FLOODSTAND Integrated Flooding Control and Standard for Stability and Crises Management
FP7-RTD- 218532

FLOODSTAND-deliverable:

D0.4a Progress in RTD during the first half of the project

Authors	Risto Jalonen
Organisation	AALTO
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Authors: R. Jalonen, M. Kajosaari, P. Ruponen, A. Jasionowski, P. Corrignan and A. Papanikolaou

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Comments: This deliverable D0.4a is intended to give a description of the technical progress of the RTD-work in the project during the first half of it. **Note!** D0.4a is not the 1st Periodic Report of the project as it only discusses the progress in the RTD, not the management etc.

Abstract: This deliverable lists the objectives of the project for the first half of the project duration and describes how they were met in each work package. It also makes a more detailed view on the RTD work progress in each part of the project and describes additionally the achievements during the first 18 months of the project. Main results of the project within this project period (18 months) are by no doubt the experimental tests as well as the numerical analyses carried out to produce previously non-existing data to support flooding simulations and analysis.

Acknowledgements
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Contents

1. Executive summary

This report is written to describe the objectives, the work done and the results achieved during the first half of the project FLOODSTAND, which was started in March 2009. Originally, this report, deliverable 0.4a was planned to simultaneously stand for the first (18 month) periodic report of the project. However, a change to this original plan was made based on the recommendations from EC. Thus, the contents of this report has been changed to concentrate more on the RTD issues in the project. Another distinction between the periodic report and this deliverable is the audience. Unlike periodic report, this report is not written just for the Commission. The readers of this report may include, in addition to the EC and the project participant organizations, their employees and members of the Advisory Committee.

Project FLOODSTAND was established to derive most of the missing data for validation of time-domain numerical tools used in the assessment of ship survivability and to develop a standard for a comprehensive measure of damaged ship stability by concentrating on the risk of flooding. The work was divided in seven Work Packages (WPs):

In WP1 two cruise ship designs were developed by MW and STX to meet current regulations with two different typical cruise ship sizes. These ship designs are used in other work packages for testing the developed methods and standards. Most of the research in WP2 has now been carried out. Research efforts included full-scale tests at CTO on various semi-watertight structures, e.g. fire doors. Model tests were carried out by AALTO for determining discharge coefficients, and by MARIN for investigating the effect of modeling details and air compressibility. CFD computations were performed by CNRS and CTO, including both cross-flooding ducts and calculations for typical air pipe arrangements in tanks. MEC completed FEM analysis for various non-watertight structures. Experimental and numerical results have been compared, with good results. In WP3, the first stage of the development of a flood sensors data interpreter has been carried out by NAPA. The work will continue in the 2nd period of the project, including development of guidelines, e.g. for flood sensor placement.

The activities in WP4-WP7 were focused on formulating and testing of crises management principles, expressed by an analytical construct viable to numerical implementation. The demonstration platform has been adopted and a real environment of an existing operating passenger vessel has been set up. Results and observations derived to date have proven to be revealing both in terms of fundamental problems of crises management, as well as solutions which prove to be only intuitive and obvious. First results of WP4-WP7 have been produced, but the main progress will take place in the second period of the project, in 2010-12.

The results of this project are published at the public website: http://floodstand.aalto.fi . These results will support pre-normative research towards guidelines, standards and regulations, and explanatory measures to assess their impact. The flooding calculations will be more reliable/easier for the ship designers to select novel design options. In this way the project helps the designers to better protect the vulnerable persons onboard. The improvement of the reliability of flooding simulations will increase the quality of onboard real time damage stability assessments and estimates of the safety onboard, which may be a very demanding task for any operator faced by the rare, but hazardous event of flooding.

Ship designers, builders & ship owners, and the scientific community at large, on relevant workshops, journal and conference publications, as well as at scheduled presentations to the International Maritime Organization form the media of the results. The reception in all venues proves to be encouraging.

FLOODSTAND will contribute in reducing the risk to human life, by ensuring that the level of safety of the transport system will respond to the increasing demand, featured by large passenger ships. Prospects for this development look encouraging, based on the results achieved during the first 18-month period of the project.

2. Introduction

This report is written to describe the objectives, the work done and the results achieved during the first half of the project FLOODSTAND, which was started in 1st of March 2009. Originally, deliverable 0.4a was planned to stand simultaneously for the first (18 month) periodic report of the project and for the management report. However, a change to this original plan was made based on the recommendations from EC. Thus, the content of this report has been changed to concentrate on the RTD issues in the project and not on the management, administrative, economical or legal issues.

The distinctive difference between the periodic report and this deliverable is the audience. Unlike periodic report, this report is not written just for the European Commission. The readers of this report may include, in addition to the EC and the project participant organizations, their employees and members of the Advisory Committee.

3. Project objectives

There are two main objectives (with further sub-objectives) for the whole duration of the project:

a) Increase the reliability of flooding simulation tools in design and onboard use by establishing modeling principles and uncertainty bounds, in particular by striving to the following sub-objectives of the different Work Packages:

- Objectives of WP1: Establishing guidelines for modeling leaking through closed doors and the critical pressure head for collapsing under the pressure of floodwater.
- Objectives of WP2: Simplified modeling of pressure losses (discharge coefficients) in flows through typical openings. Feasible and realistic modeling of compartments with complex layout, such as cabin areas, for flooding simulation tools.
- Objectives of WP3: Use of flooding monitoring systems and time domain simulation for assessing the damage and flooding extent onboard the damaged ship.

b) Establish a method for instantaneous classification of the severity of ship flooding casualty, with the following sub-objectives of the different Work Packages:

- Objective of WP4: Stochastic ship response modeling: establish requirements and uncertainty bounds for methods for prediction of the time it takes a ship to capsize or sink after damage.
- Objective of WP5: Rescue process modeling: establish requirements and uncertainty bounds for models of mustering, abandonment and rescue operations.
- Objective of WP6: Standard for decision making in crises: establish a loss function $loss(N)$ and $p_{N|i}\left(N \middle| decision_i\right)$ for the integrated standard. The loss function must reflect in a balanced manner the societal concerns pertinent to a "large" loss. The $p_{N|i}\left(N \middle| decision_i\right)$ will reflect the above requirements on the methods to be used for generating basis information on stability, evacuation and rescue process as well as the associated uncertainty.
- Objective of WP7 Demonstration: develop implementation system and test effectiveness of the standard in rating different decisions for various casualty cases as well as test the approach in design environment.

Project objectives for the first half of the project and how they were met

The next sub-chapters provides an overview of the project objectives for the reporting period in question, as included in Annex I to the Grant Agreement (DoW).

3.1 Objectives of Work Package 1 (WP1): Design and application

The objectives of WP1 in the first 18M-period were related to:

- Development of design concepts for flooding simulations

This objective was met. Both shipyards carried out their duties in Task 1.1 by creating general arrangement plans for the sample ships, creating the corresponding 3D NAPA-databases and by performing damage stability calculations for the sample ships according to SOLAS2009, and by creating the deliverables D1.1a and D1.1b. The other objectives in WP1 (e.g. to improve the flooding behaviour of cruise vessels by analyzing the different concepts with flooding simulation tools) are scheduled for the second 18M-period.

3.2 Objectives of Work Package 2 (WP2): Flooding Progression Modelling

The objectives of WP2 in the first 18M-period were related to:

The main objective of this Work Package is to extend knowledge about partitions safety concerning flooding effects. This main objective was split into the following partial objectives in Annex I:

Partial objective 1:

- Obtaining results of leaking and collapsing structures (partitions) by conducting experimental study with the use of new build mock-up test stand

This objective was met. The commonly agreed, prioritised list of structures to be tested in Task 2.1 and the test plan were created, the test stand was designed, analysed and constructed (Deliverable D2.1a), the structures to be tested were delivered within their test frames to CTO, where the tests were carried out. The tests were analysed and, finally, the test report with results was submitted (Deliverable D2.1b).

Partial objectives 2:

- Obtaining results of numerical analyses of leaking and collapsing structures (partitions)
- Development of easy-to-use criteria for the partitions in flooding simulation

The first objective was met. The second partial objective (i.e. development of easy-to-use criteria for the partitions in flooding simulation) is scheduled for the second 18M-period. Numerical analyses were carried out and a report with the results was submitted. Tests with small test samples of materials and tested structures were also included in the Sub-Task 2.2.1.

Partial objective 3:

- Evaluating water flow characteristics through various openings by experimental means

This objective was met. Experimental tests in the test flume were carried out in Task 2.3 with a full sized manhole, and various setups/parts of a model of a cross-flooding duct. A report of all the tests and their results (Deliverable D2.3) was submitted.

Partial objectives 4:

- Evaluating water flow characteristics through various openings by computational means
- Assessing the ventilation effect related with the flow of air inside the inner structure of the vessel)

These objectives were met. CFD calculations were carried out for a manhole by both CNRS and CTO with different codes, and compared to the experimental results. This little benchmark study showed excellent correspondence between both numerical tools and test results. CNRS also performed CFD calculations for cross-flooding duct both in model scale and in full scale. The results matched well with the experiments and they were reported in Deliverable D2.4a. CTO performed calculations for pressure losses in two typical air pipe arrangements, confirming the second partial objectives 4 in Deliverable D2.4b.

Partial objectives 5:

- Further insight in water flow around and through typical cruise vessel cabin arrangements
- Insight in required level of detail and scale in the modelling of cabin arrangements in flooding simulation programs

Large scale (1:20) modeltest were done under atmospheric and scaled air pressure conditions. Two models with a different level of detail were used. Various difficulties were encountered which negatively influenced the measurement accuracy. Despite 3 attempts and various improvements to the setup there seem to be no significant differences between the tests in atmospheric and scaled air pressure. The same applies to the difference between the detailed and more simple model. However, in view of the difficulties encountered this may not be the definitive answer to these questions. The tests and their results were reported in deliverable D2.5b (D2.5a is a draft report).

Partial objective 6:

- Assessing the sensitivity of flooding simulation tools to variations in the input data (discharge coefficients, critical pressure heads, etc.).

This partial objective was scheduled for the second 18M-period.

3.3 Objectives of Work Package 3 (WP3): Flooding Simulation and Measurement Onboard

The objectives of WP3 are related to:

The development of flood sensors data interpreter for instantaneous use in flooding prediction tools, as well as to derive methods for assessment of uncertainty in such data interpretation or for resolution of conflicts with alternative data acquisition methods (e.g. verbal description by the crew). Development of guidelines on principles for design of flooding monitoring systems compatible with numerical simulation tools belong to these objectives.

All of these objectives (for WP3) are mainly scheduled to be attained in the latter 18M-period, so a full assessment of their fulfillment is not possible, yet.

3.4 Objectives of Work Package 4 (WP4): Stochastic ship response modelling

Establishing requirements and uncertainty bounds on methods for prediction of the time it takes a ship to capsize or sink after damage. The requirements must list and categorise importance of key variables to be accommodated by the methods used, e.g. how the damage is described, is the wind effect accounted for, how accurately is the wave impact represented, how is ship manoeuvrability accounted for, how to address geographical location, etc. The requirements must also put forward

uncertainty bounds to be assigned to such methods and input variables. The objectives (for WP4) are mainly scheduled to be attained in the latter 18M-period, so a full assessment of their fulfillment is not possible, yet. However, in WP4/Task 4.1, two partial deliverables (D4.1 Part a and Part b) were delivered.

3.5 Objectives of Work Package 5 (WP5): Rescue process modelling

Establishing requirements and uncertainty bounds for models of mustering, abandonment and rescue operations. The requirements must specify the degree of realism of the foundering process required to be accounted for in prediction of vessels evacuability, the detail of representation of rescue operations, etc. The requirements must also put forward uncertainty bounds to be assigned to such methods. The objectives (for WP5) are mainly scheduled to be attained in the latter 18M-period, so a full assessment of their fulfillment is not possible, yet. However, in WP5/Task 5.1, the deliverable (D5.1) was delivered.

3.6 Objectives of Work Package 6 (WP6): Standard for decision making in crises

Establishing a loss function $loss(N)$and $p_{N|i}\left(N\middle|decision_i\right)$ for integrated standard. The loss function must reflect in a balanced manner the societal concerns pertinent to a “large” loss. The function will reflect the requirements on the methods to be used for generating basic information on stability, evacuation and rescue process as well as the associated uncertainty. The objectives (for WP6) are mainly scheduled to be attained in the latter 18M-period, so full assessment of their fulfillment is not possible, yet.

3.7 Objectives of Work Package 7 (WP7): Demonstration

The main objective of WP7 is to test within working environment the effectiveness of the standard in rating different decisions for various casualty cases for a series of hypothetical as well as real-life (historical) scenarios as well as test the approach in the design process. The results will provide feedback to other work packages for modification, improvements or fine-tuning of the proposed standard. The objectives (for WP7) are thus mainly scheduled to be attained in the latter 18M-period, so a full assessment of their fulfillment is not possible, yet. In WP7/Task 7.1, the deliverable (D7.1) was delivered.

4. Work progress and achievements during the reporting period (1.3.2009-31.8.2010)

4.1 WP1 Design and application (WP-leader: STX)

Task 1.1 Development of basic design of passenger ships (Responsible: STX, Participants: MW)

In WP1 the first tasks were related to the design of sample ships A and B, cruise passenger ships of two different size categories. Both shipyards carried out their duties in Task 1.1 by creating general arrangement plans for the sample ships (see Figures 1 and 2), producing the corresponding 3D NAPA-databases and by performing damage stability calculations for the sample ships according to SOLAS2009, and by creating the deliverables D1.1a and D1.1b.

- The sample ship designs are significant results of the project, they represent modern cruise ship designs of two different size. Both sample ship designs created can be used in several design assessments, although the main focus in FLOODSTAND is in their further assessments focused on ship stability;
- No remarkable deviations from Annex I occurred;
- Statements on the use of resources, in particular highlighting and explaining deviations between actual and planned person-months per work package and per beneficiary in Annex 1 (Description of Work) are available in chapter 3.4;

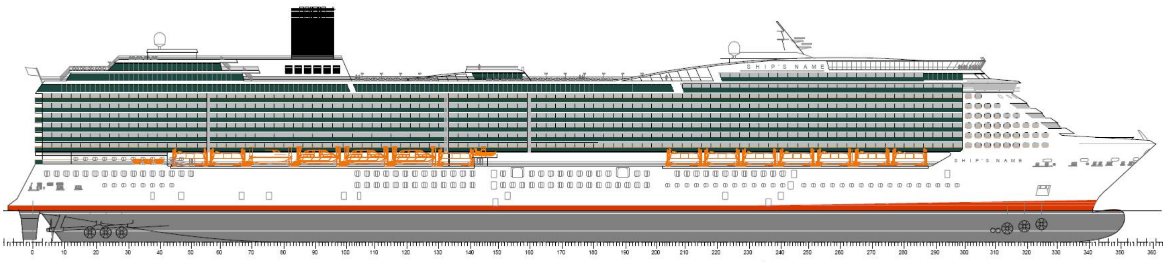

Figure 1 Side view of the post-Panama sized cruise ship design created by STX in FLOODSTAND WP1/Task 1.1; 125.000 GT, L = 327 m, B = 37.4 m, T = 8.8 m (Source: Deliverable D1.1a)

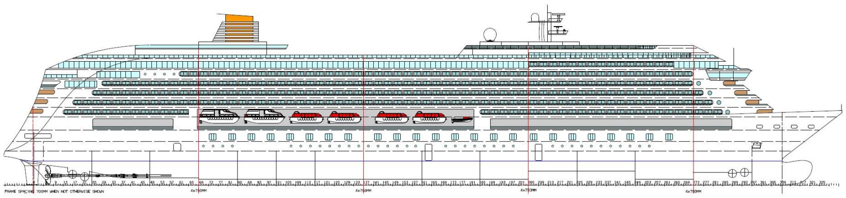

Figure 2 Side view of the medium sized cruise vessel design created by MW in FLOODSTAND WP1/Task 1.1; 63.000 GT, L = 238 m, B = 32.20 m, T = 7.4 m (Source: Deliverable D1.1b)

Scientific publications (list):

- Jalonen, R.P.S., Jasionowski, A., Ruponen, P., Mery, N., Papanikolaou, A., **Routi, A.L.**, (2010), FLOODSTAND – Integrated Flooding Control and Standard for Stability and Crises Management, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23.

4.2 WP2 Flooding progression modelling (WP-leader: AALTO)

Task 2.1 Experiments with leaking and collapsing structures (Responsible: CTO; STX, MEC, MW, AALTO)

In WP2, the first task, T2.1, was divided in two sub-tasks:

Sub-Task 2.1.1 Design of the test stand for static pressure loading of the ship structure mock-ups (e.g. walls with cabin, fire doors or SWT-doors)

This sub-task included the preliminary planning of the tests and planning & decisions on the structures to be tested as well as the planning & development & construction of the new test stand & equipment needed for the tests and the planning of the test procedures.

One of the most important parts of the test stand was built in the form of a watertight tank with one exchangeable wall where each structure to be tested (i.e. the test specimen) was installed (see Figure 4). The tank was fitted with piping system for static pressure adjustment with pumps. Other elements of the test stand design included the measurement and monitoring equipment arrangement for stress distribution within the structure and for obtaining of the flow rate through the leakages during the structure collapse.

The design & production & outfitting of the test stand was a challenging task, not least due to all safety aspects. However, the test stand was completed at the time of the project assembly meeting/workshop in Gdansk, 9.-10.3.2010. At that time test specimens from STX had already been delivered to CTO. MW delivered the next test specimens a bit later.

Sub-Task 2.1.2 Experiments (Responsible: CTO)

The model basin of CTO was used for the experiments enabling controlled conditions of water outflow. Furthermore the capabilities provided by the model basin infrastructure enabling the construction of the pressure piping installation at least 7 m above the basin bottom level as well as the effective operation of the mock-up. The tightened requirement for a higher pressure head up to 15-20 m was a challenge, but it could be solved. During the measurements the test stand/mockup was filled with water, gradually increasing the pressure up to the level with starting leakage and structure collapse. (See Figures 3 and 4)

The tested structure was monitored with respect to the loading (pressure) and stress distribution. A laser equipment was found necessary for recording the deflections. After the start of the test the pressure, the deflections of the tested structure and the leakage rate were measured, until the tested structure collapsed or until the maximum leakage rate, the test setup could counteract, was attained. A total number of 20 tests were carried out, the number of tests was slightly smaller than originally planned due to combining of some doors with the neighbouring wall panels and the incurred costs.

- Significant results attained so far in this task (T2.1):

- Test methodology developed
- Test stand/mock-up
- Test results of the unique destructive tests carried out

a) SWT-door, sliding		*b) Cabin wall*

c) Close-up of the bottom part of a door in a test (Door deflection at points 4, 5 and 6 were measured with laser equipment)

Figure 4 a, b &c (above): Some test specimens (= test objects or stuructures) during the experiments at CTO in WP2/Task 2.1. (Photos: Deliverable D2.1b, CTO)

Test methodology developed in Task 2.1, the test stand/mock-up itself and the test results, described in the public reports D2.1a & D2.1b are clearly significant results of the project. To our knowledge the results of the tests in Task 2.1 are unique. A short overview of the experimental tests in T2.1 was included in a general presentation of FLOODSTAND in the 11th International Ship Stability Workshop in Wageningen, The Netherlands, in June 2010. Results of the tests in Task 2.1 will also be introduced to IMO in SLF53 in January 2011 (together with a short overview of project FLOODSTAND and some other results of WP2).

Figure 3 Test stand with a test specimen (in a frame) attached for the test in WP2/Task 2.1. In this case the test specimen is: cabin wall panel. (Photo: Deliverable D2.1b)

- Deviations etc.:

In spite of the many challenges in this Task 2.1, no remarkably detrimental deviations from Annex I occurred; some deviation (~4M) from the originally planned schedule was mainly caused by the delay in the start of the work at CTO, which could not happen before the funding for this project was confirmed. Although the delay in the delivery of the final version of deliverable D2.1a was not insignificant, it was either significant as the principal information related to it, i.e. the general descriptions of the mock-up and test procedure as well as the list of structures to be tested, being most important for the other participants (especially shipyards) was available already at a very early phase of this Task. A technical meeting was arranged in order to avoid potential misunderstandings between CTO and other parties involved in the planning of the tests on the 7th of October 2009 at STX shipyard in Turku. This meeting, with the co-operation all its participants (e.g. two persons from CTO) was essential for attaining a common understanding and agreement about many issues related to the tests and their preparations. The decision to build the test pieces in standard frames (see Fig. 5) at the shipyards before shipping them to CTO was made in this meeting.

a) A-class fire door, double leaf *b) B-class door*

Fig. 5 a & b: Some examples of test specimens (doors & other structures to be tested) attached to the test frames, specially manufactured by STX, waiting for transportation to Gdansk, Poland, to be tested at CTO in WP2/Task 2.1. (Photos by STX)

Another relevant issue related to the schedules of the deliverables of Sub-Task 2.1.1 and Sub-Task 2.1.2 was the importance to concentrate on confirming the tests themselves and on solving all the practical challenges involved, by using such methods, that made it possible to complete all tests without any significant additional delays. The decision to complete the structures to be tested by building them in the frames at the shipyards made the actual testing phase much faster, with a possibility to test of even two structures per one day. Thus, planning, showed its power.

A slight delay in the actual testing phase and the analysis & writing process of report (D2.1b), due to the lively internal review process within Task 2.1 etc., caused a slight consequential delay to the report from the first sub-task of Task 2.2, but resulted in unique reports (D2.1a & D2.1b) that take the needs of various parties well into account. In spite of many challenges tests could be carried out and a report, deliverable D2.1b, was published well before the project's Mid-Term meeting.

- Statements on the use of resources, in particular highlighting and explaining deviations between actual and planned person-months per work package and per beneficiary in Annex 1 (Description of Work) are available in chapter 3.4; The work to design and manufature the test frames, into which the test specimens were attached, increased the amount of work at the shipyards and the transportation costs. However, this choice confirmed well-fitting parts (with test specimens) to be easily attached to the test stand for the tests and thus a clearly shorter delivery cycle of the actual tests. No severe impacts on other tasks or on available resources and planning have been identified.

Task 2.2 Numerical modeling and criteria for leaking and collapsing structures (Responsible: MEC)

In WP2 the second task T2.2, with the above title, was divided in two sub-tasks, the first of which, Sub-Task 2.2.1, was scheduled for the first half of the project. The second sub-task, Sub-Task 2.2.2, was scheduled to be started after the end of the previous sub-task.

Sub-Task 2.2.1 Numerical studies and analysis of leaking and collapsing structures (Responsible: MEC, Participants: CTO)

- A summary of progress towards objectives in sub-task 2.2.1:

The numerical studies in sub-task 2.2.1 involved analyses where the standard doors and lightweight walls were subjected to hydrostatic pressure. The aim was to estimate the collapse pressure for named structures and understand their behaviour. This knowledge helps to develop simplified formulas for collapse pressure estimation that can be used later on in flooding simulation.

Four types of structures were studied: cold-room structure (including wall and door), cabin wall, A-60 hinged door and A-60 semi-watertight sliding door. All these structures were analysed with non-linear finite element method. As a result, the collapse pressure was determined. The study included determination of material mechanical properties through testing. In order to validate the finite element results (see e.g. Figure 6) full-scale laboratory test were carried out on cold-room and cabin wall panels.

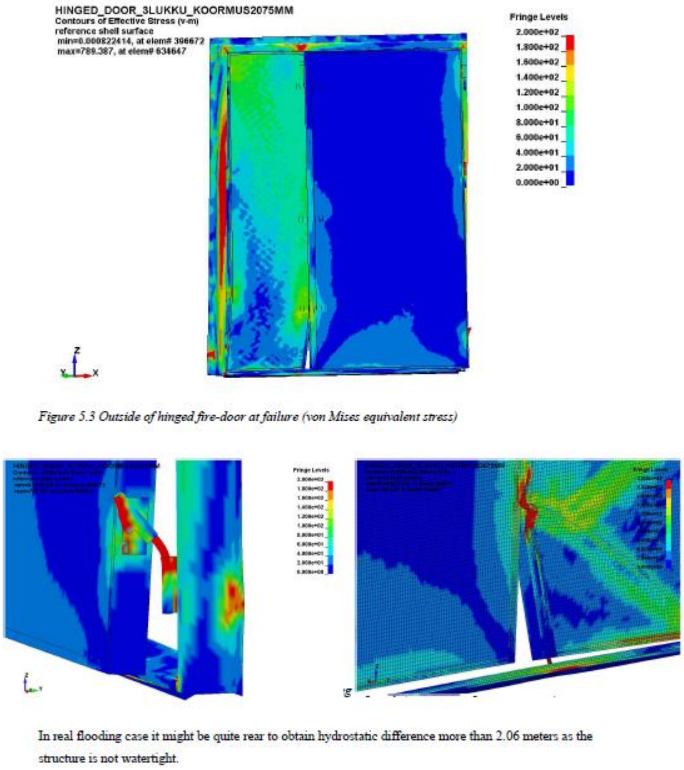

Figure 5.3 Outside of hinged fire-door at failure (von Mises equivalent stress)

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

Figure 6 Numerical test on water pressure effects on a hinged fire-door; WP2/Task 2.2 (Photo: Deliverable D2.2a)

For cold room panel and for cabin wall panel the analytical models where developed in order to estimate the critical pressure heads. For standard door solutions the use of analytical methods is not practical as door failure often depends rather on the strength of joints (like screws, rivets, supporting profiles) as on the strength of the door itself. As a result of analyses critical pressure heads for above mentioned partitions were determined.

In all cases the critical pressure heads are well estimated as they coincide with the tests performed at CTO. The cold room panel sustains approximately 2.7 m of water pressure. A-60 SWT sliding door will collapse at water height 8.1 m where CTO tests indicated collapse at 8.36 m of water height.

According to simulation A-60 door will collapse at approximately 2 m of water level due to
deformation of door joints. However, in tests CTO pointed out that the leakage limit was reached at 1 m of water level. Tests conducted in MEC and simulation on single cabin wall panel indicates that the panel will fail due to bending already at 1.1 m of water level. However, the panel will not collapse at that point as at the membrane forces start carry the load. Therefore, the final failure occurs at point where the total shear force reaches to value equal to the shear strength of the panel-deck connection. According to CTO the cabin wall panel can carry the load up to 1.2-1.4 m of water level.

- Significant results attained so far in this task (T2.2):

- Results from the laboratory tests carried out by MEC and published in deliverable D2.2a.
- Results obtained by comparing the results of the tests in Task 2.1&2.2 and those of the numerical analyses indicate that with the proper modelling technique the collapse of partitions due to water pressure can be estimated quite well. The modelling accuracy less than 20 % compared to test results can be achieved. However, this means that very detailed models must be analysed and material properties have to be known on stress-strain curve level.
- A short overview of T2.2 will be introduced to IMO in SLF53 in January 2011 (together with an overview of project FLOODSTAND and some other results of the project).

- The reason for a minor deviation (~1M) from the original schedule of the delivery of the first draft of D2.2a was related to the minor deviation from the original schedule of the availability of some of the test results from T2.1. The first draft of D2.2a was sent to the coordinator already in the end of August and for SC’s comments on 16.9.2010. The latter delay was caused by the coordinator’s sick leave. The complete draft version of D2.2a was available for the SC on 6.10.2010 and the final version of D2.2a was published on the project’s web site on 25.10. 2010. No big impacts on other tasks or on available resources and planning are expected.

Task 2.3 Experimental studies on pressure losses (Responsible: AALTO, Participants: STX, MW)

The experimental studies in T2.3 were carried out by AALTO (ex. TKK), with support from both shipyards, STX Finland and Meyer Werft GmbH. Important support in some special questions was also provided by the assisting Technical Coordinator for WP1-WP3 (NAPA), who acted as the host of the first planning meeting for T2.3 (and partially T2.1, too) on the 27.3.2009, soon after the official start of the project.

Figure 7 Flooding through a full-sized manhole in a flume tank tested in WP2/Task 2.3(Photo: Aalto University)

Valuable comments on the plans and details of the model of the cross-flooding duct to be built by AALTO were received from all partners (STX, MW and NAPA). Experimental studies on the pressure losses in man-holes were performed in scales: 1:1, 1:2 & 1:3, to obtain numerical data for validation of CFD-calculations. The full scale manhole for the tests (see Figure 7) was provided by STX Turku shipyard.

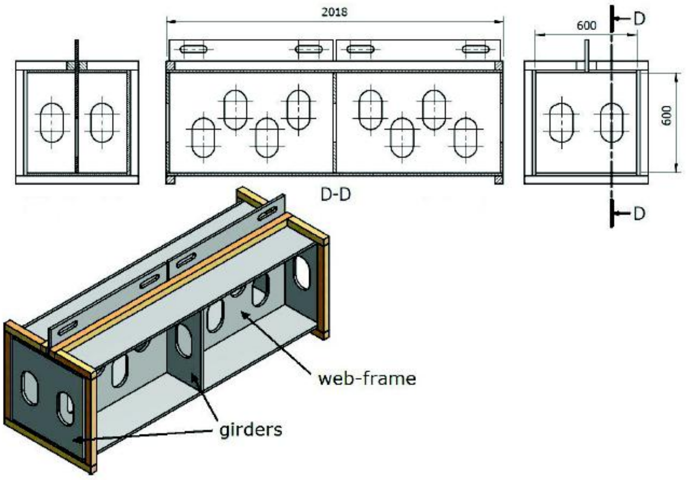

Figure 8: The dimensions of one 1:3 scale model cross-duct module with a web frame in the middle
of the cross-duct built in WP2/Task 2.3
(Note! The web-frame was not present in the model during most tests. Stiffeners are not included in this figure, although present in most of the tests. See Fig. 11 for comparison)

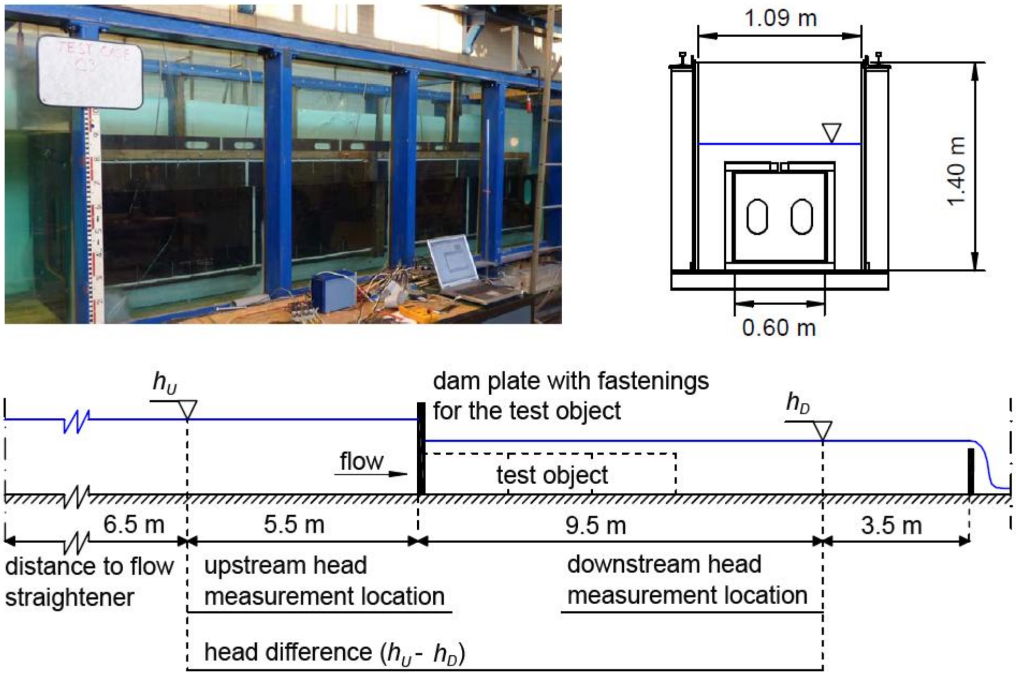

Figure 9 Longitudinal and cross-sectional views of the experimental set-up in the flume for cross-flooding duct tests in WP2/Task 2.3 (Aalto University/TKK)

The test were continued by systematic model tests with different modifications of a typical arrangement of a cross-flooding duct (see Fig. 8 & Fig 9) of a large passenger ship, with the interest in deriving conclusions on the effects of some parameters, such as the number of girders and openings on the pressure loss. Preliminary results were exchanged with Task 2.4 (CNRS). A demonstration of a test in the flume was arranged for the Task-participants in December during a Task-level meeting. Tests were completed before the project meeting in Gdansk, 9.-10.3.2010, where the results were presented. The full draft deliverable D2.3 was completed & submitted for the comments of the project Steering Committee on 27.4.2010, and the final version of it was published on the project's public web site later in May 2010.

- Significant results attained in this task (T2.3):

- Results from all laboratory tests carried out by AALTO are published in D2.3
- Key results:
  - -- The structural stiffeners inside the cross-duct and on the single girders were found to significantly increase the value of the discharge coefficient CD.
  - -- The influences of the web frame and the inclination of the cross-duct on the value of the discharge coefficient were negligible.
  - -- There is a risk that the discharge coefficients of cross-ducts are overestimated if the guidelines of the IMO Resolution MSC.245(83) are applied without properly considering the geometrical properties of the girders in the cross-ducts (see Fig. 10).
- Results of the tests in Task 2.3 will be introduced to IMO in SLF53 in January 2011 (together with a general overview on project FLOODSTAND and with some other results of the project)
- A journal paper related to these tests has been submitted to Ocean Engineering

- A short overview of the tests in T2.3 was included in a general presentation of the project FLOODSTAND, too, in the 11th International Ship Stability Workshop in Wageningen, The Netherlands, in June 2010

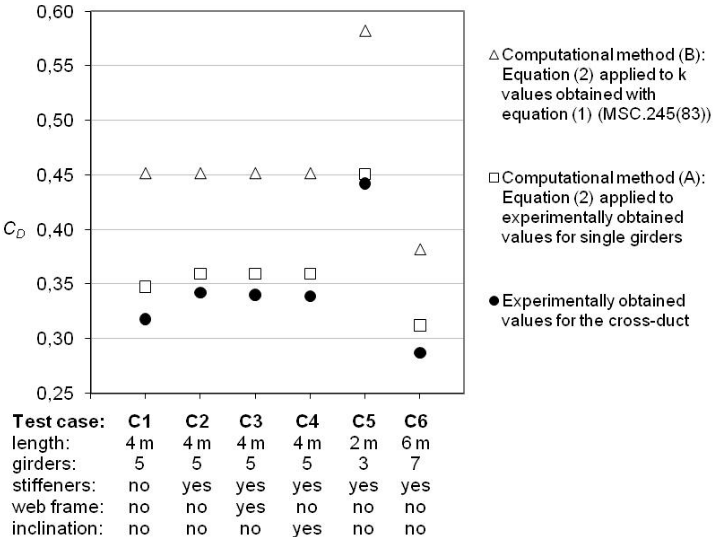

Figure 10: Comparison between the experimentally obtained discharge coefficient for the crossduct and the corresponding computed value (Source: Deliverable D2.3 v.1.2.1)

Task 2.4 Computational studies & RANSE CFD (Responsible: CNRS, Participants: STX, CTO)

Task 2.4 was divided in two sub-tasks, the first of which is:

Sub-Task 2.4.1 Computational studies (Responsible: CNRS, Participants: CTO))

This sub-task deals with CFD computations on detailed parts of the ship using the configurations chosen in Task 2.3. The list of openings etc. to be studied was also originally planned in the first planning meeting for T2.3 (and partially T2.1, too) on the 27.3.2009, soon after the official start of the project. However, the detailed research objects were confirmed later, during the second 6-months period of the project, when EC had signed the contract with the Consortium and CNRS could start their efforts (after summer vacations).

The CFD computations can be used to provide a global and simplified flood-simulation tool with unknown coefficients (pressure loss in various openings, for instance). Since the number of configurations of interest is very large, these computations were distributed among two CFD partners, CNRS using their in-house RANSE solver ISIS-CFD and CTO using Fluent. The CFD computations made are reported in D2.4a. (Some Figures of this report are presented in Figs. 11 and 12).

Some test cases were computed in model scale in order to study the scale effects. Test cases, with three different water elevations were computed by both project participants. The slight delay (~1M) of the delivery of the final version of the D2.4a, accepted by the SC, was insignificant and it was at least partly caused by the non-optimal placement of the first deadline coincident with the summer vacations and by the project starting several months before the signature of the GA.

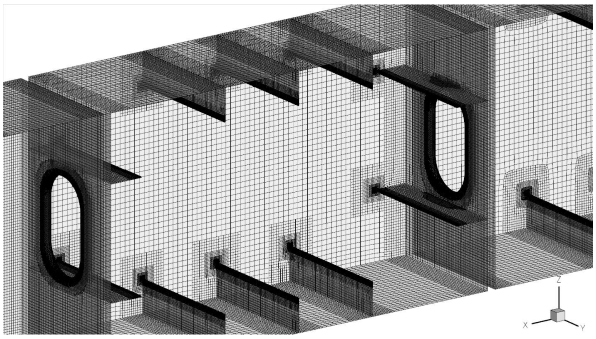

Figure 11: Surface grid details illustrating part of the surface grid in the middle region of the cross-duct (Source: Deliverable D2.4a)

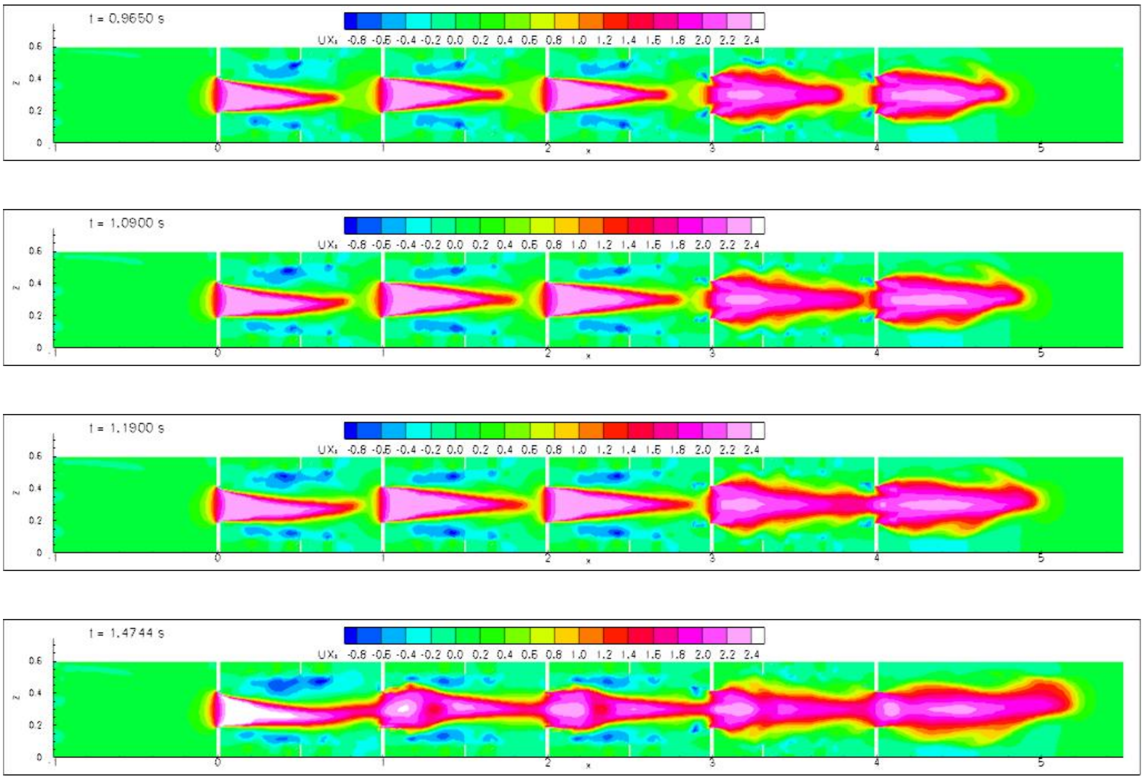

Figure 12: Time history of iso-U distribution in Y middle cut plane of a cross-flooding duct composed of three modules, one of which is presented in Fig. 8, without stffeners (Source: Deliverable D2.4a)

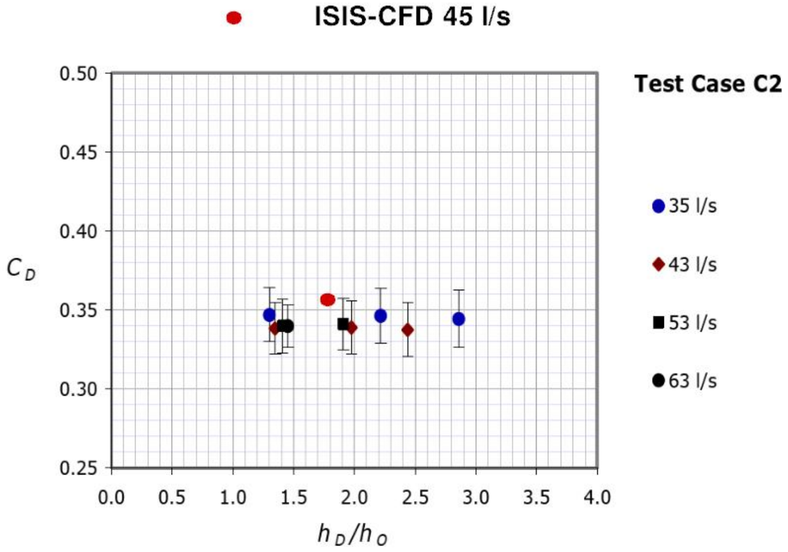

Figure 13   Plot of the discharge coefficient and the downstream head to opening; a comparison between CFD & model test results (Sub-Task 2.4.1 & Task 2.3)

- Significant results attained in this sub-task (Sub-Task 2.4.1):

- Results from these studies, carried out by CNRS & CTO, are published together in D2.4a
- The CFD simulation of the model-scale cross-duct is in good agreement with the experimental results (see Fig. 13). Furthermore, calculations for full-scale duct with high pressure heads at the inlet (5 m and 10 m) resulted in very similar discharge coefficients. This supports the application of CFD, allowing studies with much higher pressure heads than in the experiments (carried out)

- A short overview of these studies, based on the D2.4a will be introduced to IMO in SLF53 in January 2011 (together with the project FLOODSTAND and some other results of the project). An annex to the relevant Inf.-paper has already been submitted to IMO. Further publications in journals etc. are planned/developed.

Sub-Task 2.4.2 Effects of air compression (Responsible: CTO, STX)

This sub-task has studied the important and often neglected effects of air ventilation on progressive flooding. A systematic analysis on the ventilation in a typical tank compartment of a modern passenger ship was performed by dedicated CFD simulations carried out by CTO in order to assess the pressure losses in typical air pipes from the voids since the counter pressure of air can have a significant effect on the cross-flooding time. The air compressibility is taken into account in the computations.

The analyses apply to a situation described as follows (D2.4b): flooding of the ship's double bottom causes air compression in the compartments located far from the damage region, and the effect of air cushion appears. The air discharge through the air pipes of the compartment venting system influences the flooding rate. The computational models are reduced to the air pipes only, with prescribed overpressure at the inlet and atmospheric pressure at the outlet. Such model allows for evaluation of the pressure loss coefficient as a function of over-pressure for particular air pipes.

Two types of air pipes were considered: an air pipe with free outlet and air pipe with air cap on the outlet (the air cap closes the pipe outlet in case of water on deck). The presented results include:
- Visualization of the pressure and velocity distribution in the airpipes;
- Values of air mass flow rate for given overpressures;
- Derived quantities: speed reduction factor & pressure loss coefficient for given overpressures.

The CFD results (pressure loss coefficient) for the airpipe with free outlet are compared with the results of simplified calculation based on the IMO resolution No. MSC.245(83). This comparison shows that the simplified approach yields considerably higher values of pressure loss coefficient than CFD computations.

- Significant results attained in this sub-task (Sub-Task 2.4.2):

- The dependency on the overpressure difference seems to be marginal, and consequently it is reasonable to apply constant factor in cross-flooding time calculations.
- All results of the studies carried out by CTO are published in D2.4b
- A short overview of the studies in T2.4 will be introduced to IMO in SLF53 in January 2011 (together with the project FLOODSTAND and some other results of the project).
- The results have affected on the air pipe designs on planned newbuildings
- The delivery of the first draft D2.4b for the comments of the SC was made on 30.8.2010 almost according to the original schedule (in Month 17). The final D2.4b was published on the public web site of project FLOODSTAND on the 20th of September, 2010.

Task 2.5 Model tests for cabin areas (Responsible:MARIN, Participants: STX, MW, NAPA)

The model tests done by MARIN for the FLOODSTAND project ad are related to the tasks in work package WP2 Task 5.1. The objective of the modeltests was to investigate the influence of the detail of modelling and the influence of scaled air pressure on the flooding process.

The tests were done in the DTT (Depressurised Towing Tank) of MARIN. A simple model and a more detailed model were created of PERSPEX (in scale 1:20). Both models were flooded under atmospheric and low pressure conditions. All the tests were done with captive models (see Figure 14) that were fixed at a number of heel/trim combinations. The draft was kept constant.

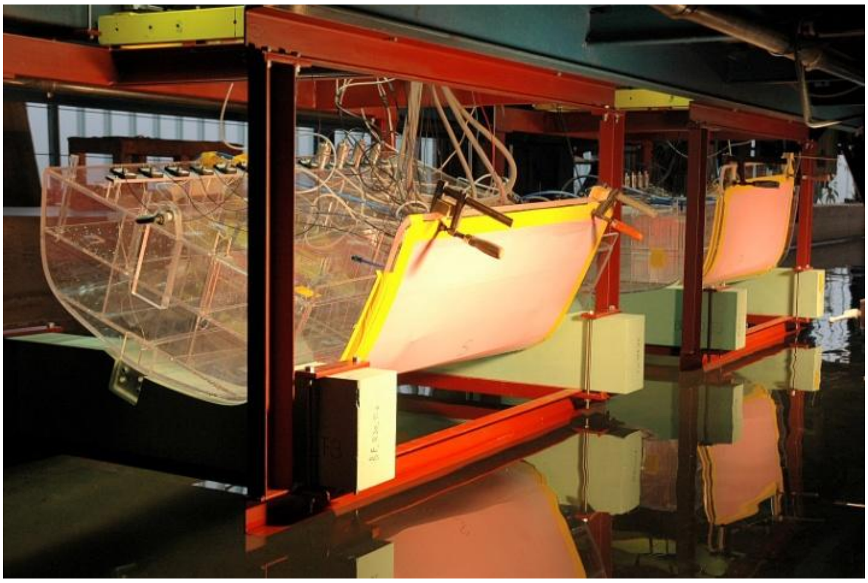

Figure 14 Model & Sub-Carriage before they were lowered in water, Test setup in WP2/Task 2.5 –related model tests (Source: Deliverable D2.5b)

These types of flooding tests were never before done on such a large model scale and under both atmospheric and low pressure conditions. The type, the amount and the required accuracy of the measurements in combination with the low pressure conditions, the model complexity and the required positioning accuracy of the model made this a very challenging project.

In view of the explorative character of these modeltests a considerable effort was spent in the preparation phase of this project. Potential risks were identified and contingency measures or design changes were made to eliminate or minimize them. Nevertheless, a number of problems surfaced in the first attempt that made it necessary to repeat the tests because the required accuracy could not be achieved.

The problems that surfaced mainly had to do with the repeatability of the positioning of the models in the facility. To be able to compare modeltest runs in atmospheric and vacuum conditions both the attitude and the draft of the models should be controlled very precise. In addition to this, there were problems with the water level measurement accuracy. Most likely those were related to the difference in water properties between vacuum and atmospheric.

Despite modifications to the facility equipment and other measures the required accuracy was not achieved. Further research will be required to unravel all the details of these problems and hopefully find solutions for future projects

Comparing the results of the different runs is not easy due to the uncertainty in the measurements caused by the problems described above. In general, for the model geometries used in the tests, the influence of scaled air pressure seemd not significant. The same can be said about the difference in detail of both models. In addition to these findings an important number of lessons with respect to the preparation and execution of this type of tests have been learned.

Draft deliverable D2.5a was submitted for the acceptance of the Steering Committee with a delay (of ~6M) caused by the challenges described above. However, the final version of D2.5b was published on the project web site in a clearly better agreement with the original schedule (with a delay of ~2M).

- Significant results attained in this task (T2.5):

- The lessons learned from the modeltests are listed in the report and are valuable results as such
- An other remarkable result is the experince from special modeltests of this particular type that they proved to be even much more complicated than originally foreseen. The test type and the environment, in which the model tests were carried out, form together an extremely challenging combination

After initial discussions the focus of these tests was on the influence of the level of details and on the influence of correctly scaled air pressure on the flooding process. The model scale was chosen as large as possible (1:20). All tests were done captive to eliminate the added complexity of vessel dynamics on the flooding process. It was tried to make use of other modeltests data done with the same geometry (but on a different scale) but eventually no permission was given by the owner of the data and thus the data was not available.

The budget for this task was severely overrun in view of the problems described below. Instead of the planned 11 manmonth for task 2.5.1 & 2.5.2 MARIN has spend almost 19.5 manmonth. This budget overrun is accepted (however reluctantly) and shows that MARIN has gone to great length to provide useful results. Unfortunately, despite this effort MARIN did not achieve the goals that were set at the start of this sub-project. In view of the budget overrun MARIN might request a reallocation of the budgets that are allocated to task 2.5.3 and task 3.2.

Originally there was only one test period planned. Despite the thorough preparations several difficulties were encountered during this first test period:

- Measurement repeatability and accuracy far too low
- Positioning of the models was problematic
- An average test cycle took more time than expected

- Corrective actions that were undertaken during the past 18-month period in this task (T2.5):

- Corrective actions that were taken for a second test period (within Task 2.5):
  - -- Much more time was scheduled for calibration and calibration checks (repeatability checks)
  - -- Extra measurements were added to be able to check the calibration (to measure the direct relation between level difference and air pressure)
  - -- Three draught measurements were added to have more feedback on the draught and attitude of both models
  - -- The software controlling the attitude of the measurement frames containing both model s was changed (feedback control was implemented)
  - -- The number of tests was reduced leaving the tests that were expected to be the most interesting

The second test period was stopped prematurely due to failing facility equipment in the low atmospheric part of the basin.

The third test period was eventually done some 3 month after the first. The results were not satisfactory. Main reasons were:

- Continued in-accurate vertical positioning of both models
- Unreliable draught measurements. These were probably caused by an inhomogeneous mixture of basin water which resulted in a difference in

conductivity of the water (the measurement principle of the draught (and level) sensors is based on conductivity).
- The deterioration of the quality of the level sensors inside the model (corrosion, delamination) combined with conductivity problems (see above).

Publications of WP2:

Scientific publications (list):

- **Jalonen, R.P.S.**, Jasionowski, A., Ruponen, P., Mery, N., Papanikolaou, A., Routi, A.L., (2010), FLOODSTAND – Integrated Flooding Control and Standard for Stability and Crises Management, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23.
- Stening, M., Järvelä, J., Ruponen, P., Jalonen R., (2010), Determination of discharge coefficients for a cross-flooding duct, (Submitted to *Ocean Engineering* in July 2010).

Task 2.6 Sensitivity of simulation model (Responsible: AALTO, Participants: NAPA)

This task was scheduled to be started in the second 18-month period of the project, because of the need for results from the previous tasks in this and the previous WPs (WP1 and WP2). Therefore, the research related to this task will be carried out mainly during the second 18-month period.

4.3 WP3 Flooding Simulation and Measurement Onboard (WP-leader: NAPA)

The research efforts & work in WP3 were started soon after the project kick-off with Task 3.1. The results of the first study on the inverse method for assessing the breach size and location by applying time-domain flooding simulation were presented in the 5th International Conference on Collision and Grounding of Ships ICCGS'2010 in June 2010. The performed case study showed promising results, but the performance of the breach detection was not as good as initially expected. Consequently, a somewhat simplified approach is needed for the development of the demonstration platform. Also the results from the experiments and calculations in WP2 will be taken into account. In general, the research is progressing in schedule.

It was agreed in the Steering Committee meeting in Gdansk in March 2010 that the demonstration part of the developed flood sensor interpreter will be transferred to WP7.

The work in Task 3.2 (Effects of sea state) was started before it's original scheduled time at AALTO, in close co-operation with the WP leader NAPA. Even though Task 3.3 is scheduled to the last year of the project, some initial discussions and meetings on this topic have been organized between NAPA and SFC, too. An example of the flooding status in compartments for the development of flood sensors data interpreter in WP3/Task 3.1 is presented in Figure 15.

Publications:

Scientific publications (list):

- Penttilä, P., Ruponen, P. (2010), Use of Level Sensors in Breach Estimation for a Damaged Ship. Proceedings of the 5th International Conference on Collision and Grounding of Ships ICCGS, June 14th - 16th 2010, Espoo, Finland, pp. 80-87.
- Jalonen, R.P.S., Jasionowski, A., **Ruponen, P.**, Mery, N., Papanikolaou, A., Routi, A.L., (2010), FLOODSTAND – Integrated Flooding Control and Standard for Stability and Crises Management, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23

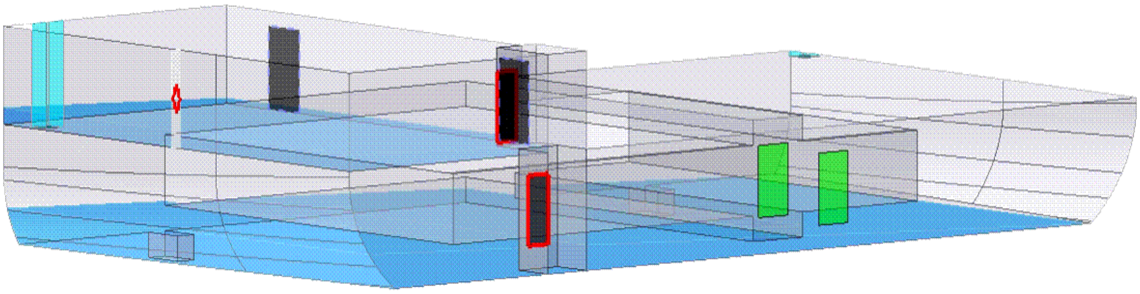

Figure 15 An example of flooding status in compartments described for the development of flood sensors data interpreter in WP3/Task 3.1 (Source: Napa Ltd)

4.4 WP4 Stochastic ship response modelling (WP-leader: SSRC)

- A summary of progress towards objectives in Task 4.1:
  Benchmark data on time to capsize, ttc (Responsible: SSPA, Participants: SSRC)

The experimental studies in T4.1 were carried out by SSPA, with the 1:40 model of M/S Estonia. The model tests were carried out in three phases, two of which taking place in 2009. All tests were made in irregular seas, to study the effect on significant wave height on the survivability of the damaged ship, with a big hole, simulating an opening caused by an other ship, struck on the afterbody (and detached thereafter). The first part of these tests (Part a) were carried out with a free drifting model. In the second part of the tests (Part b) included tests with a soft moored model. Both parts of these tests were carried out in beam seas. The third part of the tests, Part c include slowly towed model in head seas.

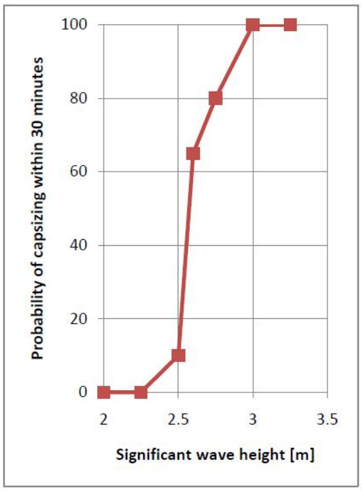

Figure 16 The probability of capsizing within half an hour as function of significant wave height for the ROPAX (Estonia) in beam waves (in the specific loading & damage condition).A total number of 83 tests were performed in WP4/Task 4.1, Part a. (Source: Deliverable D4.1a)

Figure 17 The 1:40 model of M/S Estonia in waves with the large opening in the aft (on the right side of this photo) representing constant parameter in all the tests (in WP4/Task 4.1)

- A summary of progress towards objectives in Tasks 4.2-4.5:

Tasks 4.2/3/4 and 5 focused on analytical, numerical, hybrid and uncertainty modeling principles, respectively. Extensive numerical simulations have been performed to attain understanding of the processes underlying ship capsizing in any of statistically feasible flooding scenarios. Advanced stochastic simulation techniques were used. Prototyping studies of developing, testing, re-testing and calibrating of mathematical and numerical constructs were undertaken. State of the art regressive and posterior probabilistic fitting exercises were carried out. Dozens of possible models were developed in this process. The studies on various possible approaches, from very simple, to sophisticated simulations, combined with validation studies by means of comparisons with experimental data from Task 4.1 as well as other projects have led to identifying of some observations on key physics of importance to the whole concept of decision support. Robust model has been put forward as an outcome, including global as well as local uncertainty quantifications. The model seems universal, defendable and groundbreaking in revealing nature of the problem, but also solution to it. Some serious conclusions emerge on effectiveness of state of the art ship safety legislation to protect ships from catastrophic but feasible scenarios.

Main achievements so far:
- Test results from Task 4.1, parts a and b available (see Fig. 16)
- Demonstrated the reliability of numerical simulations (WP4)
- Identified robust modeling principle for use in any decision support system

Main deviations etc. (if any):
- The test program was devided to three parts (a, b and c) with a partial report of each one:
- The first draft of D4.1a was made available for the SC, for SC’s comments on 29.1.2010. The final version of this first Partial report was published on the projects public web site on 28.2.2010, just within the originally planned schedule (project month 12).
- The draft of the second Partial report of D4.1 was made available for the SC, for SC’s comments on 1.3.2010. The updated report 4.1b rev. 2 was available for the coordinator on 10.9.2010. Thus, the final version of this partial deliverable D4.1b was published in September 2010.
- The third part of the tests, to be reported in deliverable D4.1c is planned to be completed, if possible, in January 2011 (i.e. project month 21). Thus, the final deliverable D4.1, composed of partial reports a-c and a cover document, is not completed yet. However, depending on the always dynamics and situations that may possibly change on the commercial model test markets, some already booked tests may sometimes be cancelled, which may offer an opportunity to get an earlier slot for the final tests, too. (SSPA has everything ready, so this possibility exists.)
- The observations on nature of ship capsizing merit revision of the decision support functionality originally planned in this project. It seems the problem can be tackled much simpler. Work is ongoing on modeling to ascertain findings attained thus far.

Publications:
Scientific publications (list):

- Spanos, D.A., Papanikolaou, A.D., On the Time Dependent Survivability of ROPAX Ships, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23
- Jalonen, R.P.S., **Jasionowski, A.**, Ruponen, P., Mery, N., Papanikolaou, A., Routi, A.L., (2010), FLOODSTAND – Integrated Flooding Control and Standard for Stability and Crises Management, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23
- Qi Chen, Jasionowski, A, “A New Methodology for Modelling Stochastically the Time to capsize”, 4th International Maritime Conference on Design for Safety, October 18-20, 2010 in Trieste, ITALY.

4.5 WP5 Rescue process modelling (WP-leader: BV)

- A summary of progress towards objectives:

Task 5.1 Benchmark data on mustering/abandonment/rescue

Sub-Task 5.1.1: Analysis of regulations

Bureau Veritas started to gather and go through the regulations, guidelines and (classification) rules relevant to the rescue process onboard. Amongst others, the SOLAS convention, the ISM Code, the STCW Code, the SAR Code, IMO MSC and Assembly circulars and resolutions, bring together requirements and advice for the evacuation procedures and plans, design of the evacuation/life-saving system, managing stability of large passenger vessels, and coordinating search and rescues operations.

Sub-Task 5.1.2: Design questionnaires and interviews

BV attended an evacuation drill organised by Carnival on the 16/04/09, interviewed the company's personnel about typical evacuation procedures and could identify some of important issues/obstacle of large passenger ships' evacuations.

BV and BMT started to draft a basis for questionnaires addressed to large passenger ships' Masters, aiming to get information on:
- how important decisions such as "Whether and when to abandon the ship?" are made, had a flooding occurred onboard,
- how decision support systems may help Masters,
- any past experience of evacuations and drills.

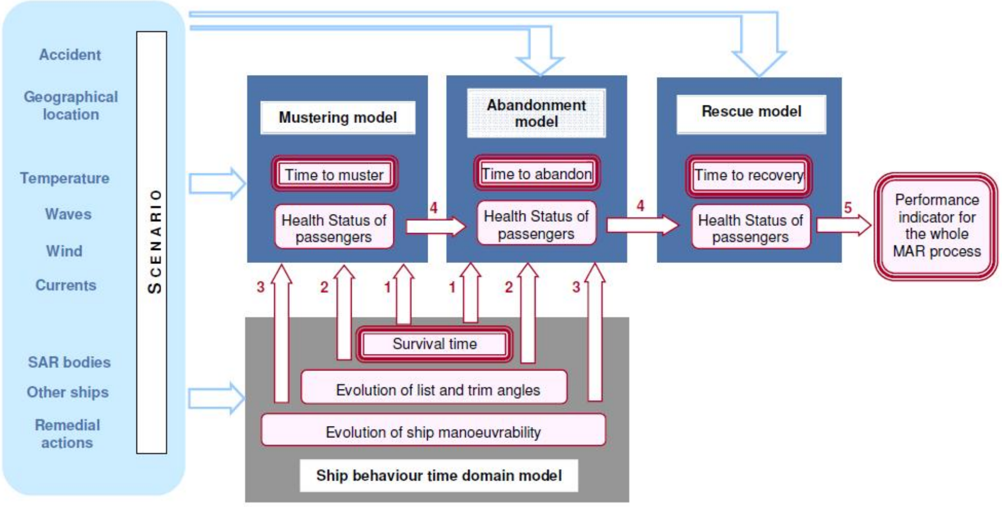

Figure 18 A schematic view of the M-A-R model to be developed in WP5 (Source: Deliverable D5.1)

In the meantime, BMT contacted cruise ship owners of FLOODSTAND's advisory panel namely, Carnival and RCCL and asked for possibilities to get information on drills, real emergency evacuations through questionnaires and interviews. BV contacted the MCA and asked for the possibility to have interviews with their SAR personnel; the latter suggested to disseminate questionnaires to their SAR surveyors.

Task 5.1 resulted in the deliverable D5.1, the complete draft version of which was submitted to the coordinator within the scheduled time (i.e. project Month 24). After the time reserved for comments by the Steering Committee and consequent revisions, the final version of D5.1 was published on the public web site of FLOODSTAND on 15.3.2010.

The WP5 objectives for the 3rd 6-month period were updated and presented at the FLOODSTAND Assembly meeting n°2 in Gdansk (9th and 10th March): completing tasks 5.2-4.1, 5.2-4.2 and 5.2-4.3 and start tasks 5.2-4.4, 5.4-4.5 and 5.5:

- Sub-task 5.2-4.1 is almost completed
  - Most of the data concerning the two demonstration cases were gathered concerning the type and number of Life-Saving Appliances, their characteristics (capacity and internal arrangement), the characteristics of the means of rescue used, etc.). Some marginal missing data needs to be collected during September 2010.

- Sub-Tasks 5.2-4.2 are almost completed:
  - The obstacles associated to the Mustering, Abandonment and Rescue phases were listed, the phenomena to be modeled in order to assess their influence were identified, and a primary specification of the tools to be used or analyses to perform to assess the influence of obstacles was carried out, for both Human Factors and Hardware obstacles as well as for their influence on the time spent to complete the MAR process (mustering and rescue in particular). This data was gathered in a unique .xls spreadsheet). The relevance and significance of the obstacles was discussed by all partners. A final consolidated list needs to be agreed in September 2010. The significant parameters of the models for assessing the obstacles need also to be defined in September 2010.

- Sub-Tasks 5.2-4.4 and 5.5 are started and a refined time schedule has been established

The WP leader broke down these tasks into more detailed subtasks and proposed a schedule to the other WP5 partners. This schedule has been presented during the 3rd FLOODSTAND Steering Committee meeting (September 2010, Helsinki).

The small delays (1 month) encountered in tasks 5.2-4.1 to 5.2-4.3 are mainly due to the summer holidays and will have no influence on the work planning of subsequent WP5 tasks.

- Significant results in WP5:
- A (long) list of obstacles and the associated phenomena to be modeled was identified and discussed / commented by WP5 partners
- A proposal of reduced consolidated list of obstacles
- A proposal of analyses to be performed to assess the obstacles

WP5 deliverables:

Deliverable D5.1 with three annexes was issued in this 18-month reporting period.

Deviations from Annex 1:
No significant deviations identified. D5.1 was published on the public web site of project FLOODSTAND already on the 15th of March, 2010, although in SESAM somewhat later.

Publications of WP5:

Scientific publications (list):

- Jalonen, R.P.S., Jasionowski, A., Ruponen, P., **Mery, N.**, Papanikolaou, A., Routi, A.L., (2010), FLOODSTAND – Integrated Flooding Control and Standard for Stability and Crises Management, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23

4.6 WP6 Standard for decision making in crises (WP-leader: SSRC)

- A summary of progress towards objectives in WP6:

The activities of WP6 have focused on constructing the decision standard. Various prototype constructs have been derived. The overall evolving concept or concepts have been presented on a meeting on 20th Jan 2010 between partners of WP4-7 in London. There has been considerable effort spent on formalizing various elements, pertaining to logic of a decision standard with literature review on rationales prevailing in other industries. The prime difficulty arose after considerable revision of the prototype studies revealed that only small percentage of some 1-3% of cases could in any way be ambiguous with majority remaining either completely un-survivable or completely survivable. Given underlying uncertainties in establishing actual casualty case extent, it seems plausible that the standard could be simplified to a stability threshold concept, whereby the decision would be “stay onboard” if below the threshold, and “abandon”, if threshold exceeded, regardless of any other information (sea state, SAR proximity, abandonment arrangements, etc).

The prototypes of a system as well as underlying models of cruise ship and ro-pax ship developed for the project have proven groundbreaking in highlighting the key issues and testing ideas for standards. Furthermore, a new paradigm has been established for an onboard decision support to implement an “a priori” principle of crew preparedness before accidents, which seems far more effective device in enabling crew response than traditional approach of “posteriori” advice. Efforts are ongoing to reach critical mass in understanding of relative merits of either of approaches, which is reliant on building complete models and their rigorous examination.

Task 6.1 Develop loss function

This task should complete a deliverable at month 18. Although the efforts have been expanded, and the relevant literature reviewed, it proves impossible to commit to any specific representation without complete prototype model testing. It seems that the planning for deliverable D6.1 without deliverables D6.2 and D4.2/3/4/5 and D5.2/3/4/5 has no merit and should be amended for delivery at month 30th. Most studies on risk-neutral, risk-prone or risk-averse standards for decision making on rare events are based on utility expectations, which imply need of complete decision model.

Task 6.2 Develop likelihood function

Planned efforts have been expanded on development of the likelihood function, and it’s dominant part pertaining to the state of the ship have been put forward and can be considered complete. Further efforts have been spent on constructing of the abandonment and rescue parts. Various discussions have taken place, with questionnaires and suggestions circulated among partners. Very extensive initial model composition is being reduced to a manageable construct, which could be used as a standard. Major steps have been achieved in agreeing mathematical formats of the model. Sophisticated simulation models have been built and used for putting forward of very simplified models useful for decision making. Considerable study of uncertainties has also been performed and requisite modeling corrections have been incorporated within parts of the proposed functions.

WP6 deliverables:

Deliverable D6.1 was not issued within this 18-month reporting period. Its original delivery time in project month 18 is planned to be postponed to project month 30, until all the data and theories have been carefully analyzed.

Deviations from Annex 1:

> Deliverable D6.1 could not be delivered within the scheduled time (project month 18). A significant prolongation (of 12 months) was proposed to reschedule the delivery month of deliverable D6.1 to project month 30.

Publications related to WP6:

Scientific publications (list):

- Jalonen, R.P.S., **Jasionowski, A.**, Ruponen, P., Mery, N., Papanikolaou, A., Routi, A.L., (2010), FLOODSTAND – Integrated Flooding Control and Standard for Stability and Crises Management, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23.
- Jasionowski, A., (2010), Decision Support for Crises Management and Emergency Response, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23.
- Jasionowski, A, “Decision Support for Ship Flooding Crisis Management”, Journal of Ocean Engineering, (submitted in September 2010).

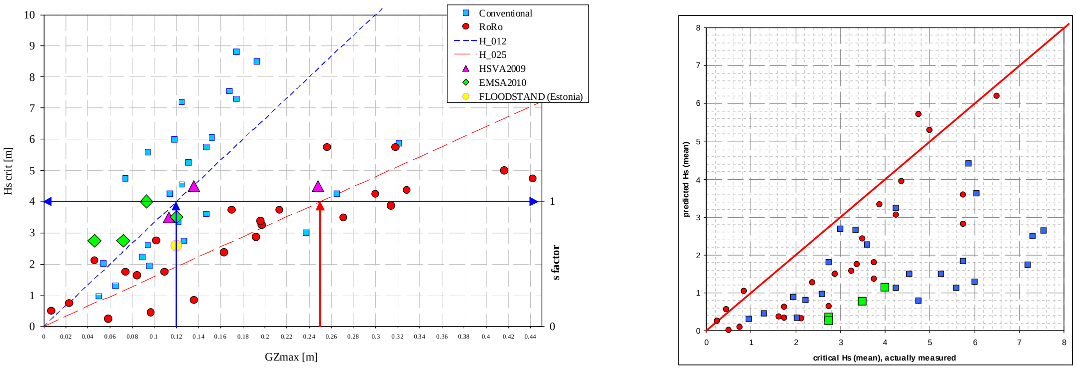

Figure 19 a) The critical wave height (H_s) vs. Gz_{max} and b) predicted vs. actually measured mean of critical wave height H_s

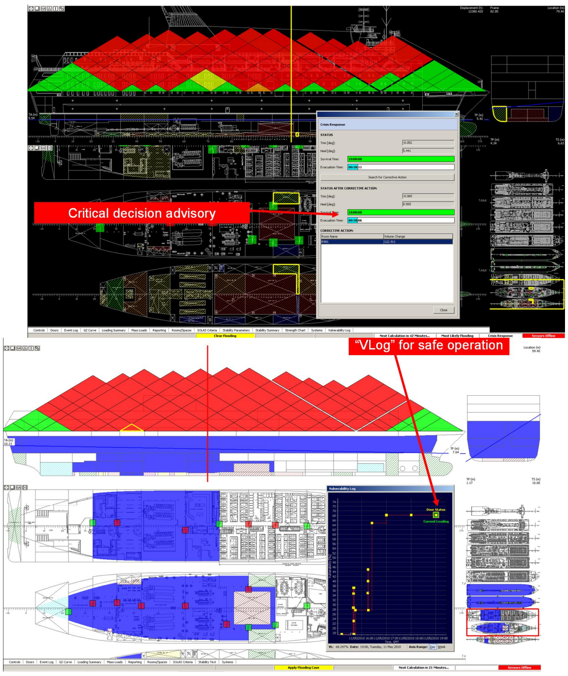

Figure 20 The decision advisory tested with the prototype model of ROPAX (Source: WP4&WP6)

4.7 WP7 Standard for decision making in crises (WP-leader: NTUA)

- A summary of progress towards objectives in WP7, Task 7.1:

The demonstration of the FLOODSTAND developments is worked out in WP7 by developing and testing characteristic benchmark scenarios. In line with the WP7 plan the developed standard is hosted by an Emergency Management System which is used as the basis for the tests and demonstration. The system being developed by SSRC (called thus far FLOODSTAND-ISTAND or iStand) has been evaluated and approved for this purpose. This system disposes readiness in required functionality which may also ensure smooth testing in subsequent tasks of both operational and design stages. Demonstration is also completed with the presentation of the crisis management in operational conditions implementing the achievements of WP3 by NAPA.

For the development the benchmark scenarios (task 7.1), a sufficiently representative set of damages have been produced by random selection of the damage parameters. The random characteristics correspond to the statistics of collision damages. The time to capsize in waves that corresponds to this set of damage cases was analyzed by use of numerical simulation method. Then having determined the time related to each damage scenario, a specific set of scenarios could be selected which define a comprehensive group of benchmark cases. In particular the characteristic damage cases differ with respect to the time to capsize and they provide a means for comparison of the survivability assessment with the FLOODSTAND standard.

For the demonstration in operational conditions some incident damage opening is assumed to be determined, to extent possibly, and then the survivability of the damaged ship is questioned. Then the estimated actual survivability and the evacuation characteristics of the damaged passenger ship are combined to evaluate the potential risk of people on board. In the design stage the effect on the survivability of the ship of an internal opening, like a watertight door, can be questioned and investigate whether the developed standard could provide valuable guidance even at this detailed level. The development of benchmark scenarios is reported in D7.1.

Task 7.1 resulted in the deliverable D7.1, the complete draft version of which was submitted to the coordinator with a minor delay (in project Month 20). After the time reserved for comments by the Steering Committee and consequent revisions, the final version of D7.1 was made available.

- Significant results/Main achievements:
  - Determined comprehensive benchmark damage cases (in Task 7.1)

- Main problems, deviations etc. (if any): -

- Deviations from Annex 1: No significant deviations have been identified

Publications:

Scientific publications (list):

- Spanos, D.A., Papanikolaou, A.D., On the Time Dependent Survivability of ROPAX Ships, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23
- Jalonen, R.P.S., Jasionowski, A., Ruponen, P., Mery, N., **Papanikolaou, A.**, Routi, A.L., (2010), FLOODSTAND – Integrated Flooding Control and Standard for Stability and Crises Management, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23.

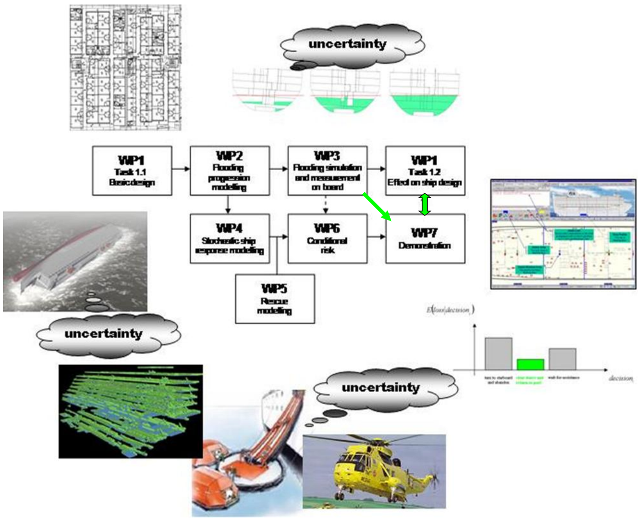

Fig. 21 Relationship between the FLOODSTAND technical work packages

5. Conclusion

The progress of the work has been quite good and almost all of the objectives set to the first half of the project were met. Project FLOODSTAND was established to derive most of the missing data for validation of time-domain numerical tools used in the assessment of ship survivability and to develop a standard for a comprehensive measure of damaged ship stability by concentrating on the risk of flooding. In the first half of the project the results obtained satisfied almost all of the identified needs for the validations.

Nearly all of the scheduled RTD-deliverables could be produced in each Work Package and they could also be approved by the Steering Committee (SC) up to Mid-Term Meeting, i.e. during the first half of the project are listed as follows:

Work Package	Total number of deliverables to be submitted (in months 1-36)	Number of deliverables submitted at MTM*	Comments
1	3	2	As originally planned
2	11	8	As originally planned
3	3	0	As originally planned
4	5	2/3	Almost as originally planned
5	5	1	As originally planned
6	2	0	As agreed by the Steering Committee**
7	3	1	As originally planned
Total	32	12 2/3	As originally planned

*   MTM = Mid-Term Meeting

** It was agreed in the third Steering Committee meeting that 12 months of additional time for D6.1 could be admitted

The concept cruise ship designs in WP1 were developed as planned, which gives good prospects for their further analysis during the second half of the project. In spite of the intentionally front heavy schedule of the experimental part of the work in WP2 and WP4, almost all of the scheduled tests could be made and reported during the first half of the project. The results from the model tests, and from the tests in real scale, as well as from the numerical analysis, and from the other, yet non-reported parts of the project, can be considered to be a good groundwork for further analysis and thus, a promising start for the project.

6. References

RTD-deliverables produced and approved up to the Mid-Term Meeting of the project FLOODSTAND (218532):

Del. no	Deliverable name	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date (month)
D1.1a	Concept Ship Design A	1	STX	R, P	PU	3
D1.1b	Concept Ship Design B	1	MW	R, P	PU	3
D2.1a	Description of the mockup and test procedures; List of structures to be tested	2	CTO	R, P	PU	3
D2.1b	Experimental study on the critical pressure heads	2	CTO	R, P	PU	15
D2.2.a	Numerical study on the critical pressure heads	2	MEC	R, P	PU	17
D2.3	Results of the experimental study on the pressure losses in openings	2	AALTO	R, P	PU	14
D2.4.a	Results of the computational study on the pressure losses in openings	2	CNRS	R, P	PU	17
D2.4.b	Results of the studies of pressure losses in air pipes and effects of ventilation	2	CTO, STX	R, P	PU	17
D2.5a	Draft report on flooding tests on detailed cabin arrangements	2	MARIN	R, P	PU	11
D2.5b	Report on flooding tests on detailed cabin arrangements and on the effects of different scale	2	MARIN	R, P	PU	17
D4.1	Report on physical model experiments with ship model	4	SSPA	R	PU	12
D5.1	Report on the data collection on mustering/abandonment and rescue	5	BV	R	PU	12
D6.1	Report on the details and the rationale of the loss function	6	SSRC	R, P	PU	~~18~~ 30
D7.1	Report on the benchmark data on casualty mitigation	7	NTUA	R	PU	18

Other publications of the project:

European Commission (2011) Sustainable Surface Transport Research Research, 7th Framework Programme 2007-2013, Project Synopses – Volume 1, Calls 2007 & 2008, Directorate-General for Research Cooperation/Transport (including Aeronautics), ISBN 978-92-79-16415-6, doi: 10.2777/1839, European Union, 2011, pp. 266-269.

Jalonen, R. (2009) FLOODSTAND – Integrated Flooding Control and Standard for Stability and Crises Management,,Maritime Research News, 1/2009, Vol. 24/ISSN 0784-6010, pp. 3-4.

Jalonen, R.P.S., Jasionowski, A., Ruponen, P., Mery, N., Papanikolaou, A., Routi, A.L., (2010), FLOODSTAND – Integrated Flooding Control and Standard for Stability and Crises Management, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23, 2010, pp. 159-165.

Jasionowski, A. (2010) Decision Support for Crisis Management and Emergency Response, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23, 2010, pp. 209-216.

Jasionowski, A, “Decision Support for Ship Flooding Crisis Management”, Ocean Engineering 38 (2011), pp. 1568-1581. (doi.org/10.1016/j.oceaneng.2011.06.002)

Penttilä, P., Ruponen, P. (2010), Use of Level Sensors in Breach Estimation for a Damaged Ship. Proceedings of the 5th International Conference on Collision and Grounding of Ships ICCGS, June 14th - 16th 2010, Espoo, Finland, pp. 80-87.

Qi Chen, Jasionowski, A, “A New Methodology for Modelling Stochastically the Time to capsize”, 4th International Maritime Conference on Design for Safety, October 18-20, 2010 in Trieste, ITALY.

Spanos, D.A., Papanikolaou, A.D., On the Time Dependent Survivability of ROPAX Ships, Proc. of the 10th Inter. Workshop on Ship Stability, Wageningen, The Netherlands, June 21-23, 2010, pp. 143-147.

Stening, M., Järvelä, J., Ruponen, P., Jalonen R., (2010), Determination of discharge coefficients for a cross-flooding duct, Ocean Engineering 38 (2011), pp. 570-578. (doi.org/10.1016/j.oceaneng.2010.12.004)