



Introduction to Evacuation

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The ship-sea evacuation problem

Process of evacuating a large passenger ship is very complex

- Involves the management of large numbers of people on a complex moving platform
- People often have very little knowledge

Ship evacuation differs to evacuation from airplanes and buildings

- Airplanes: relatively simple geometries
- Buildings: implies steady platforms, no need for assistance and no need for preparation for survival in a harsh environment following the abandonment



«Evacuability»

Evacuability is passenger evacuation performance capability

- Encompass evacuation time
- Identification of potential bottlenecks
- Assessment of layout
- Life saving appliances
- Passenger familiarisation with a ship's environment
- Crew training
- Effective evacuation procedures/strategies
- Intelligent decision support systems for crisis management
- Design/modification for ease of evacuation.

Evacuability problems

- Mass evacuation of thousands of people from an extremely complex environment
- Unknown inaccessibility problems exacerbated such as:
 - progressive flooding
 - fire/smoke
 - the inherent uncertainty deriving from unpredictability of human behaviour
- Limitations in time

Background: List of Accidents

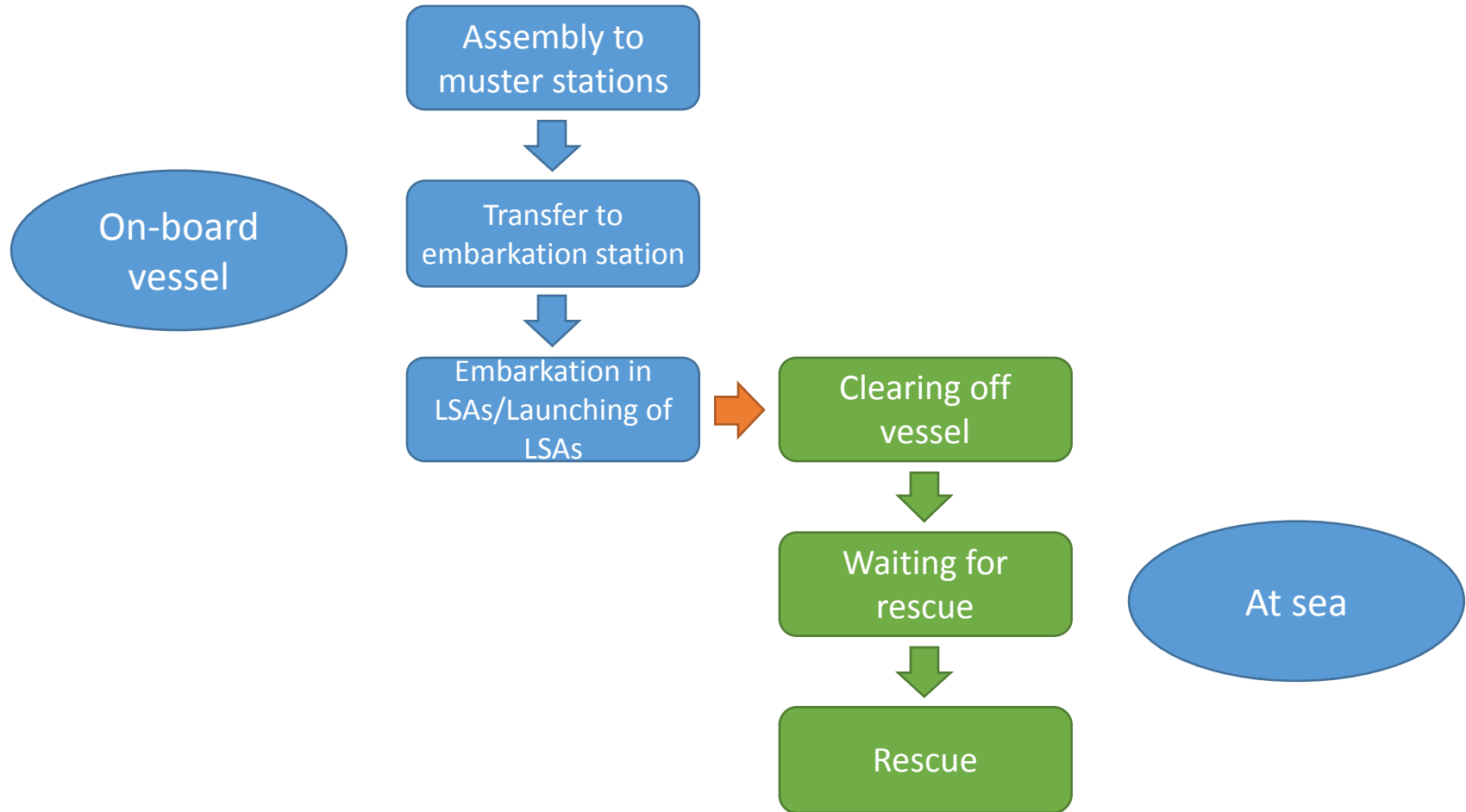
2007 – Explorer: 100 passengers, 54 crew, 0 fatalities, 3 hours evacuation time

2010 – Lisco Gloria: 203 passengers, 32 crew, 0 fatalities

2012 – Costa Concordia: 3229 passengers, 1023 crew, 32 fatalities, 6 hours evacuation time

2014 – Norman Atlantic: 422 passengers, 56 crew, 18-20 fatalities, 1 day evacuation time

Evacuation procedure



First regulations

- 1995 International Conference on the Safety of Life at Sea (SOLAS '95)

Regulation SOLAS II-2/28.3:

Escape routes on-board Ro-Ro ferries shall be evaluated by a suitable evacuation analysis

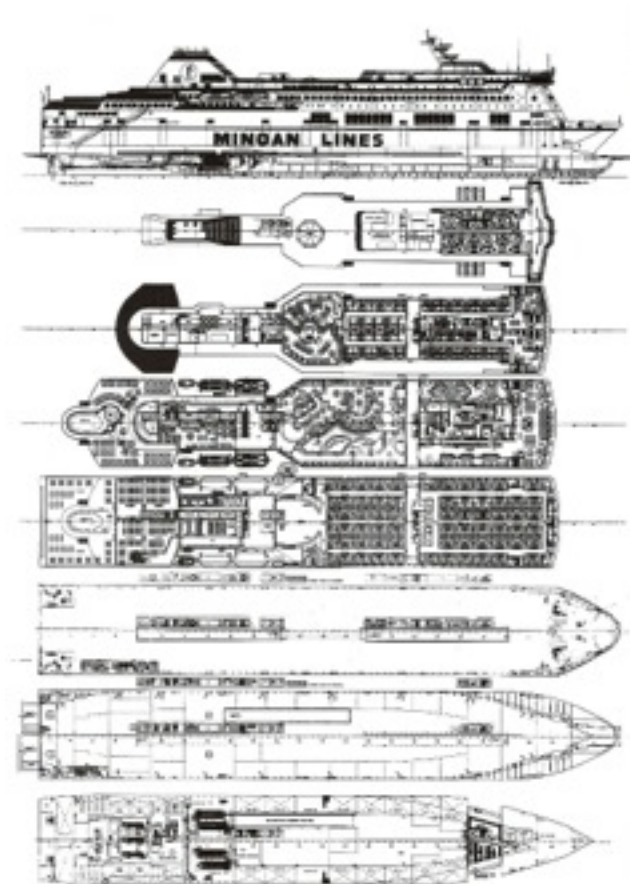
- 1999 International Maritime Organisation (IMO)

Interim Guidelines for the execution of the evacuation analysis

(Revised) address both simplified and advanced analyses

Regulations cntd.

- SOLAS-III-21/1.4: maximum time allowed for embarkation and launching of survival boats is 30 mins
- SOLAS 1995: evacuation of Ro-Ro passenger ships should be completed in 60 mins



IMO Regulations for Life Saving Appliances

LSA:

- SOLAS Ch III
- Life-Saving Appliances code
- A.689(17)
- MSC.81(70)
- A.520(13)

Alternative design & arrangement for LSAs:

- SOLAS Ch III Reg.38
- MSC.1/Circ.1212



IMO Regulations for Mustering & Abandonment

Design:

- Means of escape SOLAS Ch II-2 Reg. 13:
 1. 2 widely separated means of escape, door opened in the way of escape, direct access to stairway enclosure, lightings, locking systems of doors...
 2. FSS Chap 13: design of handrails, width of escapes, landings, assembly stations...
 3. ROPAX: Clear escapes, fixed furniture, max +/- 2 decks to climb, cabin safety instructions, load bearing handrails, evacuation analysis (MSC Circ. 1238 Guidelines for evacuation analysis)

Procedures:

- Procedure, drills and exercises (ISM Code Sec. 7&8, IMO Resolution A.852(20), Circ. 1238)
- Passengers identified (number, gender, age, disabilities, ...) SOLAS Ch III Reg.27
- Safety instructions to passengers
 1. Muster List (SOLAS Chapter III Reg. 37)

2. Muster for instructions must take place within 24h after embarkation (SOLAS Chapter III Reg. 8.2 and 8.4)
3. Drills weekly (SOLAS Chapter III Reg. 19)
4. Announcements (IMO A.691(17), Circ. 699)
 - Officers
 1. Emergency procedures (STCW Code Section AII, MERSAR)
 2. Crisis management (STCW Code Section AV)
 - Decision Support System (SOLAS Ch III Reg. 29)
 - Launching within 30 min from abandon ship signal (SOLAS Chapter III Reg. 21.1.3)

IMO Regulations for Rescue

Design:

- No specific requirement

Procedures:

- Information on passengers to be readily available to SAR services in case of undesirable event (SOLAS Ch III Reg.27)
- Procedures for alerting SAR Authorities (MSC/Circ.892)
- Crew should send daily report to their company (MSC/Circ.1043)
- Helicopter on-board facilities and landing areas (IMO Res. A.855(20), MSC/Circ.895)
- Co-operation plans between SAR and Passengers ships (IMO MSC/Circ.1079 COMSAR/ Circ.31, IAMSAR Manual)
- Recommendations to coastal states to provide SAR services (UNCLOS)

IMO MSC Circ 1033

MSC Circ 909 → evacuation analysis of Ro-Ro passenger ships (1999)

MSC Circ 1001 → interim guidelines for a simplified evacuation analysis of high speed passenger craft

MSC Circ 1033 (interim):
Passengers will not respond immediately to a call
Response time is a key component to evacuation process
Data based on land building measurements

↓
FIRE EXIT project → demonstrated that the response time data in MSC Circ 1033 was not sufficiently detailed → MSC Circ 1238

IMO MSC Circ 1238

Total passenger ship evacuation: 60 mins $\rightarrow \leq 3$ main vertical fire zones (MVZ)

80 mins $\rightarrow > 3$ main vertical fire zones

Minimum of 4 passenger evacuation cases scenarios to be considered.

- Full passenger ship evacuation at night and day
- Modelling just one of the MVZ with 50% available stairways or 50% of the passengers from a neighbouring zone are forced to move into the zone to proceed to the assembly point (night and day)

IMO MSC Circ 1238

Simplified passenger ship evacuation analysis method

Passengers moving like particles in a liquid flowing through a pipe (Hydraulic model)

- All passengers and crew will begin the evacuation at the same time and will not hinder each other
- Passengers and crew will evacuate via the main escape routes
- Walking speeds depend on the density of the people, flow is only in one direction and there is no overtaking
- Passenger load and initial distribution are based on the safety system on chapter II-2 SOLAS is known as Fire Safety System (FSS code)
- Counter-flow is accounted for by a correction factor
- Effects of ship motion, passenger age and mobility, unavailability of corridors, effects of smoke, etc., are accounted for by a correction and safety factor

IMO MSC Circ 1238

Advanced passenger ship evacuation analysis method

Passengers and crew modelled as unique individuals with specific capabilities and response times

- Crew will immediately be at the evacuation duty stations ready to assist
- Passengers follow the signage systems and crew instructions
- Guidelines provide response time, passenger sex and age distributions
- Walking speeds on flat terrain and stairs

IMO MSC Circ 1238

Guidelines for a simplified evacuation analysis for new and existing passenger ships

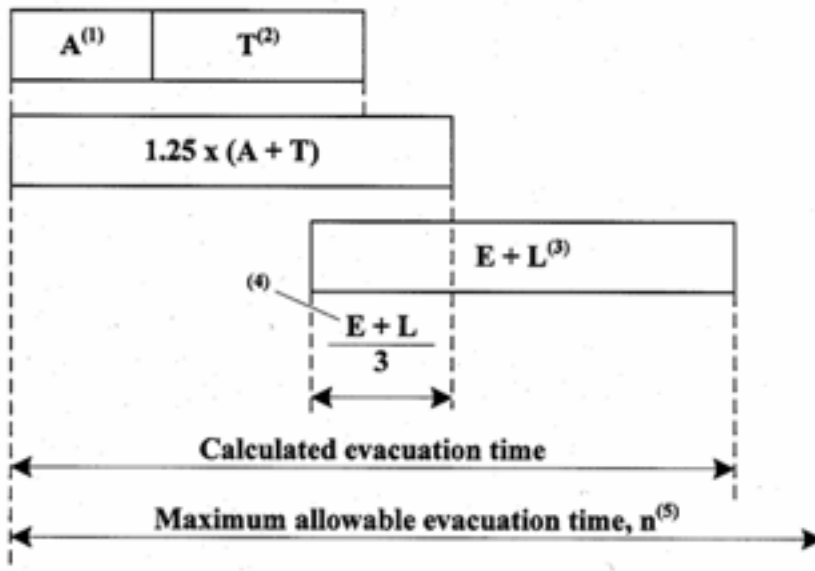
The purpose is to present the methodology for conducting a simplified evacuation analysis and, in particular, to:

1. Identify and eliminate, as far as practicable, congestion which may develop during an abandonment, due to normal movement of passengers and crew along escape routes, taking into account the possibility that crew may need to move along these routes in a direction opposite the movement of passengers; and
2. Demonstrate that escape arrangements are sufficiently flexible to provide for the possibility that certain escape routes, assembly stations, embarkation stations or survival craft may be unavailable as a result of a casualty.

IMO MSC Circ 1238

Guidelines for a simplified evacuation analysis for new and existing passenger ships

$$1.25 (A + T) + 2/3 (E + L) \leq n$$



1. 10 min in case 1 and case 3, 5 min in case 2 and case 4
2. Travel time T expressed in sec as given by: $T = (\gamma + \delta) t_l$, where:
 - γ = is the correction factor to be taken equal to 2 for cases 1 and 2 and 1.3 for cases 3 and 4;
 - δ = is the counterflow correction factor to be taken equal to 0.3 and;
 - t_l = is the highest travel time expressed in seconds in ideal conditions
3. $E + L \leq 30$ min in compliance with SOLAS regulation III/21.1.4
4. overlap time = $1/3 (E + L)$
5. **60 mins** $\rightarrow \leq 3$ MVZ, **80 mins** $\rightarrow > 3$ MVZ

Further steps...

Currently guidelines do not take account of:

1. Family group behaviour
2. Effects of heat and smoke, ship motion
3. Heel and trim on the passenger/crew performance



Source: EXODUSprogram

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