

## Research study on the Sinking Sequence of MV Estonia

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*On 28th September 1994 the Estonian-flagged Ro-Ro passenger ship MV Estonia, having departed from Tallinn with 989 people onboard for a scheduled voyage to Stockholm, sank rapidly, stern first, and disappeared from the radar screens of ships in the area at about 0150 hrs. There were 852 fatalities and 137 survivors. The accident is considered to be the worst disaster at sea in post-war Europe. The SSPA Consortium can now present the final report of the research study of the sinking sequence of MV Estonia.*

In March 2006 the SSPA Consortium (SSPA Sweden, Project Management, Safety at Sea/SSRC, Glasgow, Technical Coordination, Maritime Research Institute Netherlands (MARIN), Chalmers University of Technology, Shipping and Marine Technology, Gothenburg), was awarded a grant to investigate the sinking sequence and explain the underlying causes of the loss of MV Estonia.

The project funding was EUR 0.95 million and was provided by VINNOVA (Swedish Governmental Agency for Innovation Systems).

The project started on 1<sup>st</sup> March 2006 and the “Final Report- Research Study on the Sinking Sequence of MV Estonia”, SSPA Research Report No. 134, was submitted on 5<sup>th</sup> May 2008.

All reports, video recordings from model tests and animations are available at <http://www.sspa.se/news/2008/the-research-study-on-the-sinking-of-mv-estonia-is-now-completed> and at the project website: [www.safety-at-sea.co.uk/mvestonia/](http://www.safety-at-sea.co.uk/mvestonia/).

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### The Scientific Approach

The approach adopted in the research project was:

- To review evidence such as testimonies from survivors and observations from all available video recordings from diving and ROV (Remotely Operated Vehicle) investigations. Four diving team members from the wreck investigation were also interviewed.
- To form an International Panel of Experts (IPE) to assist the SSPA Consortium to suggest different loss hypotheses conformant with the evidence.
- To perform fundamental and systematic model experiments in order to derive data for numerical simulation models.
- To build comprehensive numerical models to describe the performance of the damaged MV Estonia during the initial foundering phase when it was manoeuvred and when drifting in wind and waves, as well as for the progressive flooding when water enters the ship.
- To evaluate the different loss scenarios and derive the most probable of these, using different numerical simulation methods.
- To substantiate the most probable scenario by means of computer simulations/animations and physical model experiments.

- To derive conclusions and to make recommendations for future safety improvements in respect of passenger vessels.

### **The Most Probable Foundering Scenario**

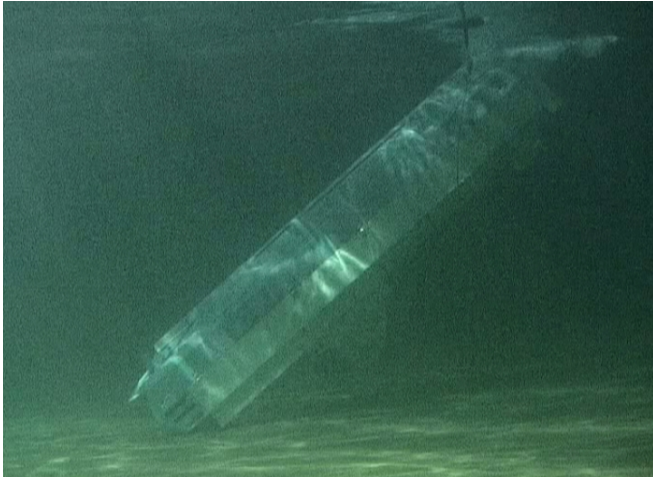
A large number of different foundering scenarios were investigated in the project. Technical evidence and testimonies were used to identify the following most likely scenario:

- The ramp was forced partially open by the bow visor prior to complete visor detachment from the vessel.
- Water was entering the car deck through the openings at the sides of the ramp resulting in a slowly increasing starboard heel angle.
- The ramp remained partially open until the bow visor detached from the hull.
- The ramp fully opened and was crashing down onto the forepeak deck as the visor completely detached from the vessel.
- A large amount of water was entering the car deck resulting in a rapidly growing starboard heel angle of up to about 35-40 degrees.
- The ramp may have been fluctuating up and down due to the interaction between waves and the pitch motions.
- Water was flooding down to the lower decks through vents and centre casing.
- The officer on the bridge decreased the ship speed and started a port turn.
- After turning, the ship heel was still increasing and the Main Engines stopped.
- Large windows at the aft part of decks number 4-6 broke.
- The heel was increasing further and the Auxiliary Engines tripped and stopped when the heel angle was more than 45 degrees.
- The ship was now drifting in wind, waves and current and when the heel was about 80-85 degrees the Emergency Generator shut down.
- The ship capsized.
- The ship sank with bow up.
- The aft part of the ship hit the seabed first.

The foundering sequence as described is estimated to have taken about one hour.

### **Model Experiments of the Foundering Scenario**

Foundering tests were carried out with a complete model of MV Estonia. The aim of these tests was twofold: to verify and validate the simulations carried out within the project and to strengthen the understanding of the foundering by means of physical experiments. The final test was also a demonstration of the most probable foundering scenario as identified by the SSPA Consortium.



*Model test with MV Estonia in SSPA's MDL. After capsizing, the ship sank with the aft part of the ship hitting the seabed first.*

### **Conclusions of the Research Study**

It was concluded that the loss of 852 people resulted from a rapid loss of stability by MV Estonia.

Therefore, all the circumstances and reasons for

- breach of hull integrity allowing unobstructed ingress of sea water into the spaces of MV Estonia
- inadequate stability to allow orderly ship evacuation and abandonment in the event of such water ingress,

are considered as the causes of the disaster.