"FLOODSTAND (218532) Final Workshop/Seminar"
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EU project FLOODSTAND – WP5 – Evacuation process

INTEGRATED FLOODING CONTROL AND STANDARD FOR STABILITY AND CRISES MANAGEMENT

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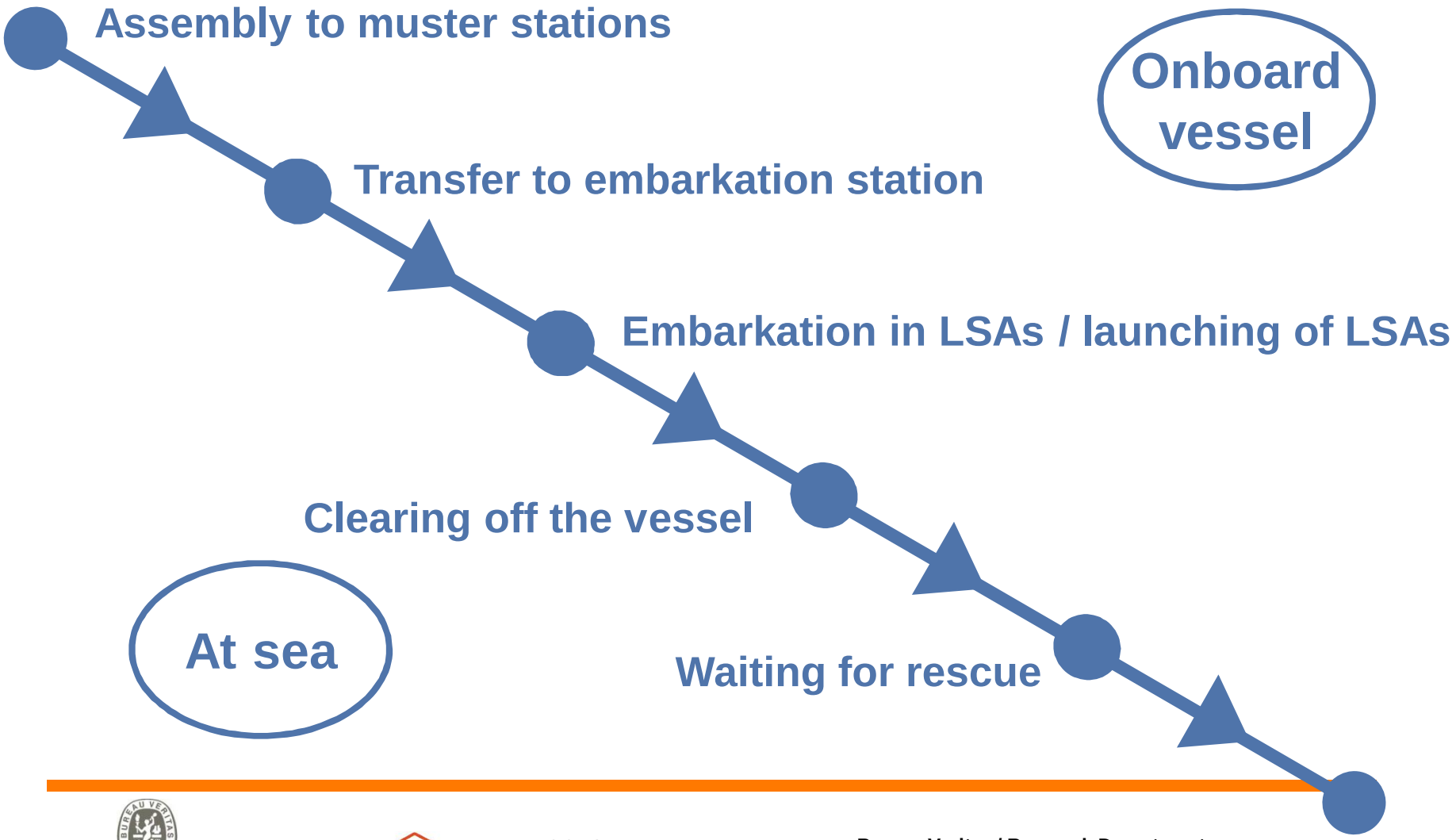
Objectives

- Assess the risk associated with Mustering, Abandonment and Rescue process:
  - Evaluate the time needed for the evacuation process to be performed (i.e. time needed for passengers to abandon the ship before she sinks/capsizes).
  - Evaluate the risk of performing an Abandonment and Rescue (injuries/casualties are to be expected).
  - Both Time to evacuate and A/R associated risks are to be exploited by WP4 and WP6 to provide the Master with assistance to decide whether or not the ship must be abandoned.
- Partners: BV, BMT, SSRC, S@S

Mustering, Abandonment & Rescue Route



MAR route – obstacles

- The Escape & Rescue Route is a conceptual approach to formalise the **sequence of actions** to perform the evacuation & rescue process
- Obstacles are the **hazards generated** by the Escape & Rescue Route that both the hardware system and the humans have to face
- Obstacles types:
  - Human Factor
  - Hardware
  - Time Related

Phases	*Elements*	*Obstacles*	*Type*
Mustering	Going to muster stations	Passengers' reaction time	Time related
		Passengers location	Time related
		Passengers mobility	Time related
		Effect of heel on mobility	Time related
Leaving the vessel	Deployment	Malfunction	Hardware
	Boarding	Mobility failure	Human factor
	Lowering	Premature release	Hardware
		Injuries / impact hull	Human factor
	Release	Fail to release	Hardware
		Injuries / Slamming	Human factor
Surviving at sea	Clear ship	Fail manoeuvring	Hardware
	At sea	Capsizing	Hardware
		Seasickness	Human factor
Rescue	Recovery	Climbing pilot ladder	Human factor

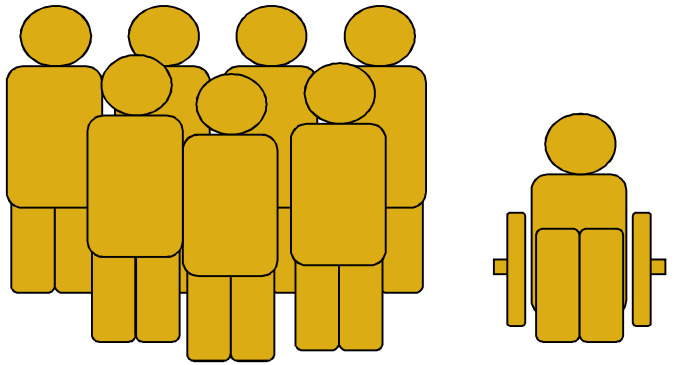
Human Health Status concept

Human Health Status		Description	Related mobility
GH	Good Health	Good physical and mental health	Good mobility
MI	Minor Injuries	Scratches, no fracture, no trauma	Mobility degraded
SI	Severe Injuries	Fractures and/or trauma	Mobility requiring assistance
D	Deceased	Fatal injury	No mobility

GH	α
MI	β
SI	χ
D	δ

HHS vector:

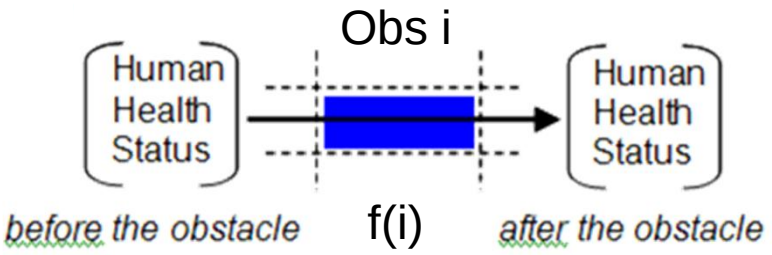
Proportions of the population with each health status



$$\alpha + \beta + \chi + \delta = 1$$

Local & global degradation matrix

- Local (for each obstacle) HHS degradation function:



$$\begin{cases} a_i + b_i + c_i + d_i = 1 \\ f_i + g_i + h_i = 1 \\ k_i + l_i = 1 \end{cases}$$

$$\begin{bmatrix} a_i & 0 & 0 & 0 \\ b_i & f_i & 0 & 0 \\ c_i & g_i & k_i & 0 \\ d_i & h_i & l_i & 1 \end{bmatrix} * \begin{bmatrix} \alpha_{i-1} \\ \beta_{i-1} \\ \chi_{i-1} \\ \delta_{i-1} \end{bmatrix} = \begin{bmatrix} \alpha_i \\ \beta_i \\ \chi_i \\ \delta_i \end{bmatrix}$$

α_i : % pop. in Good Health after obstacle i

β_i : % pop. with Minor Injuries after obstacle i

χ_i : % pop. with Severe Injuries after obstacle i

δ_i : % of the pop. lost after obstacle i

g_i : Probability of being in SI after obstacle i given in MI before

Local & global degradation matrix

- Global (over the MAR route) HHS degradation function:

$$\left[f\right] = \left[f_N\right] * \ldots\ldots * \left[f_B\right] * \left[f_A\right]$$

Initial Human Health Status

$$\begin{cases} a + b + c + d = 1 \\ f + g + h = 1 \\ k + l = 1 \end{cases} \qquad \begin{bmatrix} a & 0 & 0 & 0 \\ b & f & 0 & 0 \\ c & g & k & 0 \\ d & h & l & 1 \end{bmatrix} * \begin{bmatrix} \alpha_0 \\ \beta_0 \\ \chi_0 \\ \delta_0 \end{bmatrix} = \begin{bmatrix} \alpha_N \\ \beta_N \\ \chi_N \\ \delta_N \end{bmatrix}$$

- α_N: % pop. in Good Health at the end of the process
- β_N: % pop. with Minor Injuries at the end of the process
- χ_N: % pop. with Severe Injuries at the end of the process
- δ_N: % of the pop. lost at the end of the process

Final Human Health Status

Expected number and distribution of fatalities

- The global degradation matrix calculation has been implemented in the Casualty Calculator, that outputs:
  - Expected fatalities: final HHS
  - Standard deviations: error propagation – the only source of uncertainty is the error of the obstacle matrices
  - Probability distribution of fatalities; need to consider two types of obstacles:
    - ‘Human factor’ obstacles, affecting individual passengers (e.g. Exposure)
    - ‘Hardware obstacles’, affecting all passengers in a LSA (e.g. Capsizing of lifeboat)

Input parameters

- **Type and number of LSAs:**
  - Lifeboat; 150 people
  - Liferafts; 25 people. Two types:
    - Boarded through ladders
    - Davit launched
- **Number of passengers in 3 age groups:**
  - (Y) <50 years ; (M) 50-75 years ; (O) > 75 years

$$E(N) = \sum_{iLSA} (N_Y \times Fatality\_rateY + N_M \times Fatality\_rateM + N_O \times Fatality\_rateO)_{iLSA}$$

- **Environmental conditions:**
  - Sea State, water temperature
- **Available SAR systems:**
  - Type, characteristics (capacity, time to embark, speed), location wrt ship
- **Ship type and arrangement:**
  - Cruise liner and Ropax

List of obstacles

- Mustering

Phases	*Elements*	*Obstacles*	*Type*
Mustering	Going to muster stations	Passengers' reaction time	Time related
		Passengers location	Time related
		Passengers mobility	Time related
		Effect of heel on mobility	Time related

List of obstacles

- Lifeboat

Phases	*Elements*	*Obstacles*	*Type*
Leaving the vessel	Deployment	Davit failure	Hardware
	Boarding	Time to embark	Time related
	Lowering	Premature release	Hardware
		Injuries / impact hull	Human factor
		Structural failure / impact hull	Hardware
	Release	Injuries / Slamming	Human factor
Surviving at sea & rescue	Clear ship	Engine, release, manoeuvring failure	Hardware
	At sea	Time at sea (to rescue)	Time related
		Capsizing / downflooding	Hardware
		Injuries / LSA motion	Human factor
		Hypothermia	Human Factor
		Seasickness	Human Factor
	Recovery	Injuries / transfer of passengers through side doors, using escape or pilot ladders	Human factor

List of obstacles

- Liferaft (boarder through escape ladders)

Phases	*Elements*	*Obstacles*	*Type*
Leaving the vessel	Boarding	Time to embark	Time related
		Injuries / escape ladders	Human Factor
		Injuries / moving to seats	Human Factor
Surviving at sea & rescue	Clear ship	Fail manoeuvring (towing)	Hardware
	At sea	Time at sea (to rescue)	Time related
		Capsizing / downflooding	Hardware
		Injuries / LSA motion	Human factor
		Hypothermia	Human Factor
		Seasickness	Human Factor
	Recovery	Injuries / transfer of passengers through side doors, using lescape or pilot ladders	Human factor

List of obstacles

- Davit launched liferaft

Phases	*Elements*	*Obstacles*	*Type*
Leaving the vessel	Deployment	Davit failure	Hardware
	Boarding	Time to embark	Time related
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	Lowering	Premature release	Hardware
Surviving at sea & rescue	Clear ship	Fail manoeuvring (towing)	Hardware
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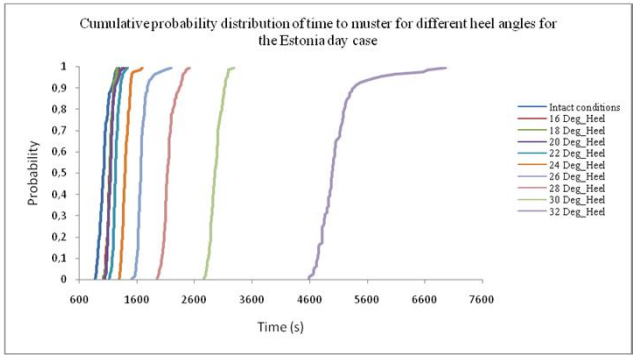
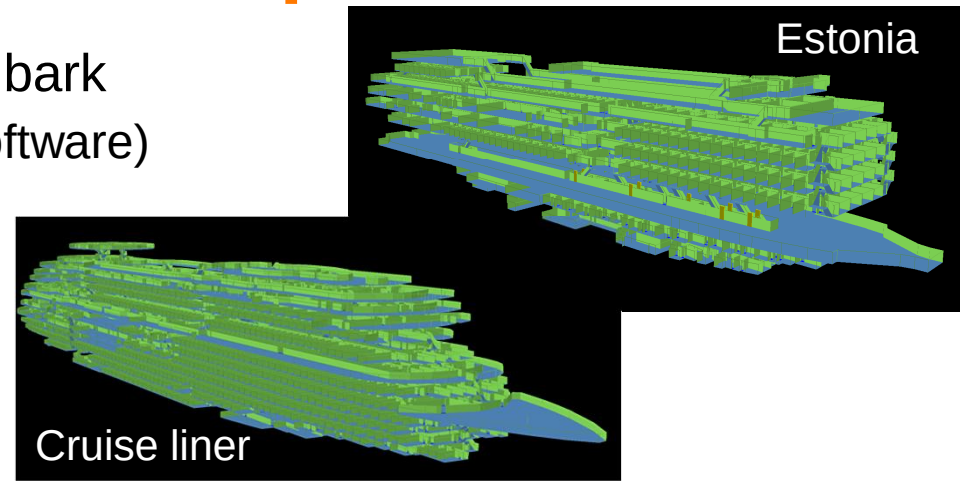
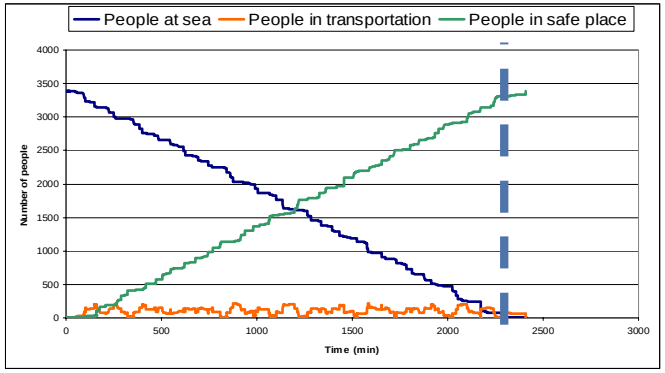
Calculation of time related parameters

- Time to Muster and Time to Embark
  - Modelled in Evi (Evacuation software)

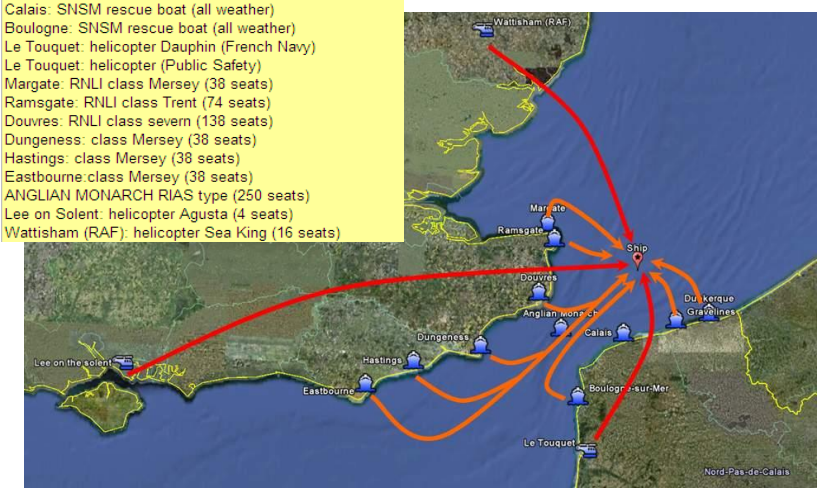




- Time to Rescue

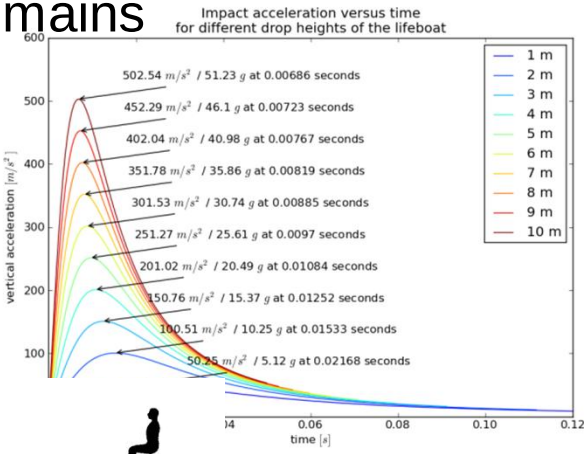


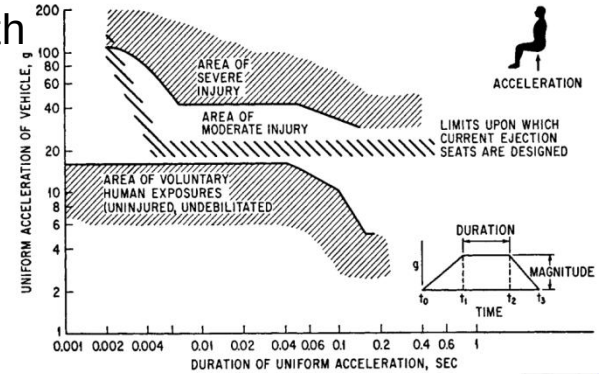
Dunkerque: rescue boat (all weather)
Gravelines: SNSM rescue boat (class 2)
Calais: SNSM rescue boat (all weather)
Boulogne: SNSM rescue boat (all weather)
Le Touquet: helicopter Dauphin (French Navy)
Le Touquet: helicopter (Public Safety)
Margate: RNLI class Mersey (38 seats)
Ramsgate: RNLI class Trent (74 seats)
Douvres: RNLI class severn (138 seats)
Dungeness: class Mersey (38 seats)
Hastings: class Mersey (38 seats)
Eastbourne:class Mersey (38 seats)
ANGLIAN MONARCH RIAS type (250 seats)
Lee on Solent: helicopter Agusta (4 seats)
Wattisham (RAF): helicopter Sea King (16 seats)

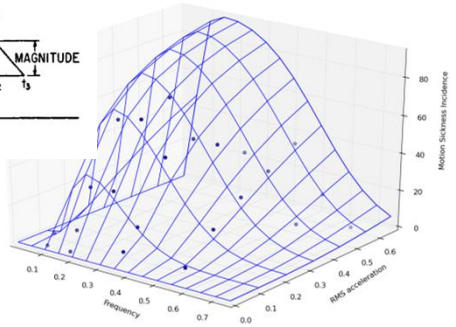


Calculation of matrices coefficients

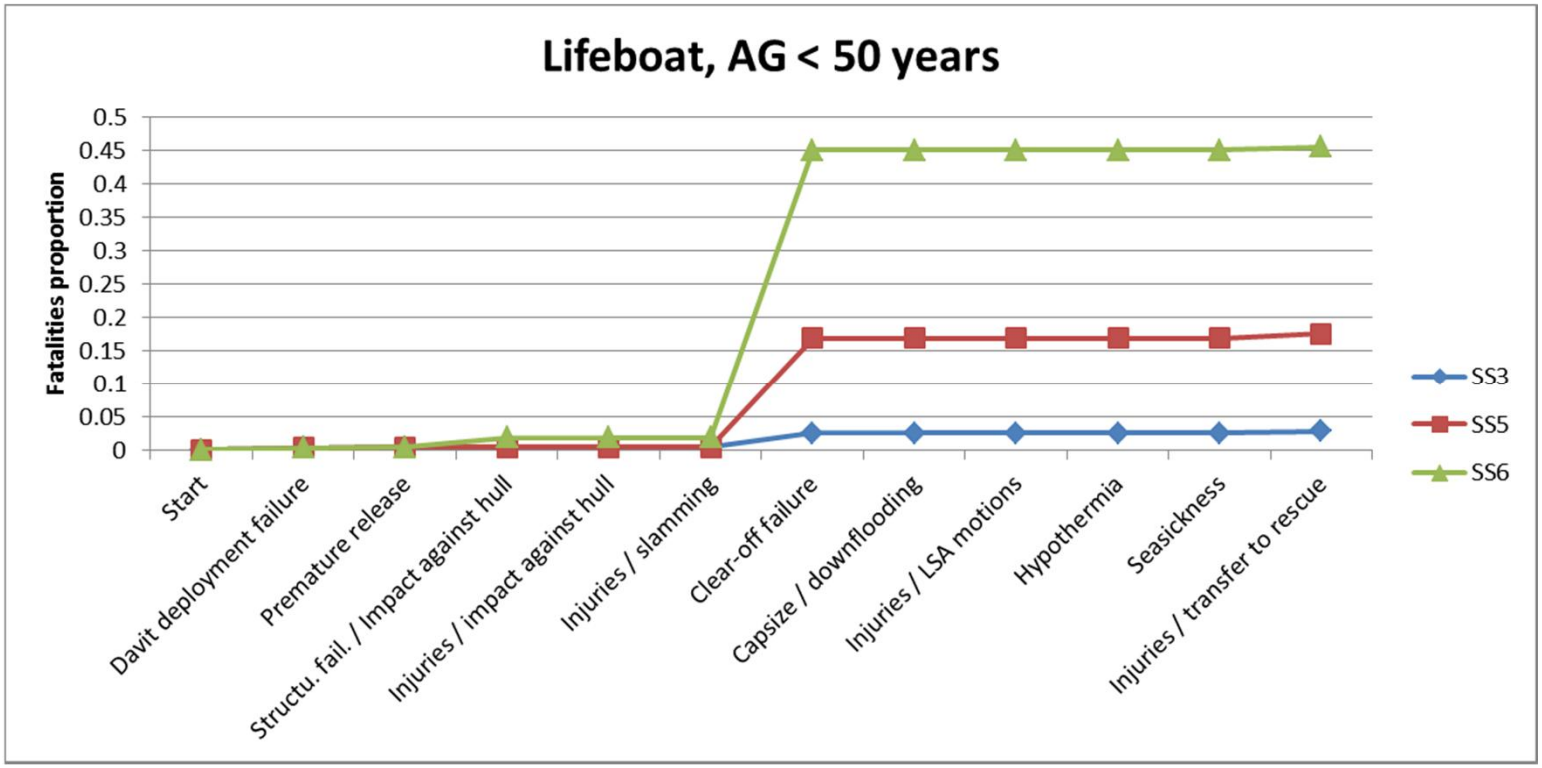
- The calculation of degradation matrices coefficients requires many specific analyses in a large range of technical domains
- Some obstacles were already studied in the EU Safecrafts project; they had to be adapted.
- Specific studies
  - Slamming
    - Accelerations calculations for slamming (Von Karman)
    - Consequences on human health (Harris & Bert)
  - Sea Sickness
    - Seakeeping calculation
    - Modelling of MSI (Motion Sickness Incidence) McCauley



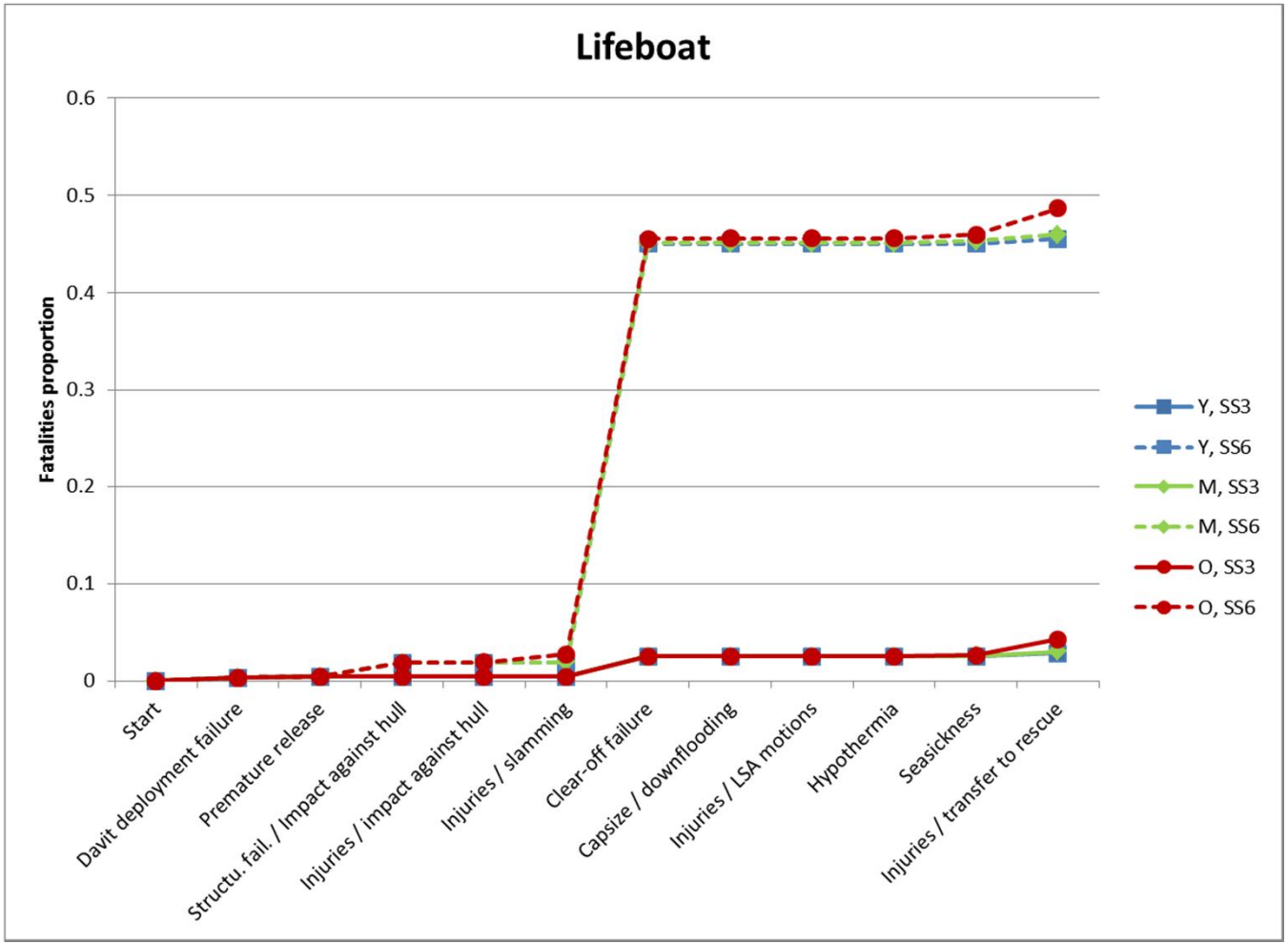




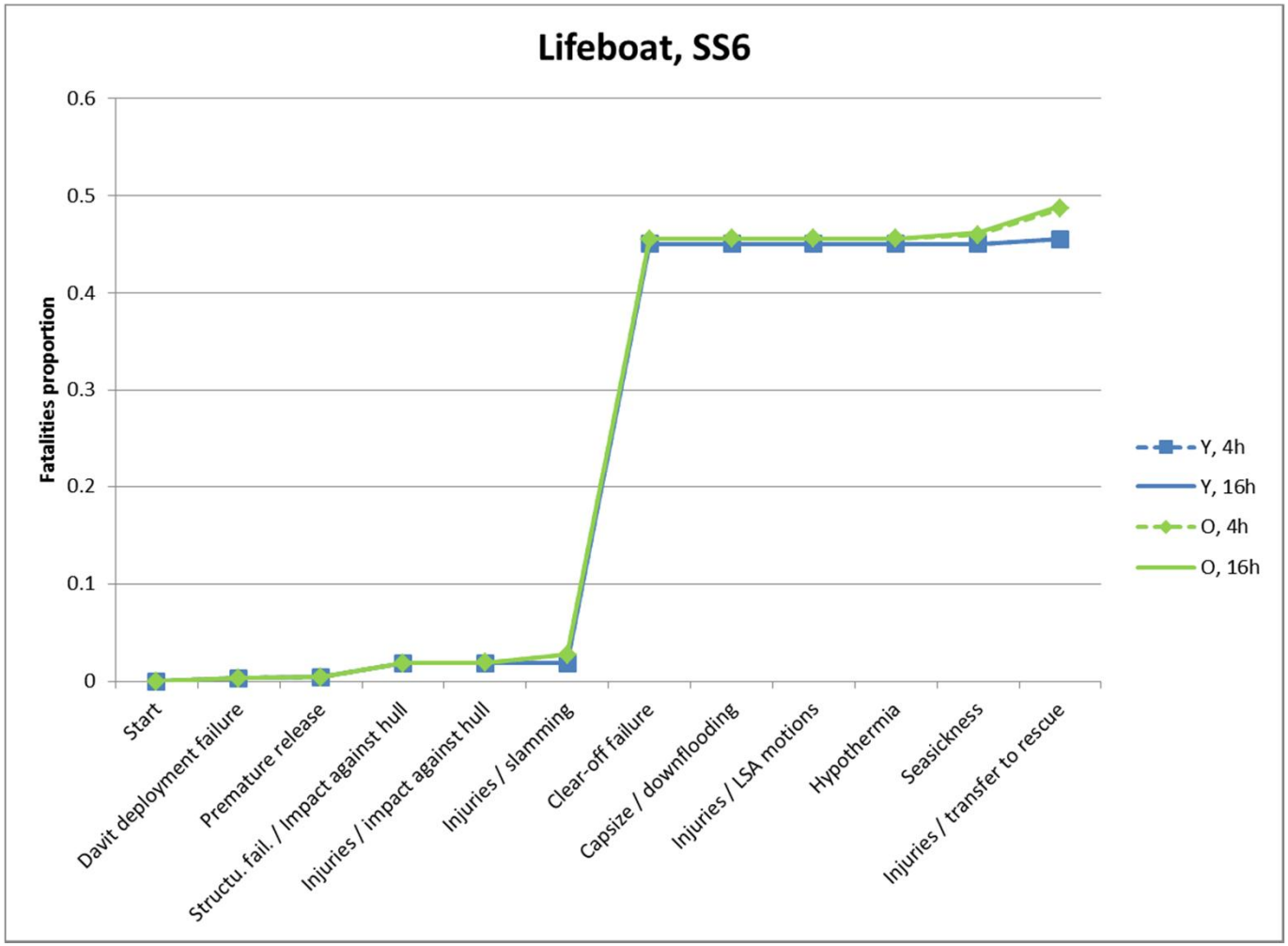
Results – Influence of sea state



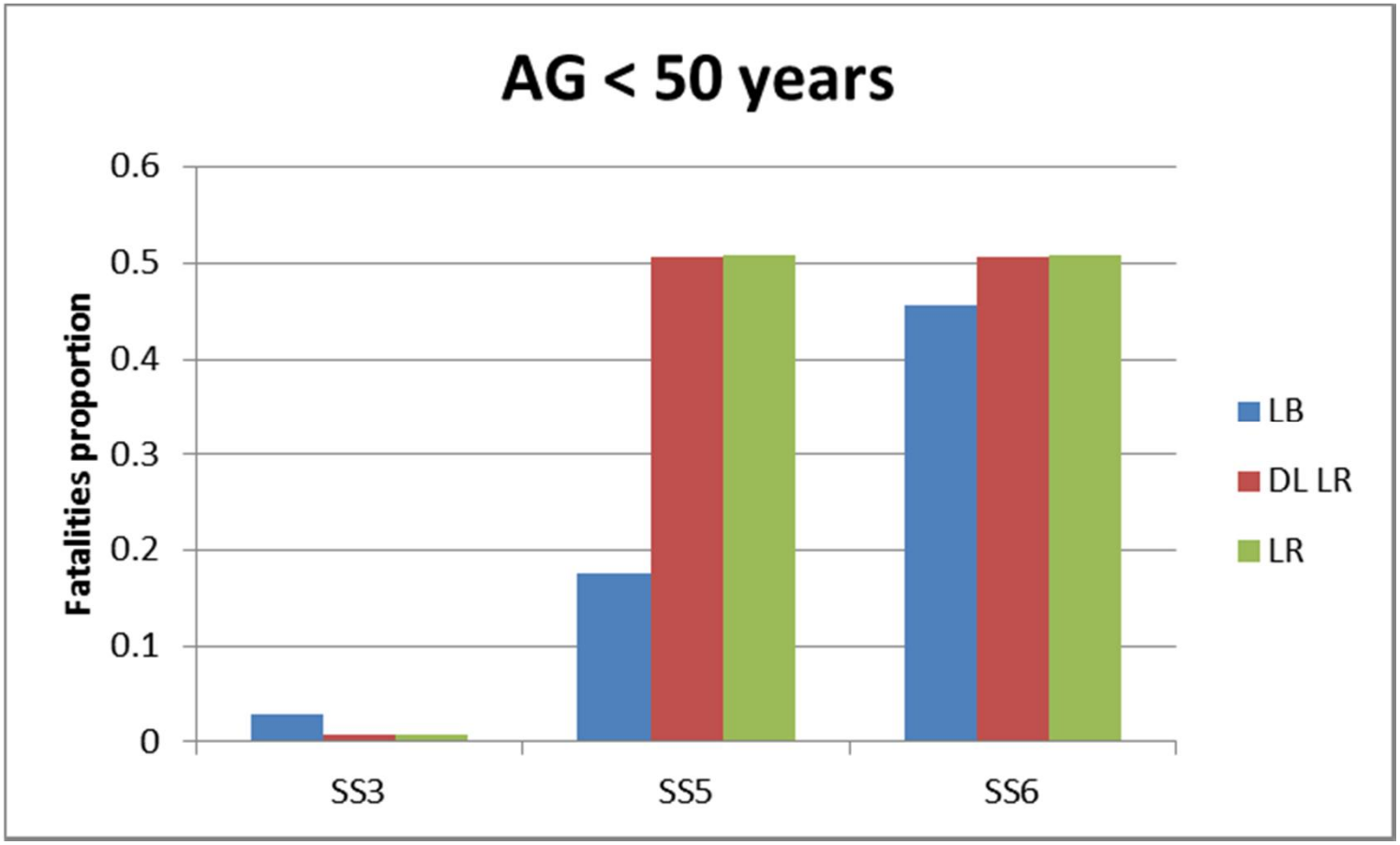
Results – Influence of age group



Results – Influence of time at sea



Results – Comparison between LSAs



Conclusion

- Models have been developed to calculate the expected number of fatalities in the MAR process for different types of LSAs; probability distribution and time related parameters are available too. They have been further exploited in WP6
- Generalization of some obstacles made to obtain generic models. Obtained accuracy difficult to assess; but
- In severe sea states, the manoeuvrability performance of LSAs to clear off the vessel is predominant
- Other possible exploitations of developed models for LSA alternative design studies

Reports

- D5.1: Regulatory analysis; collection of data on MAR process; description of the modelling approach
- D5.2: Modelling of the mustering process and description of the casualty calculator
- D5.3: Modelling of the abandonment process
- D5.4: Modelling of the rescue process
- D5.5: Uncertainty & sensitivity analysis; case study