"FP7 Maritime Transport Brokerage Event 2011 London"
1 Victoria street, London
Department of Business, Innovation & Skills
7th - 8th of September 2011

FLOODSTAND – Overview

INTEGRATED
FLOODING CONTROL
AND STANDARD FOR
STABILITY
AND
CRISES MANAGEMENT

Aalto University, School of Engineering
Department of Applied Mechanics
Marine Technology group / Marine Technology Research Unit

Contents

- Introduction
- Main objectives
- Some results of the project

Introduction: Aalto University (AALTO)

The coordinator of FP7 Project FLOODSTAND

Aalto University

AALTO is the result of the merge of three universities in Finland:

Helsinki University of Technology
University of Art and Design Helsinki
Helsinki School of Economics

→ **Aalto University**

Aalto University started 1 January 2010

Introduction (2):

Aalto University

- Aalto University statistics for 2010
  - Students: 19 516
  - Master´s degrees: 2 312
  - Doctoral degrees: 184
  - Professors: 338
- School of Art and Design
- School of Economics
- **School of Science and Technology** (2010)
  - Students: ~ 70 % (of all in AALTO)
  - Master´s degrees: ~ 80 % (")
  - Doctoral degrees: ~ 80 % (")
  - Professors: ~ 70 % (")

Note! Aalto University School of Science and Technology was divided into four new schools of technology since the 1st of January 2011):

- School of Chemical Technology
- School of Electrical Engineering
- **School of Engineering**
- School of Science

Introduction (3):

Aalto University

School of Engineering

Department of Applied Mechanics

Marine Technology

Introduction (4):

Marine Technology

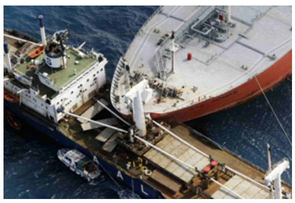
- Marine Traffic Safety Prof. P. Kujala; Head of the group
- Ship Hydrodynamics Prof. J. Matusiak
- Naval Architecture Acting Prof. J. Romanoff
- Ship Machinery (Ship Systems Eng.) Prof. NN
- Senior staff: 6
- Full time doctoral students: 14
- Support staff: 10
- In total: 40 people

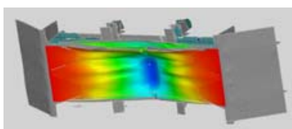
Marine Technology

Naval Architecture and Ship Structures

Prof. Petri Varsta (acting professor Jani Romanoff)

Structural Safety in Accidents





Design of Advanced Ship Structures

Fatigue Strength of Marine Structures

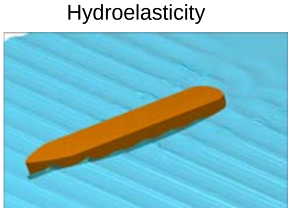
Marine Technology

Marine Hydrodynamics

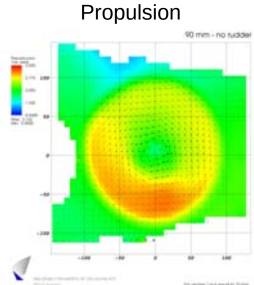
Prof. Jerzy Matusiak

Ship Stability

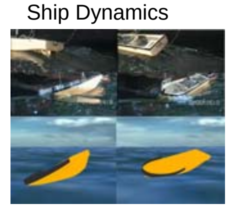
Hydroelasticity



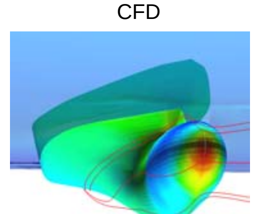
Propulsion



Ship Dynamics



CFD



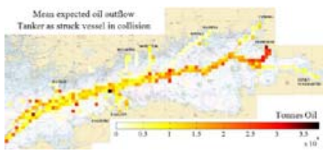
Marine Technology

Safety of Marine Transport and Winter Navigation

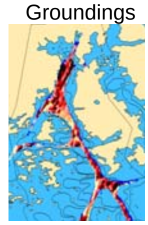
Prof. Pentti Kujala

Risk analysis of marine traffic in open water and in ice

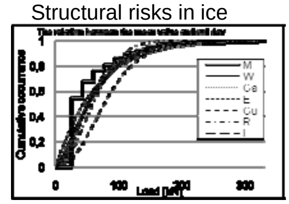
Collisions



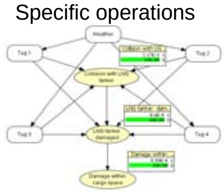
Groundings



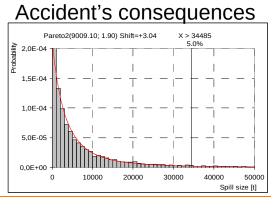
Structural risks in ice



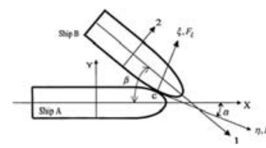
Specific operations



Accident's consequences



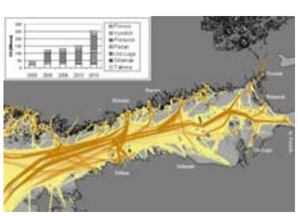
Collision energy



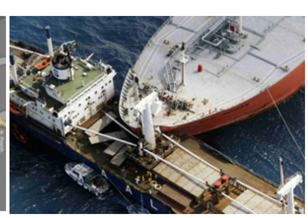
Marine Technology

Co-operation on Research Group Level
Ship Safety

Simulation of Traffic



Structural Safety in Accidents



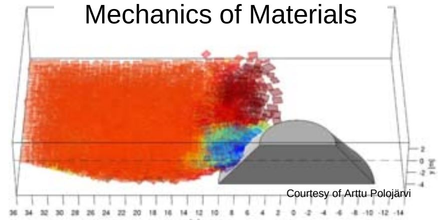
Ship Dynamics

Marine Technology

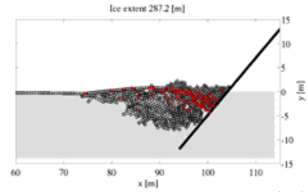
Co-operation on Department Level
Arctic Marine Technology

Marine Technology

Mechanics of Materials



Courtesy of Arttu Polojärvi



Courtesy of Jani Paavilainen

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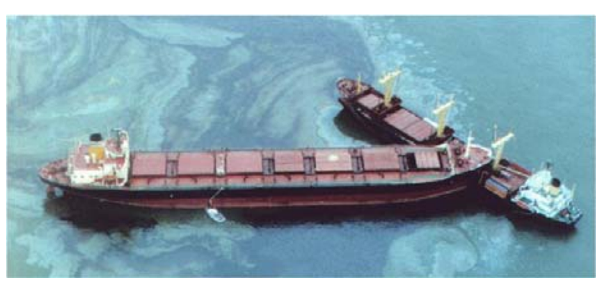
Co-operation on national level:
MERIKOTKA, Maritime research centre

Logistics and harbours (University of Turku and KyAMK)

Marine Traffic Safety (Aalto)

Environment (University of Helsinki)



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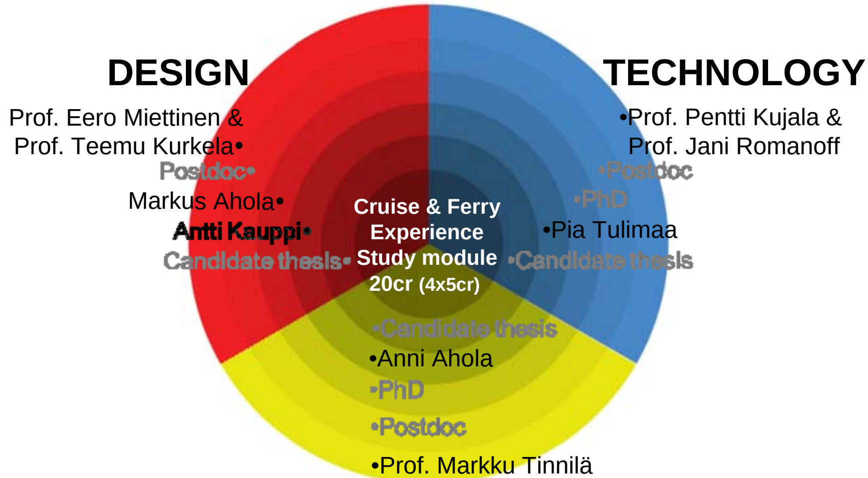
Co-operation on Aalto Level
Cruise and Ferry Experience

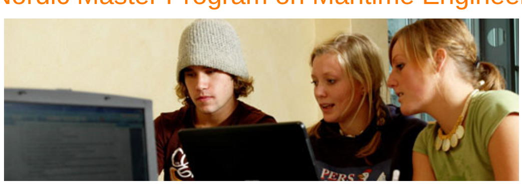


ECONOMICS

Marine Technology

•Co-operation at International Level

Nordic Master Program on Maritime Engineering



FP7 EU-projects: BESST, EFFICIENSEA, HYDROLAB, **SAFEWIN**, THROUGHLIFE, **FLOODSTAND**

etc.

Courtesy of Pekka Ruponen

Introduction (1) FLOODSTAND

Why FLOODSTAND ?

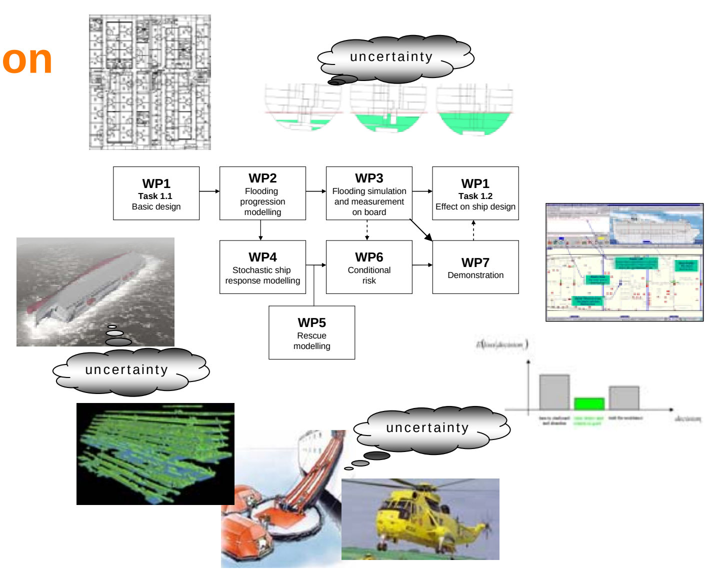
- **missing data for validation** of time-domain numerical tools
  for **assessment of passenger ship survivability**
  and
- a standard for a comprehensive measure of damaged ship stability
  addressing the **flooding risk**
  - reflecting the stochastic nature of **damaged ship stability in waves**
  - **based on first-principles** modeling
  - reflecting **foundering as a process** (loss of flotation/stability)
  - considering **risk-based decision making**

Introduction (2)

Research topics within

the structure

of the project



Introduction (3): FLOODSTAND

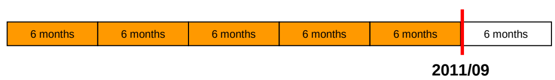
FLOODSTAND, a **3-year** collaborative research project

- focused on:

  Safety and security **by design** and

  Crisis management and rescue operations

- FLOODSTAND was started in **March 2009** and it will end in **February 2012**



- it has a planned project staff effort of almost 400 person months

- it has a total budget of over 4 M€ with nearly 70% EC contribution

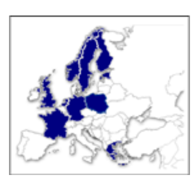
FLOODSTAND: Who we are?

- **FLOODSTAND** Consortium consists of 17 beneficiaries located in 10 European countries:

  classification societies, maritime administration, research organisations, shipyards, SMEs, universities etc.

  Aalto University (coordinator),

  STX Finland, CNRS, CTO, DNV, BMT Limited, MARIN, MEC, Meyer Werft GmbH, Napa Ltd, SSPA, SF-Control*, National Technical University of Athens, Bureau Veritas, S@S, MCA and University of Strathclyde (SSRC)



* Rosemount Tank Radar since 2011/01

FLOODSTAND: Who gives us advice?

- **FLOODSTAND** Advisory Committee consists of 8 members:

- **STA** (chairman),
  TraFi (member),
  USCG (member),
  IMO (member),
  GL (member),
  CAR (member),
  RCCL (member)
  NMRI (member)

=> maritime administrations, classification societie(s), ship operators, research institute

DNV was a member of AC in the first half of the project but acts now as a beneficiary

FLOODSTAND Objectives (1)

The main objectives of FP7 project FLOODSTAND (218532) are:

1. Modelling of leaking and collapsing of **non-watertight** structures
2. Finding out pressure losses (discharge coefficients) in typical openings
3. Simplified modelling of complex compartments
4. Flooding detection and damage estimation

Objectives (2)

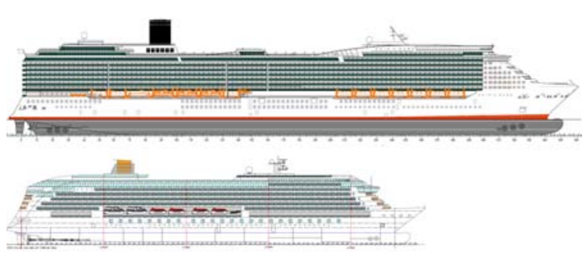
and

5. Stochastic ship response modelling
6. Rescue process modelling
7. Standard for decision making in crises
8. Demonstration

Research topic: WP1 Design and Application

Development of basic design of passenger ships => **Work completed**

Responsible partners: **STX Finland Oy**, MW



Above: **Large**
Post-Panama sized cruise ship:
125000 GT, L = 327 m,
B = 37.4 m, T = 8.8 m, and

Below: **Handy-size**
i.e. medium sized cruise vessel:
63000 GT, L = 238 m,
B = 32.20 m, T = 7.4 m

Analysis of the real flooding effects on design => **Work just started**

Responsible: **STX Finland Oy** and MW, DNV, AALTO

Research topic: WP2 Flooding progression modelling

Experiments with leaking and collapsing structures =>**Work completed**

Responsible: **CTO S.A.**; Other participants: STX Finland, MEC, MW, AALTO

- Semi-watertight doors, fire doors (sliding and hinged), cabin walls etc.
- Measured: **water pressure** and **flow rate** through the leakages during the structural deformation and collapse

Photographs of experimental tests made in full scale in 2010 at CTO in Gdansk, Poland

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Research topic: WP2 Flooding progression modelling

A photograph of experiments in full scale in 2010 at CTO in Gdansk, Poland

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Department of Applied Mechanics / Marine Technology

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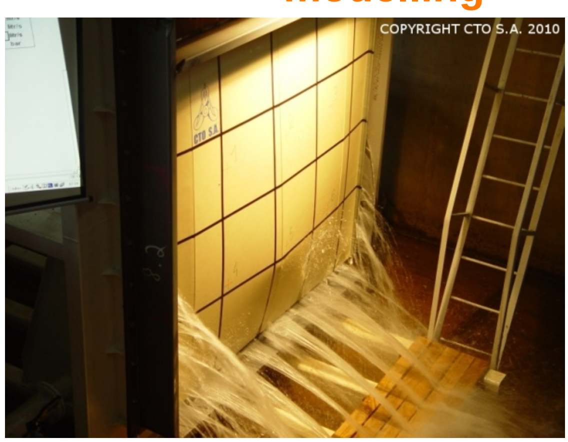
Research topic: WP2 Flooding progression modelling

A photograph of experiments in full scale in 2010 at CTO in Gdansk, Poland

Research topic: WP2 Flooding progression modelling



A photograph of experiments in full scale in 2010 at CTO in Gdansk, Poland

Research topic: WP2 Flooding progression modelling

Numerical modeling and **criteria for leaking and collapsing structures** => **Work completed**

Responsible: **MEC**; Other Participants: CTO, NAPA, STX

- Focus on **failure mechanisms** for doors and structural components
- Numerical simulations; explicit FEM code
- Flow rate vs. water pressure
- Specific data obtained also on
  - -- **the leakage pressure**, i.e. when the structure looses watertight integrity and
  - -- **the collapse pressure** gets it to collapse.
- Computations will be validated with experiments

=> criteria for leakage and collapse of doors etc.

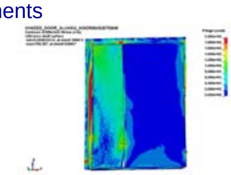
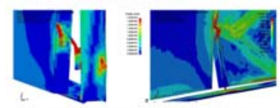


Figure 5.5 Outside of hinged fire-door at failure (von Mises equivalent stress)



In real flooding case it might be quite rear to obtain hydrostatic difference more than 2.06 meters as the structure is not watertight.

Research topic: WP2 Flooding progression modelling

Numerical modeling and **criteria for leaking and collapsing structures** => **Work completed**

(Responsible: **MEC**; Other Participants: CTO, NAPA, STX)

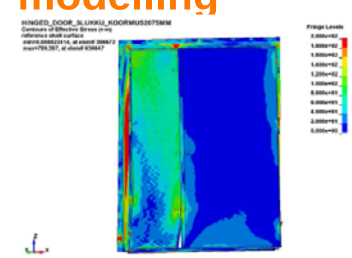
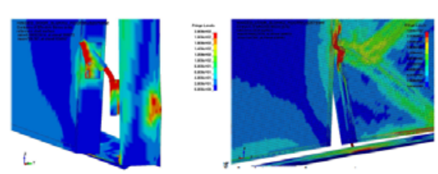


Figure 5.5 Outside of hinged fire-door at failure (von Mises equivalent stress)



In real flooding case it might be quite rear to obtain hydrostatic difference more than 2.06 meters as the structure is not watertight.

Research topic: WP2 Flooding progression modelling

An example of FLOODSTAND results:

Based on this work rough guidelines for modelling leakage and collapse of various A- and B-class doors etc. for flooding simulations could be given

These guidelines will be further provided for IMO's use.

Table 3: Rough guidelines for modelling doors and boundaries for flooding simulation, the values marked with an asterix (*) are estimations that are not based on experimental or FEM results

Type	direction	H_{leak} (m)	A_{ratio}	H_{coll} (m)	Notes
LWT	into	–	–	8.0*	minimal leaking at lower pressures, full collapse likely for $H > 8$ m; note that only direction "out" was tested
	out	–	–	8.0	
A-class sliding	into	0.0	0.025	1.0	almost constant leakage area ratio
	out	0.0	0.025	1.0	
A-class hinged	into	0.0	$0.02 \cdot H_{eff}$	2.5	A_{ratio} depends on the gap size
	out	0.0	$0.03 \cdot H_{eff}$	2.5	A_{ratio} depends on the gap size
A-class double leaf	into	0.0*	0.025*	2.0*	Not tested! Assumed to be independent on direction
	out	0.0	0.025	2.0	Collapsing could not be tested due to high leaking, value based on FEM
Cold room sliding door	into	0.0	$0.01 \cdot H_{eff}$	3.5	Only one direction tested; collapsing pressure height assessed with numerical methods
	out	0.0*	$0.01 \cdot H_{eff}$*	3.5*	
B-class joiner door	into	0.0	$0.03 \cdot H_{eff}$	1.5	panels around the door will fail first, A_{ratio} expression is very approximate
	out	0.0	0.03	1.5	door is distorted, A_{ratio} increases slowly
Windows	–	–	–	> 18	can be excluded in simulations

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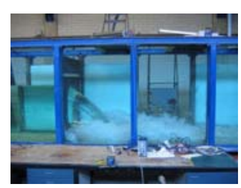
Research topic: WP2 Flooding progression modelling

Experimental studies on pressure losses => **Work completed**

Responsible: **AALTO**; Others: STX Finland, Meyer Werft GmbH

- Hydraulic experiments on specific configurations encountered in floodings
- Manholes (1:1, 1:2 & 1:3) and cross-flooding arrangements: cross-ducts (1:3)
- Results: **Discharge coefficients** etc.



Photographs of model construction and tests carried out at AALTO

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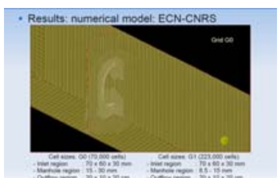
Research topic: WP2 Flooding progression modelling

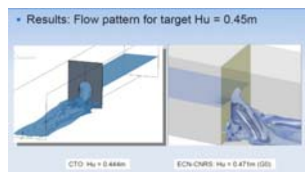
Computational studies & RANSE CFD => Work completed

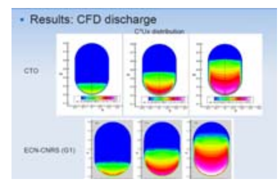
Responsible: **CNRS**; Other Participants: CTO, STX Finland

- Objective:
  to determine the ability of CFD RANSE solvers to improve the numerical prediction of the pressure loss for a typical opening in different flooding conditions

Computational flooding through openings visualised by CNRS



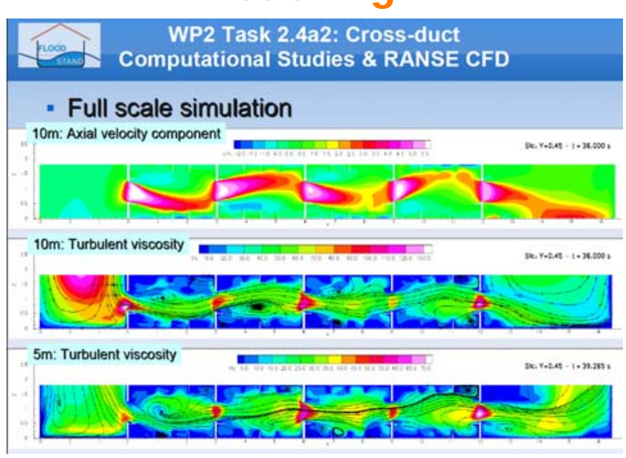




Research topic: WP2 Flooding progression modelling

An example of results:

Responsible: **CNRS**
Status: **Completed**



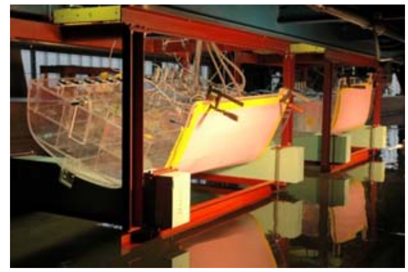
Research topic: WP2 Flooding progression modelling

Model tests for **complex compartments** in MARIN's vacuum tank

=>**Work completed**

Responsible: **MARIN**; Other: STX, MW, NAPA

- Objectives:
  - to collect validation material for simulation tools
  - to show the effect of air pressure on the flooding process
  - to show the effect of 'level of detail'


Flooding model test starting at MARIN

Sensitivity of simulation model

Responsible: **AALTO** & NAPA

=>**Almost completed**

- Objectives:
  - to conduct simulations with a typical layout of ship to vary input parameters of the simulations systematically
  - to prepare guidelines for the preferred accuracy of the input data with simple error estimations

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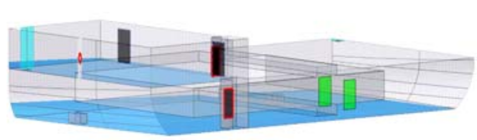
Research topic: WP3 Flooding Simulation and Measurement Onboard

- Development of flood sensors data interpreter

Responsible: **NAPA**; Other participants: STX Finland, SFC Status: Ongoing


An example of flooding status in compartments described by Napa Ltd

- Impact of ship dynamics

Responsible: **AALTO**, Other participants: NAPA Status: Almost completed

- Design of flood sensor systems

Responsible: **NAPA**, Other participants: STX Finland, DNV, SFC Status: Started

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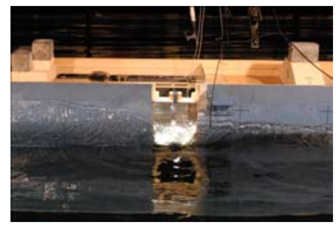
Research topic: WP4 Stochastic ship capsize modelling (WP4)

- Objectives:

Requirements and uncertainty bounds on methods for predicting the time it takes a ship to capsize or sink after damage

- Benchmark data on **time to capsize, ttc**
  Responsible: **SSPA**, Participants: SSRC **Completed**
- Test/develop **analytical** time to capsize model
  Responsible: **SSRC**, Participants: SaS, NTUA Ongoing
- Test/develop **numerical** time to capsize model
  Responsible: **NTUA**, Participants: SSRC, SSPA, SaS **Completed**
- Test/develop **hybrid** time to capsize model
  Responsible: **SSRC**, Participants: SaS, NTUA Ongoing
- Establish **uncertainty bound** on ttc models
  Responsible: **SSRC**, Participants: BMT, SaS, NTUA, MCA Ongoing



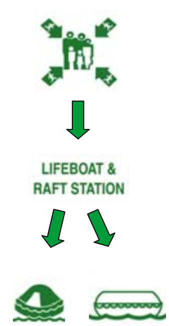
Capsize tests in model scale at SSPA

Research topic: WP5 Rescue process modelling

Objectives:

Test /develop **M-A-R**-models (Mustering-Abandonment-Rescue)

- requirements & uncertainty bounds
- required detail of representation etc.



- **Benchmark data** on mustering / abandonment / rescue
  Responsible: **BV**, Participants: SSRC, BMT Status: **Completed => D5.1**
- Test/develop **mustering** model (M)
  Responsible: **BMT**, Participants: SSRC, SaS, BV Status: Ongoing
- Test/develop **abandonment** model (A)
  Responsible: **BV**, Participants: SSRC, BMT, SaS Status: Ongoing
- Test/develop **rescue** model (R)
  Responsible: **BV**, Participants: SSRC, BMT, SaS Status: Ongoing
- Establish **uncertainty bounds** on M-A-R models
  Responsible: **SSRC**, Participants: BMT, SaS, BV, MCA Status: Ongoing

Research topic: WP6 Standard for decision making in crises (WP6)

Objectives

Loss function and likelihood for integrated standard

Reflecting the societal concerns pertinent to a "large" loss in a balanced way

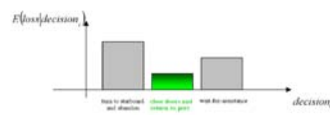
Conditional probability (likelihood) reflecting the requirements on the methods to be used for generating basic information on stability, evacuation and rescue process as well as the associated **uncertainty**

- **Loss** function
  Responsible: **SSRC**, Participants: NTUA, MCA
  Status: Ongoing

- **Likelihood** function
  Responsible: **SSRC**, Participants: NTUA, MCA
  Status: Ongoing

to be explored:

$$E(loss|decision_i) = \sum_j loss(j) \cdot p_{N|j}(j|decision_i)$$



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Research topic: Demonstration (WP7)

Objectives:

- Test effectiveness of the standard in rating decisions for various casualty cases (hypothetical & real-life, historical scenarios) in working environment
- Test the approach in design process
- Feedback for modification, improvements/fine-tuning of the proposed standard

- **Benchmark data** on casualty mitigation cases
  Responsible: **NTUA**, Participants: SSRC, BMT, MCA **Status: Completed**
- Demonstration of a **casualty mitigation standard**
  Responsible: **BMT**, Participants: SSRC, SaS, BV, MCA, NAPA Status: Ongoing
- Demonstration for use as a **design standard**
  Responsible: **NTUA**, Participants: SSRC, SaS, BV, MCA Status: Ongoing

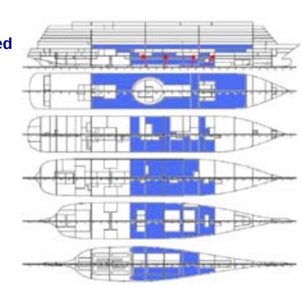

Fig.12 Long raking grounding scenario B2

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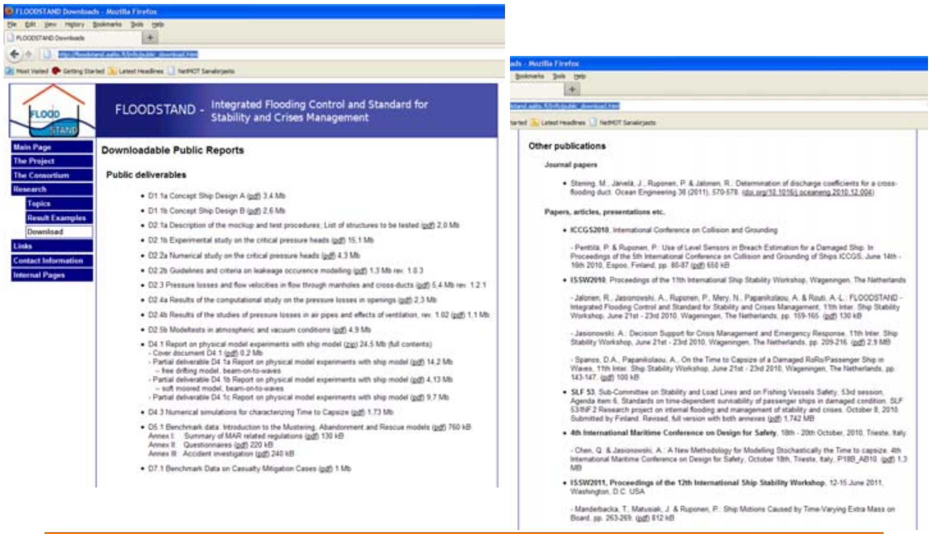
Results are (or will soon be) publicly available at our project's web page
http://floodstand.aalto.fi/Info/public_download.html



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or

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  Prof. P. Kujala; Head of the Marine technology group (pentti.kujala@aalto.fi)

Note!

Publicly available results at project web-site:

http://floodstand.aalto.fi/Info/public_download.html

Thank you!