene Coordinator (OSC)? If the OSC is not from the U.S. Coast Guard or other SAR authority, then coordinating the response on scene may become difficult if the OSC is not familiar with SAR operations and in particular, managing a large MRO.

11. Survivor accountability can be a critical issue on scene, especially in a large MRO in which a large number of survivors are rescued by several SAR facilities.[76]

An example of the challenges associated with ships rescuing persons in distress at sea was provided in a paper presented to IMO's Communications and Search and Rescue Subcommittee, *Large Passenger Ship Safety: Second Report (COMSAR 8/9, December 18, 2003)*. The report cited the experience of two survivors in the loss of their ocean racing yacht *Excalibur* off the coast of Australia in September, 2002. After seven hours in heavy seas the two men were eventually recovered from the water by the bulk carrier *Curia*. Concerning their recovery, one of the survivors, John Rogers, described in the article, "Survival" in *Yachting World* (September, 2003) their rescue:

> *"If you think you can have a large ocean-going bulk carrier simply pull up beside you and haul you aboard then you're in for a hell of a shock. This was by far the most physically demanding and most dangerous part of our ordeal."*

In the prevailing conditions, it took *Curia* 11 passes to maneuver into a position in which recovery was possible. Even then, the two men had to swim an estimated 40-50 meters to reach the ship's side. But that was just to get into position: the problem of recovery still had to be faced. Mr. Rogers stated:

> *"A variety of methods are available to ships' crew to get you on board but if you are physically incapable then things become doubly serious. Ocean-going cargo vessels are not designed for rescues, so the means of getting you out of the water come down to the basics, cargo or scramble nets over the side, roll-down ladders, lifebuoys and ropes with a loop tied in their ends…"*

It was the last method – the loop of rope being used as a substitute helicopter sling – that achieved the rescue, but only after Mr. Rogers had slipped out of the loop on the first attempt and fallen back into the sea.

12. There may be language difficulties between the SAR facilities and survivors. If instructions are not properly understood, then consequences may be dangerous. The SAR facility crew may not have a language in common with the survivor to be recovered and, even when there is, the survivor may not understand the instructions.[77]

SURVIVAL CRAFT CONSIDERATIONS

1. Assisting ships generally do not have the capability to retrieve a fully loaded survival craft – even their own. The requirements for survival craft launching appliances in the SOLAS Convention (Chapter III) and LSA Code address only the lowering of survival craft into the water.[78] There are no provisions for the *recovery* of the survival craft, particularly in a fully loaded condition. The rescue of persons in a survival craft and transporting them to a place of safety[79] must be conducted via intermediate steps which can be slow and risky.[80]

Rescue of the crew of the Fishing Vessel *Tanya Rose* - Only six people in one raft; July, 19, 2010.
Photo: Crew of the rescuing Cargo Ship *CSAV Rahue*

2. If a large passenger ship in distress is listing, some, if not all, of the ship's lifeboats will not be able to launch, further hampering MRO efforts.[81]

3. Small rafts or other survival craft are especially vulnerable if in close proximity to a responding commercial ship. There is danger of crushing the survival craft or causing other damage as the two vessels move in the seaway.[82]

4. An assisting ship using its boat(s) and davit-launched raft(s) as lifts is a difficult operation in anything other than ideal conditions. On-load/off-load release mechanisms must be disabled and lifting gear is usually unable to cope with fully laden craft, so survivors can only be lifted in small numbers.[83]

5. Deployable rafts and similar lifesaving apparatus, are not considered a "means of recovery" to the ship (or aircraft) deploying the device, but are intended to help keep people alive until SAR facilities better equipped to recover the survivors arrive on scene, or reduce their exposure to the elements.

6. Potential rescuers must be aware that for the rescue, being in or on a survival craft provides a relative degree of safety. Requiring survivors to depart the survival craft and enter the water may result in additional, complicating factors, including inducing cold-immersion shock and ingesting of water.

SURVIVOR CONSIDERATIONS

1. In a MRO, the varying degree of survivor condition has a direct effect on the success of the rescue. There are instances where survivors exhibit an almost superhuman ability to swim and climb to safety, yet in other cases, survivors are incapable or unwilling to assist in their own rescue. Infirmity, injury, and incapacitation can prevent a survivor from

climbing a cargo net alongside a vessel's hull, and psychological impairment can hinder the rescue of others.

2. In a rapid or uncontrolled abandonment, when not all survivors were able to get into survival craft, there may be persons in the water, or clinging to floating wreckage, etc. These survivors are less likely to be able to help themselves than if they were in a survival craft. Nor will they survive long.[84]

Survivor rescued: Sinking of the Russian Passenger Ship *Bulgaria* on the Volga River
July 11, 2011
Photo: Getty Images

3. The quantities and types of personal lifesaving appliances may be inadequate in view of the passenger demographics of large passenger ships, as well as availability of suitable exposure protection for the on scene environment.

4. Determining a place of safety to which large numbers of survivors can be delivered, is the responsibility of the SAR authority. The place of safety must be able to manage the survivors and their needs.[85]

5. Survivors may still be on board the ship in distress. Direct recovery may be required without the intermediate use of survival craft.[86]

6. Recovery nets, scoops, strops, slings, seats, litters, baskets, lines and lifebuoys are all – like davit-launched equipment – subject to the problem of the survivor(s) swinging against the ship's side while being lifted. In rough conditions, the results can be injury or breakage of the gear and loss of the person being lifted. With the exception of some nets and baskets, all these devices are intended for the recovery of one or two persons a time. None of the devices are able to recover large numbers of survivors.

7. Climbable devices (e.g., scramble nets, Jacob's Ladder, etc.) imply that the survivor being rescued is in a fit state to climb. Scramble nets and rope ladders are very difficult to use at the best of times. While always worth deploying in an MRO they should not be considered a viable means of rescue, especially for ships with a high freeboard. Pilot and accommodation ladders may be an effective means to rescue survivors in the water, but may be difficult to climb in other than calm sea conditions, or by people suffering from hypothermia.

8. Survivors awaiting recovery may lack the ability to help themselves, or help others help them. This may be because of injury, illness (including sea sickness after a period in a survival craft), the effects of cold or heat, (whether elderly or very young) or infirmity.[87]

9. It is likely that people awaiting recovery will have little or no experience in transferring between small craft, or from a survival craft to a large ship. For example, stepping onto a

pilot ladder and then climbing may not appear difficult for a fit person capable of doing so, but this may be extremely difficult for others, even in benign conditions.[88]

10. Compounding the survivor rescue challenge is the onset of hypothermia, which limits survivor mobility and would require SAR facilities to expedite the rescue operation.

11. Who should be recovered first? It is clear that survivors in the water should take priority over those in survival craft. It is less clear whether the injured or infirm should take priority over the more capable, who can be rescued more quickly.[89]

SUMMARY

PASSENGER SHIP MROS CHALLENGES

1. The belief that merchant ships or other Good Samaritan diverted to assist in a maritime MRO response will limit a SAR authority's involvement in coordinating and responding to the MRO is a mistake. Ships diverted to assist on scene must be supported with SAR aircraft and other surface SAR facilities that are available.

2. Any maritime MRO is an extremely complex and confusing operation that will tax on scene SAR facilities.

3. For any SAR facility in other than perfect environmental conditions, it will be extremely difficult to rescue survivors in the water or from survival craft.

4. The complexity of the response is significantly increased due to the number of survivors that must be rescued.

5. Merchant ships are not designed to rescue survivors in the water or from survival craft. It is incredibly difficult for even competent, professional mariners to maneuver single screw, extremely large ships to rescue a limited number of persons in distress, let alone a large number of MRO survivors. The SMC must understand this critical, on scene reality.

PASSENGER AIRCRAFT MROS CHALLENGES

1. All passenger ship MRO considerations would apply in the ditching of a passenger aircraft.

2. MROs involving passenger aircraft in the maritime environment are extremely rare. Most passenger aircraft disasters occur at landing and takeoff. However, there are occurrences of passenger aircraft MROs in the U.S. SAR regions.

3. The U.S. Coast Guard must anticipate and plan that a passenger aircraft will again ditch in the U.S. SAR regions.

4. Anticipate that for any passenger aircraft ditching scenario, there will be survivors requiring rescue.

5. Whereas most passenger ship MROs provide an opportunity for notifying SAR authorities of the location and nature of the distress, in many instances, passenger aircraft in distress may not be able to give verbal distress notification directly to SAR authorities. Notification may only be via emergency locating transmitter (ELT), or when the passenger aircraft misses a mandatory verbal report. As a result, SAR authorities may be required to search for the distress location, as well as rescue any survivors.

MRO REALITIES[90]

In the U.S. Coast Guard's *Proceedings* (Fall, 2011) magazine, a list of *10 U.S. Coast Guard Mass Rescue Operational Realities* was published.[91] The list was compiled from actual MRO cases and exercises that highlight the need for MRO specific planning, and to introduce recommendations and job aids to improve local MRO preparedness. The ten Operational Realities are detailed below and serve as an excellent basis for future MRO planning requirements.

Reality #1: *MROs are not confined to a single organization, or to strictly search and rescue (SAR) functions*. An MRO, particularly an MRO offshore, will require the assistance of any available SAR facilities to assist.

Reality #2: *Accountability of passengers and crew will be elusive and difficult.* A survivor accountability process must be developed, implemented and stressed from the start, and then checked and double-checked at each opportunity.

Reality #3: *There will be delays, often lengthy, between rescuing and officially accounting for people.*

Reality #4: *The demand for information from internal and exterior requestors will be overwhelming unless a process is implemented early to manage the content and flow of communications.*

Reality #5: *Dedicated SAR resources will be limited and "Good Samaritan" vessels will be critical for success*.

Reality #6: *Coast Guard SAR Mission Coordinators (SMC) and On Scene Coordinators (OSC) receive minimal training in managing MRO activities*.

Reality #7: *The physical or emotional condition of survivors may prevent them from helping themselves*.

Reality #8: *Local communities are vital partners in providing shore side MRO response actions, but most have minimal guidance or training on the functions expected of them*.

Reality #9: *Continuum of care for rescued victims will be required. Once delivered to shore, the functions of accountability, emergency medical care, human health, shelter, food, and other survivor support needs must be continued and coordinated.*

Reality #10: *Past success does not guarantee future results.* Continuous training and plan improvement is required.

CONCLUSION

Maritime disasters are not necessarily more numerous than disasters in other modes of transport, but they can be very large. Some of the largest transport disasters in the world, and in Europe, have been maritime disasters.

One can easily think of reasons why maritime disasters can claim many lives. Commercial passenger ships are getting bigger. Large ferries and cruise ships may carry more than a thousand passengers and crewmembers. Disasters at sea can happen very quickly: if a ship capsizes in rough weather, it can go down within minutes, taking everybody with it to the sea bed. Rescue operations can be difficult at sea, particularly in rough weather. Those who jump into the sea will often die soon because of hypothermia. For all these reasons, the potential for great disasters at sea is always present.[92]

The purpose of this analysis was to provide a limited review of the risks and challenges associated with the response to an MRO; in particular, an MRO that may occur offshore. Significant work has been accomplished, both nationally and internationally, in the *prevention* of disasters at sea. However, it is the *response* to this worst case scenario – with a large number of survivors in the water or survival craft – that must be understood, planned for, and a rescue operation effectively coordinated and conducted to minimize loss of life.

With the large number of passenger ships and aircraft that transit over and through the U.S. SAR regions every day, the threat of a disaster at sea will continue to be a planning and response challenge for any SAR authority. In particular, the difficulty of the response significantly increases when the MRO occurs possibly hundreds of miles from available SAR facilities. Who will respond? Who will be the OSC and coordinate the rescue of thousands of survivors on scene?

Collision and sinking of the passenger ship *Andrea Doria* (above) with the passenger ship *Stockholm* (below); 25 miles west of the *Nantucket Light Vessel*; July 25, 1956.
Photos: U.S. Coast Guard

As explained in this analysis, the response to an MRO is extremely difficult no matter the location. Yet one MRO planning assumption is that the incident will occur close to available SAR facilities, whether U.S. Coast Guard, military, State, local, industry or volunteer, that can be relied on to assist in the response with limited time delay.

This may very well *not* be the case.

SAR authorities must incorporate planning for the worst case low probability, high consequence MRO scenario – a maritime disaster that occurs offshore, away from available SAR facilities. In addition, these MRO scenarios should include a SAR authority's support to other nations within that request lifesaving assistance.

In the wake of the 2009 ditching of U.S. Airways Flight 1549, the 2012 *Costa Concordia* grounding, as well as other lessons learned from previous MRO exercises and disasters, passenger ship and aircraft industries, and other regulatory and safety organizations and agencies, have become more aware of the challenges associated with this type of low probability, high consequence disaster which may include the conduct of a MRO. Safety continues to be a high priority in preparing for this type of disaster.

However, these disasters will continue to occur, requiring the U.S. Coast Guard to be prepared to respond.

Responding effectively in a maritime disaster and subsequent MRO can and will be difficult, and may very well have a large loss of life. Depending on the nature of the incident, on scene weather, location, the passenger ship or aircraft involved, and available SAR facilities, will all be important determining factors in how many survivors are rescued. The more effectively SAR authorities can analyze and understand potential maritime disaster and MRO risks, develop plans with other SAR authorities and industry stakeholders, and how well the plans are exercised and improved, can make the difference in the number of survivors rescued.

In a maritime MRO, when the potential scenario could involve the rescue of thousands of survivors, a SAR authority will never be able to go it alone. This is an “all hands on deck” evolution requiring the immediate execution of MRO response plans, as well as the assistance of anyone “out there” that can assist.

SAR authorities and rescue forces should continue to address the requirements associated with recovering large numbers of survivors either from the water for from survival craft and moving the survivors to a place of safety.

RECOMMENDATIONS

Based on this analysis of the challenges associated with the conduct of a maritime MRO, in particular, an MRO that occurs offshore, the following recommendations are provided for consideration. The recommendations will not *solve* the MRO challenge, but only help to mitigate the issues associated with the MRO response.

The authors understand that each SAR authority has unique maritime MRO challenges. MRO plans must be developed based on risk; MRO exercises conducted to practice MRO plans; and lessons learned identified from the MRO exercises to improve the MRO plans. This work must be accomplished routinely so that SAR authorities can effectively respond when a maritime disaster and subsequent MRO does occur.

The emphasis of the following recommendations is for improving a SAR authorities response to a MRO *offshore*, where there are limited SAR facilities available to render assistance.

1. MRO LIFESAVING APPLIANCES

Issue: The key MRO challenge is people in the water – *many* people in the water, where hypothermia will cause even more deaths. If a SAR authority can provide lifesaving appliances (e.g., liferafts) on scene that can get survivors out of the water until SAR facilities arrive on scene and conduct a rescue, then more lives can be saved.

> ***Recommendation #1****: Research, procure and maintain high-capacity MRO lifesaving appliances for rapid air or sea-based deployment to MRO survivors.*

2. MRO EXERCISES

Issue: MRO exercises provide the basis for ensuring U.S. Coast Guard District MRO plans are effective. SAR authority personnel turnover every year. MRO exercises must continue to be a priority, conducted on a periodic basis to ensure personnel understand the challenges associated with maritime MROs (especially offshore MROs), as well as to assess MRO coordination and response procedures.

MRO exercises are a great opportunity for community and industry partners to work together to ensure inter-agency procedures are understood. These exercises should address issues such as unified command; passenger landing site(s); passenger reception center(s); passenger triage and mass casualty coordination and support; and communications. MRO exercises should incorporate a post-exercise assessment that details an objective-by-objective assessment of the exercise, as well as lessons learned, that are documented and shared within the SAR organization and with other SAR authorities and responders, as well as industry stakeholders.

> ***Recommendation #2****: Support a multi-year MRO exercise program that includes full scale, table-top and seminar-based MRO exercises on a recurring basis, that incorporates both near and offshore MRO scenarios.*

3. MRO COORDINATION AND COOPERATION

Issue: SAR authorities must continue to work other national and international SAR authorities and passenger ship and aircraft industry stakeholders to ensure MRO plans, policies and procedures are harmonized between the SAR authority and other MRO responders.

Any SAR authority will need assistance in a MRO where a large number of survivors require rescue. Proactive planning and preparation accomplished prior to a disaster will only add to the effectiveness of the response.

> ***Recommendation #3****: SAR authorities must ensure effective planning is conducted for responding when a maritime disaster occurs offshore requiring a MRO, with other response stakeholders. Personnel in other agencies, as well as industry representatives change over time. MRO coordination and planning must continue to be conducted on a recurring basis.*

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NOTES

[1] Meg Jones, "A year later, Oshkosh survivor of cruise ship crash still cruising," *Milwaukee-Wisconsin Journal Sentinel* (January 14, 2013); article available on the Internet at http://www.jsonline.com/news/wisconsin/one-year-later-survivor-of-cruise-ship-crash-still-cruising-nh8cn8s-186859382.html; accessed on January 15, 2013.

[2] The International Maritime Organization (IMO) is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships.

[3] The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations, with responsibility for promoting the safe and orderly development of international civil aviation throughout the world.

[4] Currently, there are passenger aircraft capable of transporting up to 850 passengers (e.g., Airbus A380).

[5] For example, considered one of the top ten rescues in U.S. Coast Guard history, in 1980 the U.S. Coast Guard, U.S. military and Canadian rescue forces rescued 520 passengers and crew from the burning passenger ship *Prinsendam* in the Gulf of Alaska.

[6] Ibid.: 6-7. SAR authorities have acknowledged it would be counter-productive to assign a "number of persons in distress" requirement to the definition of an MRO. How many persons in distress would be required for the incident to be considered an MRO? If there was one less person in distress than the required number, would an incident *not* be considered a MRO? In many instances, the time of day, location, weather, sea state, etc., may be a better determiner of whether a SAR case is an MRO, not necessarily the number of persons in distress.

[7] The U.S. National Search and Rescue Committee (NSARC; www.uscg.mil/nsarc) differentiates between the internationally recognized definition of an MRO and "Catastrophic Incident," which in the U.S. is defined in the *National Response Framework* as, *"Any natural or manmade incident, including terrorism, that results in extraordinary levels of mass casualties, damage, or disruption severely affecting the population, infrastructure, environment, economy, national morale, and/or government functions."* In the U.S., catastrophic incidents involve the destruction of infrastructure (e.g., hurricanes, earthquakes, tsunamis, etc.); MROs are considered to involve passenger transportation systems, such as passenger ships, ferries, aircraft, etc.

[8] IMO and ICAO, *International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual: Volume 1 – Organization and Management* (London: IMO, 2010): 6-7.

[9] As defined in the IAMSAR Manual (Volume 1), a *SAR Coordinator (SC)* is, *"One or more persons or agencies within an Administration with overall responsibility for establishing and providing SAR services and ensuring that planning for those services is properly coordinated."* As detailed in the *U.S. National Search and Rescue Plan (2007)*, the U.S. Coast Guard is the SC for the U.S. aeronautical and maritime SRRs in the oceanic environment.

[10] See "Rescuer's MRO Challenge" Section in this analysis.

[11] As defined in the *International Aeronautical and Maritime Search and Rescue* (IAMSAR) *Manual Volume 1 – Organization and Management*, a *Search and Rescue Region (SRR)* is an

area of defined dimensions, associated with a rescue coordination center, within which search and rescue services are provided.

[12] Established in 1958 by the U.S. Coast Guard, *Amver* (Automated Mutual Assistance Vessel Rescue System; www.amver.com) is a computer-based voluntary global ship reporting system used worldwide by search and rescue authorities to arrange for assistance to persons in distress at sea. There are thousands of vessels enrolled in Amver, representing over 150 countries. On any given day there are over 5,000 vessels available to divert and assist in a distress situation worldwide.

[13] Kenneth E. F. Watt, *The Titanic Effect: Planning for the Unthinkable* (New York: E. P. Dutton & Co., Inc., 1974): 7.

[14] Maritime Administration, U.S. Department of Transportation, *North American Cruise Statistical Snapshot, 2011*; available on the internet at http://www.marad.dot.gov/documents/North_American_Cruise_Statistics_Quarterly_Snapshot.pdf; accessed on January 11, 2013.

[15] Ibid., 6.

[16] Kenneth E. F. Watt, *The Titanic Effect: Planning for the Unthinkable* (New York: E. P. Dutton & Co., Inc., 1974): 7.

[17] Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable*, 2nd Edition (New York: Random House Trade Paperbacks, 2010).

[18] Ibid., xxii.

[19] Frank. E. Grubbs, "Procedures for Detecting Outlying Observations in Samples," *Technometrics Vol. 11, No. 1* (February, 1969): 1; available on the Internet at http://web.ipac.caltech.edu/staff/fmasci/home/statistics_refs/OutlierProc_1969.pdf; accessed on January 10, 2013.

[20] Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable*, 2nd Edition (New York: Random House Trade Paperbacks, 2010): xxii.

[21] "Cruise ship safety: timeline of disasters and safety regulations," *Telegraph* (January 16, 2012); available on the internet at http://www.telegraph.co.uk/travel/cruises/9017985/Cruise-ship-safety-timeline-of-disasters-and-safety-regulations.html; accessed January 10, 2013.

[22] Robin des Bois, "From the Titanic to the Costa Concordia," (April 12, 2012); available on the internet at http://www.robindesbois.org/dossiers/Titanic/From-Titanic-To-Costa-Concordia.pdf; accessed on January 10, 2013.

[23] Anita M. Rothblum, "Human Error and Marine Safety;" available on the internet at http://www.bowles-langley.com/wp-content/files_mf/humanerrorandmarinesafety26.pdf; accessed on January 10, 2013.

[24] U.K. Parliamentary Office of Science and Technology, "Managing Human Error," *Postnote No. 156* (June, 2001): 5; available on the internet at http://www.parliament.uk/documents/post/pn156.pdf; accessed on January 11, 2013.

[25] *Place of safety* is internationally defined as: *A location where rescue operations are considered to terminate; where the survivors' safety of life is no longer threatened and where their basic*

human needs (such as food, shelter and medical needs) can be met; and, a place from which transportation arrangements can be made for the survivors' next or final destination. A place of safety may be on land, or it may be aboard a rescue unit or other suitable vessel or facility at sea that can serve as a place of safety until the survivors are disembarked to their next destination. This definition has been approved by IMO and will be included in the 2013 revision to the IAMSAR Manual.

[26] Ultimately, it is immaterial what the source of the MRO is, whether passenger ship, aircraft, overloaded migrant vessel, etc. The critical issue is that there is a disaster offshore with a large number of survivors in the water, or in survival craft, that must be rescued.

[27] As defined in the *IAMSAR Manual (Volume I)*, a *SAR Mission Coordinator (SC)* is, *"The official temporarily assigned to coordinate response to an actual or apparent distress situation."*

[28] As defined in the *IAMSAR Manual (Volume 1)*, a *SAR Facility* is, *"any mobile resource, including designated search and rescue units, used to conduct search and rescue operations."*

[29] When most U.S. Coast Guard MRO plans are reviewed, it seems the planning assumptions have a bias towards a disaster with large numbers of survivors occurring *near shore*, not offshore – the worst case scenario. In addition, it appears there is an assumption that other local emergency response stakeholders (e.g., Federal, State and local emergency response agencies, commercial stake holders, etc.) will be available to assist in the MRO response. Offshore, this will most likely *not* be the case. Other emergency response stakeholders may be able to assist once the survivors arrive on shore (e.g., assisting in triage of survivors requiring medical treatment), but they will most likely will *not* be able to transit offshore into international waters to participate in a MRO response.

[30] U.S. Coast Guard Research and Development Center, *Maritime Mass Rescue Interventions; Availability and Associated Technology - Final Report* (December, 2010): 11.

[31] U.S. Coast Guard Research and Development Center, *Mass Rescue Operations Scoping Study, Final Report* (April, 2007). The study identified concepts and technologies that would lead to improvements in mass-rescue operations. This research effort included a review of past successes (and failures), current plans, programs (including interagency agreements) and equipment, assessment of risks and plans for consequence management, and identification of new ideas, techniques, equipment and methods that might help to improve the U.S. Coast Guard's ability to respond to mass-rescue events.

[32] Ibid, v.

[33] This analysis is not deemphasizing the other MRO scenarios identified. For example, the *Deep Water Horizon* MRO scenario *("Rig sinks; crew must be located and rescued")* is a critical issue U.S. Coast Guard Districts with this possible scenario must plan for. However, it is passenger ship and aircraft MROs offshore with a large number of survivors that must be rescued, not within range of most SAR facilities - that is the emphasis of this analysis. U.S. Coast Guard SCs must plan for this type of scenario to ensure the effective coordination of a timely response to the disaster.

[34] United Nations, *United Nations Convention on the Law of the Sea (UNCLOS) 1982 (New York, United Nations, 2001): 23. Article 3: Every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles, measured from baselines determined*

in accordance with this Convention. The TTS is regarded as the State's sovereign territory, extending to the airspace over and seabed below.

[35] In the U.S. Coast Guard Seventeenth District, *Mass Rescue Exercise Lessons Learned Report (January, 2007)*, a major lesson learned was that in general, local response agencies have limited mass rescue response experience during poor weather conditions. This is another planning factor that must be considered.

[36] While the U.S. Coast Guard has an emphasis on the response to passenger ship MROs, passenger aircraft carrying potentially hundreds of passengers on daily transoceanic flights must also be considered in MRO planning. When aircraft crash data is reviewed, it has been determined that most passenger aircraft disasters occur in the vicinity of the airport during takeoff and landing operations, a near-shore MRO event. However, there have been aircraft disasters offshore, which this analysis will discuss.

[37] On January 13th, 2012, at approximately 9:45 PM, the cruise ship, *Costa Concordia*, struck a rock in the Tyrrhenian Sea near the eastern shore of Isola del Giglio, off the west coast of Italy. A 164 foot gash was torn into the port side hull, which flooded parts of the engine room and caused loss of power to propulsion and electrical systems. With water flooding in and listing, the ship drifted back to Isola del Giglio, where she grounded, lying on her starboard (right) side in shallow water with most of her starboard side under water. The evacuation of *Costa Concordia*, with 4,252 passengers and crew known to have been aboard, took over six hours to complete. Even with these near ideal environmental conditions (i.e., near calm seas, near shore (the ship grounded), etc.), 32 people were killed.

[38] For the purposes of this analysis, international waters include all ocean areas outside of a State's TTS.

[39] Aircraft and vessels may have different weather limitations that affect their ability to be deployed during an MRO incident. A clear day with steady high winds may not limit a helicopter response. However, waves produced by high winds may prohibit a vessel from responding. Conversely, a calm day with no wind but with relative humidity nearing 100% forming fog, may limit aircraft from flying, but are conditions in which vessels can operate.

[40] How far a helicopter can transit offshore is based on several factors, such as on scene weather, water temperature, as well as whether the helicopter is carrying a rescue swimmer and hoist basket. Any of these factors will reduce the helicopter's range, on scene endurance and number of survivors that can be rescued and may not always be avoidable.

[41] As defined in the *IAMSAR Manual (Volume 1)*, an *On Scene Coordinator (OSC)* is, *"A person designated to coordinate search and rescue operations within a specified area."*

[42] For example, one of the largest cruise ships in the world, Royal Caribbean's, *Allure of the Seas*, is 1,181.1 feet long and 225,062 tons. *Allure of the Seas* is capable of carrying over 8,000 passengers and crew.

[43] According to Cruise Lines International Association (CLIA), a record 16.3 million global passengers went on a cruise in 2011. Available on the internet at: http://www.cruising.org/regulatory/issues-facts; accessed on December 13, 2012.

[44] Douglas Ward, *Complete Guide to Cruising & Cruise Ships 2012* (La Vergne: Ingram Publishing Services, 2011): 9-13.

[45] Research and Innovative Technology Administration, Bureau of Transportation Statistics, Department of Transportation, *Special Report: Making Sense of Passenger Vessel Data* (July, 2011): 3-4; available on the internet at http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/special_reports_and_issue_briefs/special_report/2011_07_11/html/entire.html; accessed on January 12, 2013.

[46] IMO's SOLAS Convention: *International Convention for the Safety of Life at Sea (1974).* The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships. The main objective of the SOLAS Convention is to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety. Flag States are responsible for ensuring that ships under their flag comply with its requirements, and a number of certificates are prescribed in the Convention as proof that this has been done.

[47] IMO's Maritime SAR Convention: *International Convention on Maritime Search and Rescue (1979)*. The SAR Convention is the framework for implementation of the global, maritime SAR plan. Although the obligation of ships to go to the assistance of vessels in distress was enshrined both in tradition and in international treaties (e.g., SOLAS Convention), there was, until the adoption of the SAR Convention, no international system covering SAR operations.

[48] This statement implies that abandoning ship should be avoided if possible. However, in some circumstances there may be no other option.

[49] Unless a ship appears to be in imminent danger of sinking, it is usually advisable for passengers and crew to remain on board as long as it is safe to do so.

[50] IMO, *Guide to Recovery Techniques MSC.1/Circ.1183* (May 31, 2006): Annex, Page 2; available on the internet at: http://www.uscg.mil/hq/cg5/cg534/MassRescueOps/IMO%20-%20Guide%20to%20Recovery%20Techniques%20(MSC%201%20Circ%201182)%2031%20May%202006.pdf; accessed on December 10, 2012.

[51] Federal Aviation Administration, *Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25A)* (Oklahoma City: FAA, 2008): 1-3; available on the internet at: http://www.faa.gov/library/manuals/aviation/pilot_handbook/; accessed on December 10, 2012.

[52] Michael Lombardi, "Seventh Heaven," *Boeing Frontiers (July 2008)*; available on the internet at: http://www.boeing.com/news/frontiers/archive/2008/july/i_history.pdf; accessed on January 23, 2013.

[53] The Boeing 707 could carry 189 passengers; the Boeing 747 can carry 400.

[54] R. P. Dinsmore, *Ocean Weather Ships 1940-1980*. The idea of ocean weather stations goes back to the early days of radio communications and transoceanic aviation air service. In 1921, the Director of the Meteorological Service of France proposed establishing a ship stationed continuously in the North Atlantic for purposes of weather observations to benefit merchant shipping and the anticipated inauguration of trans-Atlantic air service. The loss of a Pan Am passenger aircraft in 1938 due to weather while on a trans-Pacific flight prompted the U.S. Coast

Guard and the Weather Bureau in 1939 to begin upper air observations using instrumented balloons from International Ice Patrol cutters.

[55] While the U.S. Federal Aviation Administration (FAA), U.S. National Transportation Safety Board (NTSB), ICAO, and other national or international aviation organizations may have different definitions for ditching, for the purposes of this analysis, an aircraft ditching is: An event where the flight crew intentionally lands an aircraft in some body of water such as a lake, a river, or the open ocean. In addition, the event would have to meet the following criteria: 1) Water landing is intentional (accidental or unintentional landings or excursions onto water are excluded, such as runway overruns or controlled flight into water); 2) Uncontrolled impacts with the water are excluded; and 3) The body of water must be deep enough that if the aircraft sinks, some or all of the occupants would have to evacuate the aircraft cabin to avoid drowning.

[56] Dr. Arnold Barnett developed a measurement important to passengers on commercial aircraft: *What are my chances of dying on my next flight?* In aviation safety, this measure is known as "Q," the death risk per randomly chosen flight. When a passenger travels on a domestic flight, that person's chance of being killed – the person's "Q" – is *one in sixty million*. That means that passenger could fly *every day* for the next 164,000 years before possibly perishing in an aircraft crash.

[57] Aircraft database (1922-2011); available on the internet at: http://www.planecrashinfo.com/cause.htm; accessed: December 12, 2012.

[58] It should be noted that there are very few cases of passenger aircraft ditched in the maritime environment.

[59] U.S. Coast Guard, *Top 10 Rescues of All Time*; available at: http:www.uscg.mil/lantarea/docs/uscg%20top%2010%20rescues.doc; accessed on December 12, 2012.

[60] Civil Aeronautics Board, *Accident Investigation Report, Pan American World Airways, Inc., Boeing 377, N90943, in the Pacific Ocean, Between Honolulu and San Francisco, October 16, 1956,* (File # 1-C121); available on the internet at: http://ntl1.specialcollection.net/scripts/ws.dll?file&fn=8&name=S%3A%5CDOT_56GB%5Cairplane%20accidents%5Cwebsearch%5C101656.pdf; accessed on January 1, 2013.

[61] Civil Aeronautics Board, *Accident Investigation Report, Pan American World Airways, Inc., Boeing 377, N90944, in the Pacific Ocean, Between Honolulu and San Francisco, November 9, 1957* (File # 1-C326); available on the internet at: http://ntl1.specialcollection.net/scripts/ws.dll?file&fn=8&name=S%3A%5CDOT_56GB%5Cairplane%20accidents%5Cwebsearch%5C110957.pdf; accessed on January 2, 2013.

[62] National Transportation Safety Board, *Aircraft Accident Report: Overseas National Airways, Inc., Douglas DC-9, N935F Operating as Antilliaanse Luchtvaart Maatschappij Flight 980 (ALM 980), Near St. Croix, Virgin Islands, May 2, 1970* (Adopted: March 31, 1970); Report Number: NTSB-AAR-71-8; available on the Internet at: http://www.airdisaster.com/reports/ntsb/AAR71-08.pdf; accessed on December 13, 2012.

[63] National Transportation Safety Board, *Accident Report: Loss of Thrust in Both Engines After Encountering a Flock of Birds and Subsequent Ditching on the Hudson River, US Airways Flight 1549, Airbus A320-214, N106US, Weehawken, New Jersey, January 15, 2009,* NTSB Number:

AAR-10-03; available on the internet: http://www.ntsb.gov/news/events/2010/weehawken_nj/index.html; accessed on December 13, 2012.

[64] National Air Traffic Controllers Association (NATCA); available on the internet at: www.natca.org; accessed December 13, 2012.

[65] Boeing Corporation, *Statistical Summary of Commercial Jet Airplane Accidents, 1959-2011* (July 2012); Available on the internet at: http://www.boeing.com/news/techissues/pdf/statsum.pdf; Accessed: December 13, 2011. National Air Traffic Controllers Association reports that there are 28,537 commercial flights per day.

[66] An excellent overview of the life-threatening challenges of cold water immersion can be found at: Alan Steinman and Gordon Giesbrecht, "The Four States of Cold Water Immersion," *On Scene: The Journal of the U.S. Coast Guard Search and Rescue* (Spring, 2011): 21; available on the internet at: http://www.uscg.mil/hq/cg5/cg534/On%20Scene/OSspr11.pdf; accessed December 13, 2012.

[67] U.S. Federal Aviation Administration (FAA), *Advisory Circular 150 / 5200-31A* (September 30, 1999): Chapter 3 (Drills and Exercises); The Airport Emergency Plan provides the framework that enables airport and community fire, security, medical, and other resources to join in an effective, coordinated response to airport emergencies. The FAA requires a full-scale demonstration of the emergency plan every three years of those airports certificated under 14 CFR 139.

[68] *Coast Guard Mass Rescue Operations Program*, COMDTINST 16711.2 (August 10, 2010). U.S. Coast Guard MROs exercises are based on a five-year cycle. At a minimum, Districts should conduct and/or participate in one discussion-based (e.g. seminar, workshop, or tabletop exercise) and one operations-based MRO exercise (e.g. drills, functional, or full scale) over a five year period.

[69] Unless otherwise stated, the information for this Section was obtained from: IMO, *Large Passenger Ship Safety: Report of the Correspondence Workgroup, Sub-Committee on Radiocommunications and Search and Rescue, First Report: COMSAR 7/10/1* (November 8, 2002), *COMSAR 7/INF.4* (November 8, 2002) and *COMSAR 7/INF.5* (November 8, 2002); and *Second Report: COMSAR 8/9* (December 18, 2003). The authors wish to thank Mr. David Jardine-Smith, Correspondence Work Group Chair, and the other Work Group members for their invaluable insights into the challenges associated with responding to a large passenger ship MRO. Another excellent resource is the *IAMSAR Manual (Volume III): Mobile Facilities* (London: IMO, 2008). It should be noted that this Section can apply for passenger aircraft as well as passenger ships. The issue is rescuing large numbers of survivors at sea.

[70] Retrieving MRO survivors from the water and survival craft is not a linear relationship when considering the number of persons to be recovered. Rescuing 1,000 people is not simply a question of requiring ten times the SAR unit capacity, or ten times the time as rescuing 100 people. It was the view of the IMO Correspondence Work Group that developed the *Large Passenger Ship Safety Report* that the rate of increase in difficulty is, based on the number of persons to be recovered, more exponential than linear. Recovering five people can be difficult in some circumstances (e.g., bad weather, darkness, moderate to heavy seas, limited survival

timeframe, high-sided or otherwise limited rescue units, etc.). Recovering fifty, or five hundred, are step changes of difficulty. Recovering five thousand persons in an offshore MRO could be insurmountable.

[71] Captain Christer Lindvall, Captain Jörgen Lorén and Captain Rolf Westerström, "Give all ships the means to assist in major accidents at sea" (March 8, 2012); available on the Internet at: http://www.first-rescue.org/assets/international-op-ed-on-mass-rescue-by-christer-lindvall-j%C3%B6rgen-loren-rolf-westerstr%C3%B6m-2012-06.pdf; accessed on December 13, 2012.

[72] While the focus of this paper is on the challenges of an offshore MRO, these considerations are relevant to any maritime MRO anywhere.

[73] There have been instances in which large passenger ships have been entirely evacuated by helicopter. For example, in the sinking of the passenger ship *Oceanus* off Eastern Cape, South Africa (August 04, 1991) all 571 persons on board were rescued by helicopters. Availability of SAR helicopters and geographic location of the MRO is critical.

[74] Survival craft are usually provided with canopies or other covers to protect their occupants. Unfortunately, these covers make getting people *out* of the survival craft difficult. When a helicopter is approaching a survival craft, the cover can cause extra windage that may cause the craft to be blown away or overturned by the helicopter's downwash. If the cover is removed or removable, it may break free in the downwash, hampering hoisting and injuring the survival craft's occupants.

[75] IMO, *Guide to Recovery Techniques MSC.1/Circ.1183* (May 31, 2006): Annex, page 7; available on the internet at: http://www.uscg.mil/hq/cg5/cg534/MassRescueOps/IMO%20-%20Guide%20to%20Recovery%20Techniques%20(MSC%201%20Circ%201182)%2031%20May%202006.pdf; accessed on December 10, 2012.

[76] This became a problem in the U.S. Coast Guard, U.S. Air Force and Canadian military response to the fire and subsequent rescue of 520 passengers and crew from the passenger ship *Prinsendam* on October 4, 1980. Two Air Force pararescuemen were deployed to one of the *Prinsendam's* lifeboats to assist in hoisting the survivors by helicopter. It was later determined that one lifeboat was missing, requiring further searches by the on scene SAR facilities. It was not until the early hours of October 5 that the missing lifeboat was located with 18 survivors and the two missing pararescuemen. Reference: Commander, Seventeenth Coast Guard District, *M/V PRINSENDAM FIRE GULF OF ALASKA; SAR Case Study* (February 3, 1981): Enclosure (1), page 2.

[77] IMO, *Guide to Recovery Techniques MSC.1/Circ.1183* (May 31, 2006): Annex, page 3; available on the internet at: http://www.uscg.mil/hq/cg5/cg534/MassRescueOps/IMO%20-%20Guide%20to%20Recovery%20Techniques%20(MSC%201%20Circ%201182)%2031%20May%202006.pdf; accessed on December 10, 2012.

[78] LSA Code: *International Life-Saving Appliance (LSA) Code (1996)*. The LSA Code provides international requirements for life-saving appliances required by the SOLAS Convention.

[79] Survival craft are not considered a place of safety.

[80] Existing SOLAS Convention requirements (rescue boat, pilot ladder, embarkation ladder, etc.) do not envision an MRO scenario. Consequently, in an MRO, survivors may need to remain in survival craft for extended periods.

[81] This problem occurred during the response to the *Estonia*, *Oceanos*, *Costa Concordia*, as well as other large passenger ship disasters.

[82] IMO, *Guide to Recovery Techniques MSC.1/Circ.1183* (May 31, 2006): Annex, Page 2; available on the internet at: http://www.uscg.mil/hq/cg5/cg534/MassRescueOps/IMO%20-%20Guide%20to%20Recovery%20Techniques%20(MSC%201%20Circ%201182)%2031%20May%202006.pdf; accessed on December 10, 2012.

[83] A raft used in this way during the response to the September 28, 1994, sinking of the *Estonia* in the Baltic Sea split while being lifted due to the weight of the persons and water in the raft. As a result, one person was lost.

[84] U.S. Coast Guard Research and Development Center, *Maritime Mass Rescue Interventions; Availability and Associated Technology - Final Report* (December, 2010): 20.

[85] Large passenger ship companies typically have expertise and capabilities to arrange transportation and other needs of survivors who are delivered to a place of safety with adequate infrastructure.

[86] IMO, *Guide to Recovery Techniques MSC.1/Circ.1183* (May 31, 2006): 2; Available on the internet at: http://www.uscg.mil/hq/cg5/cg534/MassRescueOps/IMO%20-%20Guide%20to%20Recovery%20Techniques%20(MSC%201%20Circ%201182)%2031%20May%202006.pdf; accessed on December 10, 2012.

[87] IMO, *Guide to Recovery Techniques MSC.1/Circ.1182* (May 31, 2006): Annex, page 3; Available on the internet at: http://www.uscg.mil/hq/cg5/cg534/MassRescueOps/IMO%20-%20Guide%20to%20Recovery%20Techniques%20(MSC%201%20Circ%201182)%2031%20May%202006.pdf; accessed on December 10, 2012.

[88] Ibid, Annex, Page 3.

[89] Ibid, Annex, Page 3.

[90] Special thanks to the authors of this section: U.S. Coast Guard Passenger Vessel Safety Specialists Mr. George (Rob) Lee (U.S. Coast Guard Eleventh District, Alameda, California) and Mr. Rick Janelle, (U.S. Coast Guard Seventeenth District, Juneau, Alaska). Authors expressed that each MRO is unique, depending on the type of craft or structure involved, number and condition of victims, location, weather, and available response assets, capabilities of the crew and ownership, and other contributing factors.

[91] George "Rob" Lee and Rick Janelle, "10 Mass Rescue Operational Realities," *The Coast Guard Proceedings of the Marine Safety and Security Council: Search and Rescue* (Fall, 2011): 28-33; available on the Internet at: http://www.uscg.mil/proceedings/archive/2011/Vol68_No3_Fall2011.pdf; accessed on January 02, 2013.

[92] Svenn Fjeld Olsen, "The Frequency of Maritime Disasters: A Comparison with Other Modes of Transport;" Paper presented at World Maritime University Malmo, Sweden, March 24-25,

2004; available on the Internet at: http://www.ntf-research.org/konference240304/papers/3a_summary_The%20Frequency%20of%20maritime%20disasters.pdf; accessed on January 29, 2013.