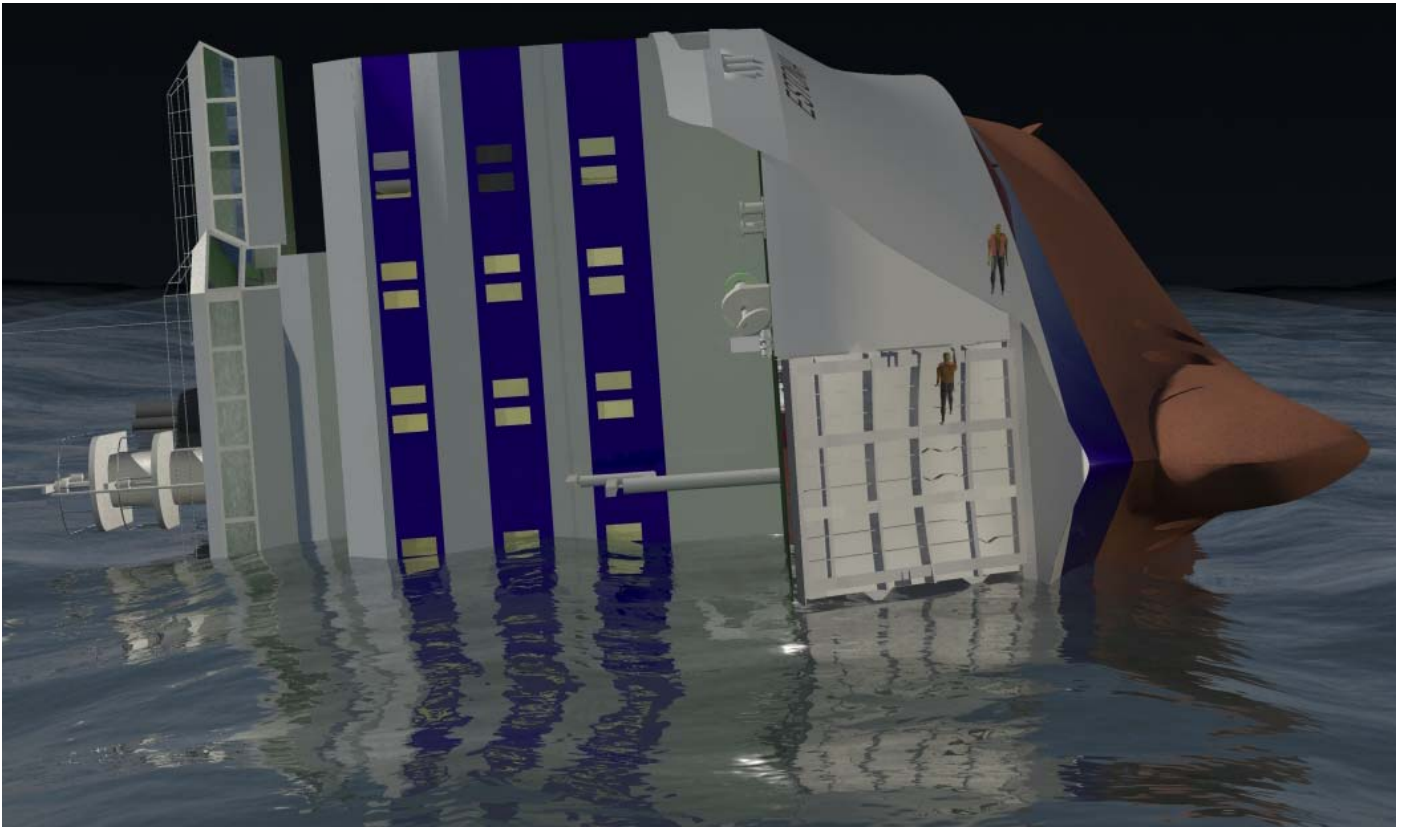


Research Study on the Sinking Sequence of MV Estonia

Virtual demonstrator



Project No.: *SaS0603-VIES01*
Reference No.: *VIES01-RE-004-AJ*
Report Date: *18 May 2008*
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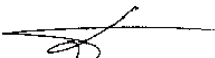

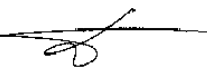
Title: <i>Research Study on the Sinking Sequence of MV Estonia Virtual Demonstrator</i>	
Summary: This report presents with a virtual model developed for helping with interpretation of the established sequence of key events of the sinking of MV Estonia. This document provides with succinct summary of the established sinking sequence. It is advised to review the “Technical Summary of The Investigation on the Sinking Sequence of MV Estonia” for better overview of the explanations and supporting evidence for the derived scenario.	
Client: <i>VINNOVA</i>	Report No.: <i>VIES01-RE-004-AJ</i>
Project No.: <i>SaS0603-VIES01</i>	Date: <i>18 May 2008</i>
Author(s): <i>Andrzej Jasionowski</i>	Checked by: <i>Dracos Vassalos</i> 
Work carried out by <i>Przemek Zagorski</i> <i>Andrzej Jasionowski</i> 	Approved by: <i>Dracos Vassalos</i> 
Type: <input type="checkbox"/> <i>Draft</i> <input checked="" type="checkbox"/> <i>Final</i>	Status: <input checked="" type="checkbox"/> <i>Open</i> <input type="checkbox"/> <i>Internal</i> <input type="checkbox"/> <i>Confidential</i>
Keywords: <i>MV Estonia, sinking, fatalities, investigation, forensic research, safety, virtual modelling</i>	

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1 Introduction

853 human lives were lost when the passenger Ro-Ro ferry MV Estonia sank on the night of 27/28th of September 1994 in the Baltic Sea, while on route between Tallinn, Estonia, and Stockholm, Sweden. Instantly, a panel of investigators from three countries, Estonia, Sweden and Finland, was set up and the accident was studied in some detail. The conclusions as to the causal factors as well as the established sequence of events leading to sinking of the vessel were published 37 months later in the official report¹. Primarily, inadequate design of the locking devices of the forward bow ramp was blamed for the tragedy.

The conduct of this investigation was criticised widely. The main reason for the criticism derived from apparent lack of objectivity of the commission in examining and openly discussing alternative opinions on many aspects of the loss.

Recognising that some aspect of the loss require further study, The Swedish Government has assigned VINNOVA (The Swedish Governmental Agency for Innovation Systems) in its capacity as the responsible agent for the national Sea Safety Programme to commission a research project with the aim of studying the sinking sequence of the MV Estonia. The results are to be used for advancing maritime safety provision for passenger ships of today and the future.

A two stage research call has resulted in the commissioning of two consortia, referred to hereafter as the SSPA Consortium and the HSVA Consortium, to do a research independently of each other.

This report describes part of the study addressing hypotheses on foundering scenarios.

2 Objectives

The key objectives of the whole project have been to understand the sequence and explain the underlying causes of the loss of MV Estonia and to derive suitable recommendations on design and operation of passenger vessels in order to prevent such tragedy from happening again.

The objective of this part of the project has been to build a virtual model and demonstration animation for the purpose of convenient conveyance of the key investigation findings.

¹ www.onnettomuustutkinta.fi/estonia/

3 Virtual model

The model has been built on the basis of all the geometrical information available to the SSPA Consortium. The cargo was distributed according to the estimates by SSPA Consortium.



Figure 1 A virtual model of MV Estonia by Safety At Sea Ltd.

4 Presented scenario

The scenario of virtual model is based on the analyses and simulation results presented in [1] and [2]. Figure 2 and Figure 3 are shown here for ease of reference of the sequence of events.

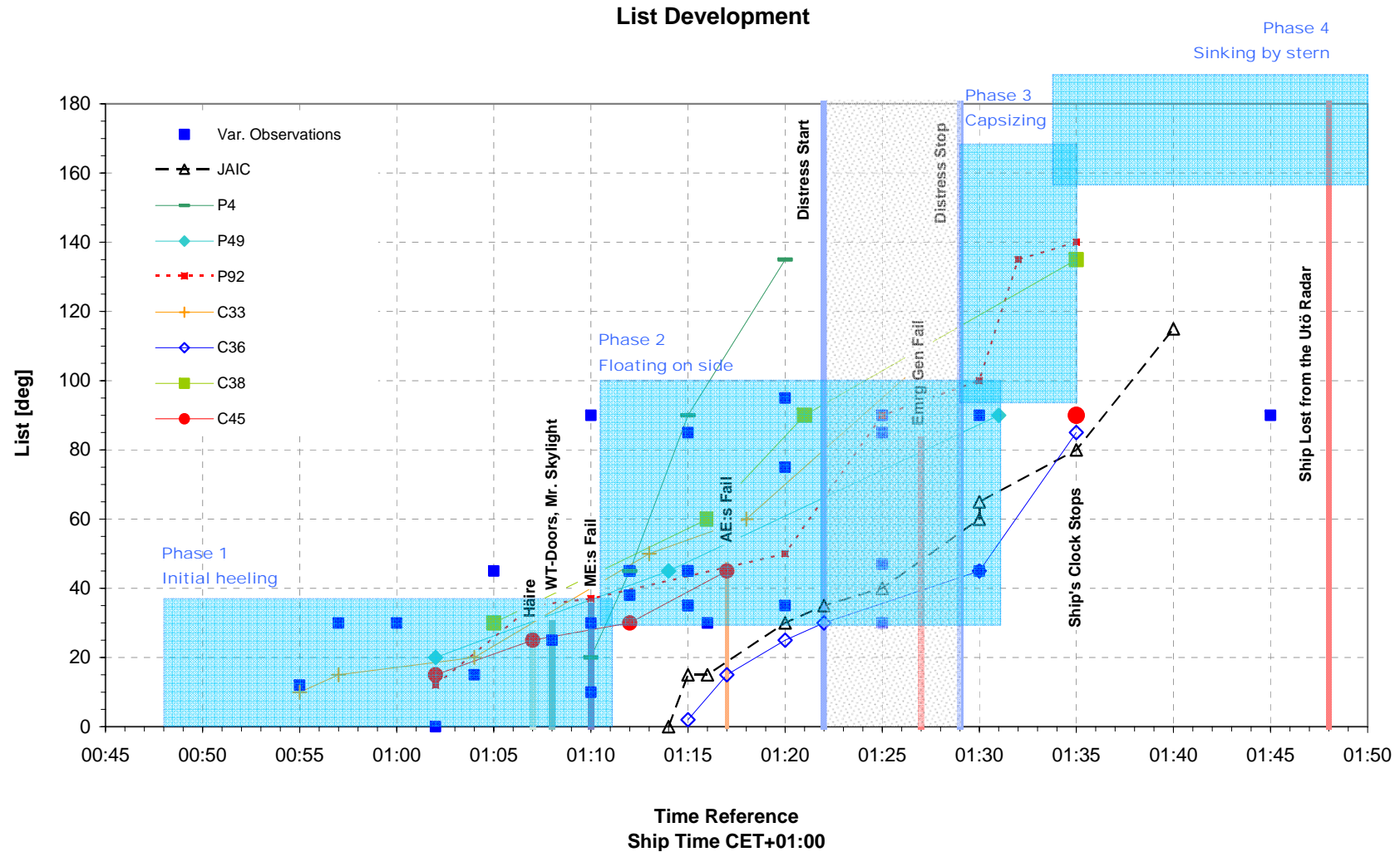
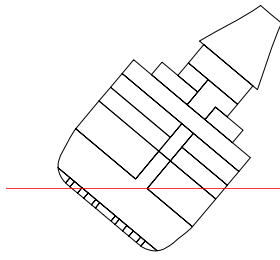
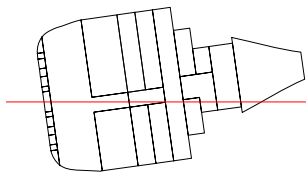


Figure 2 The sequence can be divided into the above four phases of the sinking. See [2] for summary of the sinking investigation by the SSPA consortium, and report [3] for summary of survivor's statements.



Phase 1 Initial heeling

Unobstructed inflow of water on the car deck.

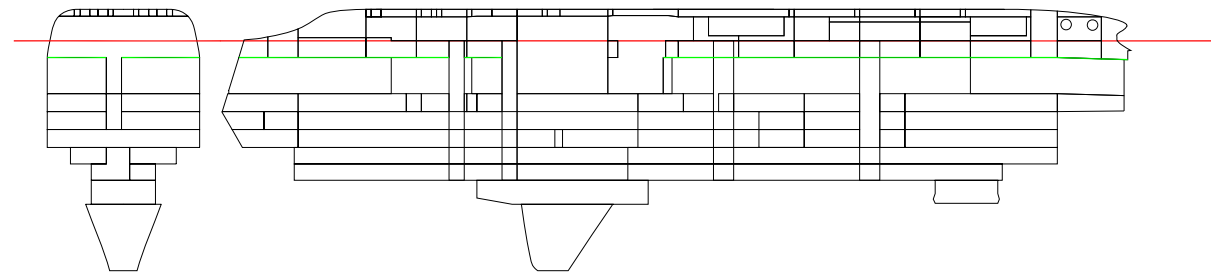


Phase 2 Floating on side

Side windows withstood considerable pressure, 5-10m. Some windows possibly never broke, as the accommodation spaces flooded. Possibly, water on the car deck reached centre casing and started flooding down to D 0/1.

Phase 3 Capsizing

After ship heels to 60-80deg, capsizing within 3-5 minutes is inevitable.



Phase 4 Sinking by stern

After capsize (heel 170-180deg) the ship starts sinking by stern. Water floods spaces in D0/1 through centre casing, possibly through D4. Sinking within 10-15 minutes is possible.

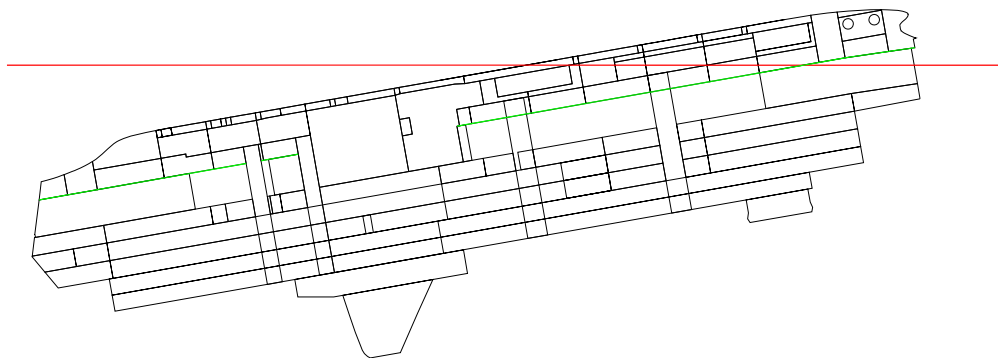


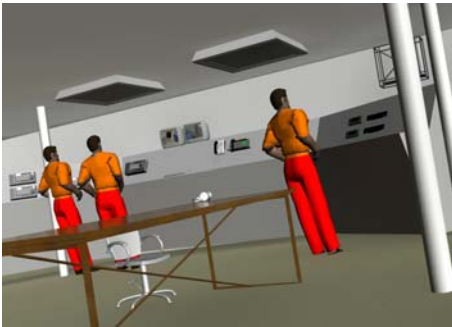
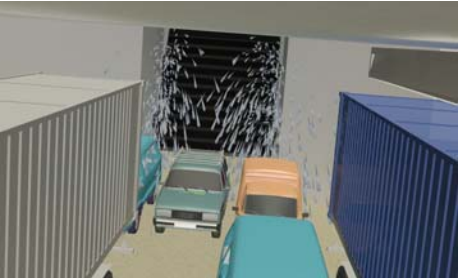

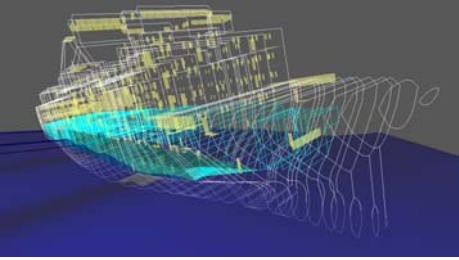
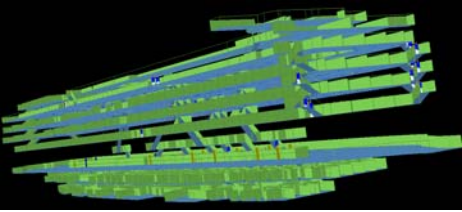
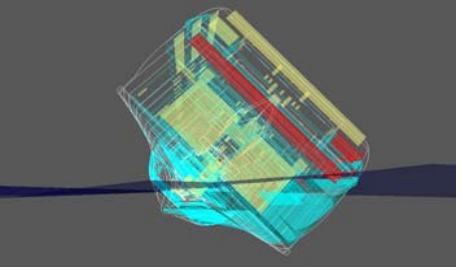

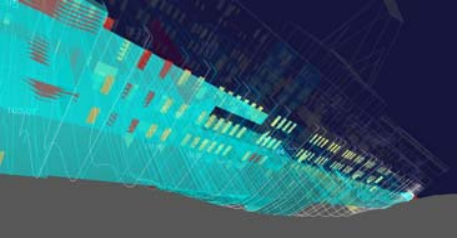

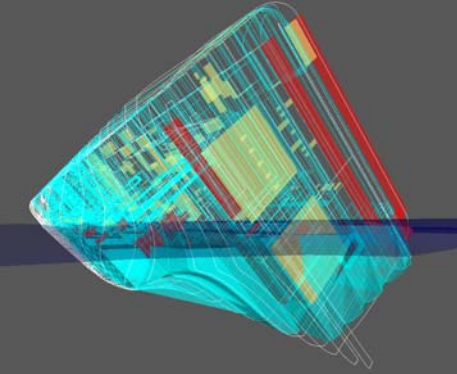



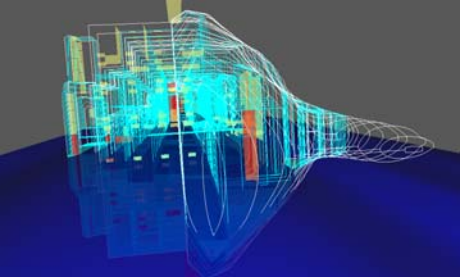

Figure 3 Sinking sequence of MV Estonia.

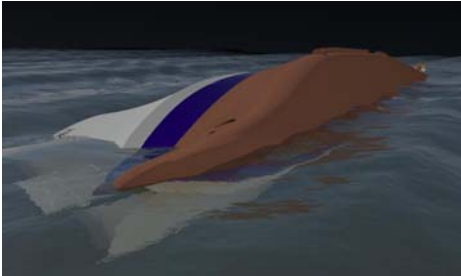
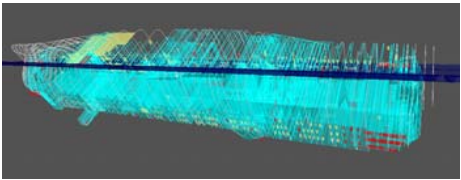
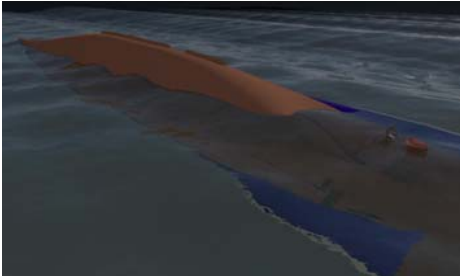
Phase 1 Initial Heeling, ca 00:47 – 01:10		
Clip 1		Ship proceeds at 14kn, port-bow quartering seas, Hs 4 - 5m.
Clip 2		Visor suffers sea loads in excess of its load-bearing capacity. Hinges break, and visor starts breaking off its attachments. Some water starts accumulating on car deck.
Clip 3		Crew on Deck 0/1 became alerted by noises and developing heel. They gathered in the Engine Control Room (ECR).

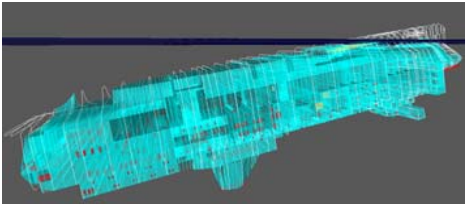
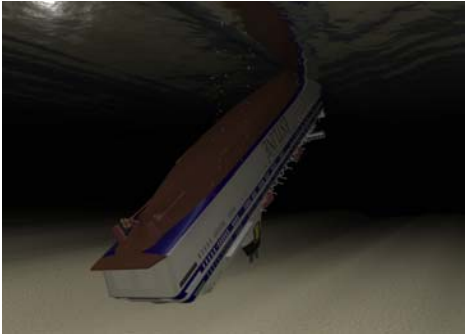
Clip 4		<p>The ECR crew observed the car deck through the monitors where they saw water pressing at sides of the ramp and water wedge forming on car deck.</p>
Clip 5		<p>At some instant the bow visor fell off, pulling the ramp behind.</p>
Clip 6		<p>Excessive amounts of water entered the car deck causing rapid heel development at every wave dive.</p>

Clip 7		Many people became alerted from very early instants of the loss and started evacuating the ship.
Clip 8		Heel angle reaches close to 35-40deg.
Phase 2 Floating on side, ca 01:10 – 01:30		
Clip 9		Deck 4 becomes submerged, but windows do not break instantly. The buoyancy of accommodation Decks 4, 5 and 6 supports the vessel.

Clip 10		<p>Some windows will eventually break. Water floods into Deck 4 and above. Due to water ingress into the accommodation, the sea pressure on windows is compensated. Only few windows break. In the meantime, water floods to machinery spaces in Deck 0/1 through the side ventilation access.</p>
Clip 11		<p>Many of the survivors reach top decks.</p>
Clip 12		<p>As the accommodation decks support temporarily the vessel, the water in the car deck builds up, reaching centre casing at 40-50 deg angle of heel. Spaces below start also flooding from car deck, possibly aft first.</p>

Clip 13		Some cargo will likely be displaced. Water continues to flood through centre casing.
Clip 14		Heel angle reaches 90deg.
Clip 15		Some survivors looked for place from which to abandon the sinking ship. They reached forward part of the vessel and climbed down the ramp. They noticed deformations of the stiffening arrangement.

Phase 3 Capsizing, ca 01:30 – 01:35		
Clip 16		One of the survivors tried to alert nearby ships by using flash of his camera, incidentally making picture of another survivor sitting on ship's bilge. Ship capsized to 130-135deg.
Clip 17		Aft spaces undergo flooding through centre casings. Ship starts attaining aft trim.
Clip 18		Some survivors noticed beach line developing, exacerbating impression that ship sank with the aft end first. 9 survivors from 6 different rescue rafts stated that the vessel sank by bow, possibly because some of them saw the aft, e.g. one saw propellers and another saw rudder.

Phase 4 Sinking, ca 01:35 – 01:48		
Clip 19		Ship continues flooding through centre casings and sinking by aft.
Clip 20		The buoyancy of the ship is lost, MV Estonia sinks to her final resting position.

5 Literature

- [1] Jasionowski, A, "*PROTEUS3 simulations of foundering scenarios*", Safety at Sea Report No VIES01-RE-002-AJ, May 2008.
- [2] Jasionowski, A, Vassalos, D, "*Technical summary of the investigation on The Sinking sequence of MV Estonia*", Safety at Sea Report No VIES01-RE-006-AJ, May 2008.
- [3] Bergholtz, J, Rutgersson, O, Schreuder, M: "WP2.1 Review of evidence Report No. 2 Conceivable course of events", Department of Shipping and Marine Technology, Chalmers, Technical Report, March 2008.