Safety at Speed - S@S

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# 1. EXECUTIVE SUMMARY SUITABLE FOR PUBLICATION

The present report is included in the Work Package 6 case study, which main objective is to test in a real-life HSC design process the majority of methods and tools developed in WP1 to WP4 of S@S project and integrated in a unique tool by WP5.

The method used for this Work Package 6 is to start using the integrated tool with a baseline existing High Speed Craft, assessing its overall safety level. The second step will be to generate an enhanced vessel, considering both safety and cost effectiveness and the third step is to compare the two designs and the use of the integrated tool during the two different processes.

This report relates the work done during task 6.1 which is to assess a baseline ship safety using the Project Tool. The chosen baseline ship is the Superseacat III, a monohull Ro-Ro Fast ferry, designed and built by Fincantieri.

The risk level associated with this ship is assessed by means of the Project Tool and the software FaultTree+. The results are analysed and several calculations are run in order to find the main critical parameters. Some comments related to the results analysis or the ease of use of the Tool can be found in this report, with the aim of improving the Tool efficiency in a real design process.

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# 2. INTRODUCTION

## 2.1 Background

The aim of the Work Package 6 case study is to use the integrated tool developed during Work Package 5 in a real-life HSC design framework. The Project Tool is an integrated version of all models developed by the other Work Packages (WP1 to WP4). Here is a list of all models developed:

- Work Package 1.
  - Human error model
  - Manoeuvring errors model
  - Mechanical and automation failures
- Work Package 2.
  - Ship availability
  - Short term analysis: ship motions
  - Long term analysis: vertical bending moment at midship
  - MSI-MII calculation
  - Hull girder vibrations
  - Noise model
  - Indoor climate model
  - Dynamic stability model
- Work Package 3.
  - Foundering risk and cost model
- Work Package 4.
  - Flooding containment
  - Fire risk and cost model.

In the integrated tool developed by WP5, the models have been set up in another way. Firstly, the models related to comfort assessment have been set together (noise, indoor climate, vibrations and MSI calculation). Then, the other models form together on one hand a risk evaluation and on the other hand a cost evaluation.

## 2.2 Objectives

This deliverable describes the objective, the methodology and the results of the task 6.1, which consists in establishing the safety results of a baseline ship. The ship in focus is the Superseacat III, a monohull Ro-Ro Fast ferry, designed and built by Fincantieri.

The aim of this task is to confirm that the integrated tool is applicable in a real-life pre-selected project. No features of the baseline ship will be changed during this task so that the real Superseacat safety is assessed.

## 2.3 Scope of work

The first step of this task is to identify the necessary technical information and drawings, or any other source of information, in order to evaluate the availability of the data required. For each Work Package model, the parameters need to be calibrated and refined in order to fit to a real design framework.
The second step is to set a value for each relevant parameter and to use the final integrated tool to assess the safety of the Superseacat III. The critical parameters, those that are influent on the safety results, are also identified with the aim of easing the work of task 6.2 where an enhanced design of the ship will be proposed.

Thus, in accordance with the scope of the work of this WP and providing a useful feedback to WP5, the comments and remarks from WP6 are addressed to the following issues:

- Eventual errors encountered when running the tool
- Ease of use and user-friendliness of the integrated tool
- Adaptability of input parameters to a real ship
- Interpretation of the safety assessment obtained with the Tool, in comparison with real observations and experts knowledge
- Preliminary analysis of Critical parameters.

# 3. METHODOLOGY

The task 6.1 has been divided in six sub-tasks.

- **Sub-task 6.1.1:**

The necessary technical information has been identified and got. The documents have been mostly provided by Fincantieri concerning the MDV 1200A.A. Superseacat type, Monohull Deep-V Ro-Ro-Fast-Ferry:

- Technical specification, AS 800G0009M
- Midship section GG1010010M
- General arrangement - upper decks GG8020201M
- Body plan GG8020021M
- Bus garage arrangement GG67300002
- General arrangement windows GG6250001M
- Technical specification and detail insulation GT63500002/01
- Propulsion study GZ8350033M
- Weight report GZ8330001M
- Hydrostatic data GZ8350002M
- Trim and stability for all loading condition-ship as built GZ8350079M
- Ambient noise in the living spaces GZ8350060M
- Sea-keeping study GZ8350023M

More general documentation has also been used:

- High Speed Craft (HSC) code, edition 2000
- Ship Designers Guide "12, 16 and 20 cylinder RK270 Fast Ferry and Naval Marine Propulsion Engines"
- Global wave statistics
- ISO 7547 (temperature), ISO 2923 (noise limits), ISO 8861 (ventilation)

Moreover interviews have been conducted among technical experts working at Fincantieri in order to provide detailed data and assumptions for all the input parameters.
Some information is also needed from an operational point of view. The questions were either directly asked to Sea Container, or assessed by means of some assumptions.

- **Sub-task 6.1.2:**

During this task, each Work Package model has been studied with the help of the User Guides in order to understand the meaning and the use of each parameter. The requested inputs have been looked at, with the aim of finding their link to the technical data available.
The models have been run with default values in order to understand how they work.
The outputs have also been analysed.
A meeting was held in Genoa with WP6 participants (Fincantieri, Cetena and Mettle). The work load has been distributed among them and assumptions and clarifications concerning the parameters have been enlightened.

- **Sub-task 6.1.3:**

In relation to other work package leaders, some parameters have been redefined or adjusted when they were not understood or not well-matched with available data. The parameter list produced by WP5 has also been studied and modified. Missing parameters have been gathered and the classification optimized. The aim is to help WP5 in implementing a user form close to a real design framework, using different parameter groups corresponding to the different design phases.

A workshop, held in Glasgow, gathered the persons in charge of all work packages. The last questions concerning the parameters meaning have been raised and answered. Further to this workshop, some Work-Packages modified their user guide or gave more information about how to assess a parameter value.

- **Sub-task 6.1.4:**

As soon as the Project Tool was available, it has been studied and tested. The different possibilities of the Tool have been tried, using the default values for all input data. During this task, a certain amount of errors in the code of the tool or of the models were encountered. These errors have been solved one by one, by Task 6.1 participants, with the help of other WP, particularly WP5. At the end of this task, the Project Tool was running correctly in Fincantieri, Cetena and Mettle and all calculations could be performed. A list of improvements still needed was established and can be found in this deliverable.

- **Sub-tasks 6.1.5:**

Once the Tool was running correctly, the next step was to use it to assess the safety level of the SuperSeaCat III. With the help of the technical documentation gathered in task 6.1.1, the values of all input parameters were found. This task implied a big communication effort among the technical expert of WP 6 but also with other WP leaders and Sea Container, since some additional clarification was sometimes needed. Many of the parameters had to be calculated or derived, because they were not directly available in the technical documentation. Some assumptions were made when the data was not available or was incomplete.

An internal meeting was held on the in Genoa between all WP6 participants in order to set definitively all the parameters values. When all parameter values were gathered, they were input in the tool and the different calculations were run.

- **Sub-tasks 6.1.6:**

After this first run, the results from the Tool were input in the FaultTree+ software. Then the outputs were analysed during an internal meeting held in Sophia-Antipolis. Different runs were performed in order to have a preliminary assessment of the critical parameters.

An assumption was used during this process: when using FaultTree+, the severity levels have to be updated manually in the fire containment event tree. Since the correspondence between consequences on ship and on human is not very clear, the following correspondence was assumed and used:

| consequence scale in Design Tool | | consequences scale in Fault Tree + | |
|---|---|---|---|
| | | Effects on human safety | Effects on ship |
| 0 | No effect | No effect | No effect |
| 1 | Minor | Minor | Minor effects |
| 2 | Significant | Significant | Minor effects |
| 3 | Severe | Severe | Major effects |
| 4 | Severe | Severe | Severe effects |
| 5 | Catastrophic | Catastrophic | Catastrophic |

# 4. RESULTS

## 4.1 List of parameter, classification.

The following classification was used to sort the different parameters required for all models.

- Background
- Project specification
- Design parameters – concept
- Design parameters – preliminary
- Design parameters - detailed
- Derived parameters

A first list was established by the WP5 and completed by the WP1 to 4.
Then this list was analysed by WP6 partners and some modifications were done in accordance with their comments. In particular, some parameters were moved to another category when they were considered as belonging to an earlier or later design phase. Other parameters were simply added to the list when they had been forgotten.

At this step some comments were also addressed by Fincantieri:

- Despite some parameters are not considered in Fincantieri design procedures, they will be considered as input data because relevant under the Safety point of view. They will be assessed using information from other WPs and/or using assumptions.
- Despite some input parameters are not representative for the pre-selected basic design configuration of SSC vessels (i.e. gas turbines, propellers…) the tool considers the above parameters in order to be as flexible as possible and cover a wide range of vessels configurations.

The result of this work was used by WP5 during the tool implementation, in order to create a user-friendly input interface. Indeed the input parameters should be as close as possible to the parameters used in a real design process.

In a later step, after the tool had been implemented, another parameter list was built. This new list was closer to the input procedure of the tool and was a basis for the gathering of SuperSeaCat parameters' values. This list can be found in Appendix 1 and contains all parameters names, units and values.

## 4.2 Parameters clarification and assessment.

In order to standardize all the parameters and their units, during the whole task 6.1, a lot of communication was needed among all partners involved in S@S.
During and after the PMC meeting in Glasgow, some modifications or clarifications were made. Few examples can be read below:

- WP3 User Guide was modified in order to bring more information concerning the Stillwater bending moment calculation, the assessment of the parameters "workmanship level", "maintenance level" and "operational lifetime", the meaning of "bow flare coefficient" . . .
- The parameters related to human factor (WP1) were discussed and it was decided to use default values during the first safety assessment (during task 6.1).

- The parameter "speed of the vessel" was split in two parameters: "maximum continuous speed" and "service speed". Indeed either one or the other parameter was needed depending on the model.
- The unit of fuel consumption (cost evaluation) was changed from L/kWh to gr/kWh.

When the meaning of all parameters was clear, the values corresponding to SuperSeaCat III have been gathered. However, the use of the tool requires having a very good knowledge of the ship which is studied, both from a design and from an operational point of view. Besides, the input parameters necessary when using the tool are not always similar to those used during the design of the boat. That is why it was difficult to assess some of the values of input data.
Some of these parameters were found directly in the technical documentation. However most of them needed to be derived from other parameters or from drawings and past experiences of technical experts. When the information needed was unavailable or incomplete, some assumptions were needed.
These assumptions are somewhat a source of inaccuracy in the absolute value of the risk level. Still, it has to be underlined that the main assumptions concern the following models: noise, indoor climate, vibrations. Those models are related to the comfort evaluation, which has a small influence on the overall risk evaluation. Moreover, the comparison between two alternative designs will not be affected by this inaccuracy.

The main assumptions are the following:

- Loading parameters: the assumption was made that the ship was sailing in Mid North Sea (whereas the actual route is Dublin-Liverpool).
- Operational diagram: the following assumptions are made: when the wave height is below 3.5 m, the ship will sail at a speed of 35 kn; when the wave height is between 4 and 6 m, the ship will sail at a speed of 15 or 25 kn; when the wave height is above 7 m, the ship will sail at a speed of 5 kn. These assumptions were considered reasonable by WP6 members.
- Wave incidence: given that the route taken by SSC3 is a west-east route, it was considered that "head sea" – that is 180°– refers to west and consequently 0° corresponds to East. Therefore this is the route Liverpool-Dublin that is under consideration rather than Dublin-Liverpool.
- Traffic distribution: the assumption is that the type of traffic distribution is chosen as "2", since it is the closest to the real distribution (provided by Sea Container). This assumption is reasonable, given that the Tool does not allow changing individually the percentage of encountered ships.
- Human factor parameters: as they are hard to assess from a designer point of view, these qualitative parameters are set to default values, that is "medium".
- Labour costs of ARPA and AIS (identification system) are set to zero, since they are respectively options of Radar and ECDIS.
- The maintenance costs were assessed using information from Sea Container. Concerning the maintenance of bridge equipment (Radar, ARPA, ECDIS, DGPS and AIS) and of communication equipment (emergency system for the VHF, emergency system for the general alarm and PA, tall back system), Sea Container provided only a global maintenance cost. The percentages of maintenance costs were assumed to be equal in each category of equipment.

- A rough assumption for "basis net present value" was set during the task 6.1. This parameter will be refined during task 6.2, where the results of the cost evaluation will be better addressed.
- Climate system: The supplied air temperature was assumed. The exhaust air flow was derived from the technical documentation of the HVAC climate system.
- The VTS will be considered as not present in the task 6.1 because a land system and considered as a background parameter.
- Midship section: the panels' location and characteristics have been assumed using a drawing from another SuperSeaCat model. These assumptions are reasonable.
- Hull sections: the weight, hydrodynamic added mass and moment of area were assumed from approximate drawings. Indeed, Fincantieri does not use the same parameters and analysis when designing a ship. Concerning the vibrations sources, only the main engine was taken in account. The model is indeed made for a ship using propellers, whereas SuperSeaCat 3 has water jets.
- Sprinkler / Detector quality: at the moment, the default values will be used for these two parameters (see paragraph 4.4.2).
- Noise sources: the maximum number of noise sources that can be input is 19. Thus the sources must be selected carefully. As a first assumption, only one source will be input per type of source in each room. For example, there are in total 30 pumps in the ship, located in the both engine rooms, but only two will be input, one in each of the engine rooms. However, the four main engines have been input, since they are the main noise sources.

Note: the list of all parameters values (assumed values in red) can be found in appendix 1.

## 4.3 Problems solved using the integrated tool.

When running the tool for the first time some bugs were identified by WP6 and were corrected. Here are some examples of these bugs:

- Some of the input parameters could not be modified due to some programming errors.
- During the installation of all the files required for the tool running, the program "install" was created within the MSI-MII calculation in order to move automatically some files. In the initial version this program did not worked correctly due to an error in the name of one file.
- After the calculation of the indoor climate system, the level of comfort should have been assessed. Due to an error in the corresponding code, the level of comfort associated to a certain level of supplied air was not set correctly. The code has been corrected.
- The flooding containment calculation could not been performed. The cause of this problem has been found: the excel worksheet were protected and could not be overwritten.

## 4.4 Remarks on the Project Tool and future improvements.

When using the Project Tool, WP6 has noticed some items that could be improved. The relevant remarks have been noted during the workshop meeting in Newcastle in order to provide the necessary feedback to WP 5; these remarks are listed here.
However it should be said that the Project Tool is now running completely and that it was used without major problems when assessing the safety level of SuperSeaCat 3.
The points raised in this deliverable concern mainly the improvement of the interface (details of the input data process).
Some of these improvements were addressed during the Newcastle meeting (see chapter 5).

### 4.4.1 User-friendliness

- One of the improvements would concern the User Guides: at the present, the Tool can be used and understood only by reading some of the project deliverables and by looking in detail at some models, in addition to the reading of the User Guides. The ideal would be to have only one user guide, containing all the information needed to input the parameters, to install and run the tool and to understand the outputs.

- The fire containment model requires a particular input method (input parameters in the calculation sheet in addition to those in the input form) and a specific export operation (from the Tool to FaulTree+).

- The Project Tool is focused also on the operational issues because of the necessity to calculate in a proper manner the risk level. Therefore, when using the tool to assess or increase the safety level, significant cooperation is needed between designers and ship owners. This remark points out the necessity to use also the operational requirements during a basic design phase.

### 4.4.2 Input data process

#### *4.4.2.1 Need for more information*

During the input data process, the user needs specific information coming from some technical experts assessment and an accurate analysis of all the user guides. Some improvements could probably be done to get a more user-friendly tool.

- Improve/complete the information buttons.
- Add more information into the button for some parameters. For example, the traffic distribution index or traffic density or traffic complexity can be fully understood only by looking at the corresponding charts/drawings. A link from the input window to these documents would probably be very useful.
- Complete the information for the noise sources input. The user has to input 14 parameters which are not defined in the tool. Both the Noise Model User Guide and the excel file S@S_WP2_Noise_model are needed to understand the meaning of these parameters 1 to 14. A link to this User Guide and to this excel file would be useful. The excel file is also needed to fill the Compartment Acoustic Parameter window.

- Improve the Structure and Fatigue parameters descriptions. The parameters are labelled with their full name (for example, “Stiffener flange thickness”), whereas in the drawing below, the abbreviation is used (for example, tw). Besides, the material and plate types are described only by 1, 2, 3, 4 with no explanation of their meaning.
- Improve the Indoor climate window parameters description: at the moment, they are named by abbreviations only (Av, Kg, Gs…) and a link to the User Guide would be helpful.
- Clarify the costs parameters. For each equipment, the cost should be divided in equipment cost, labour cost and maintenance cost per year. The units should be more consistent, for example, all labour and maintenance costs should be in % of equipment cost.
- It should also be better underlined which costs can be modified by the user, which ones are derived by the model and how to use the correction factors. This could probably be addressed in the User Guide.

#### *4.4.2.2 Need for modifications*

Some requests for modification were proposed at the Newcastle workshop and here summarized:

- Units: the unit of “required availability” should be specified (project specification). The unit of “variation in vertical location” should be clarified: % or meter (Dynamic Parameters – concept).
  The parameter “midship coefficient” should not have any dimensions, whereas it is currently specified “cm” (Dynamic Parameters – preliminary).
  The parameter “Stillwater bending moment” is expressed in kNm, whereas the information button requests that it should be expressed in MNm. This information should be modified in order to avoid mistake when inputting the value.
- The sea area parameter (Route and traffic parameters) provides a very limited number of choices and all the proposed areas are located in North Europe.
- The three parameters: reference period, max horizontal acceleration and max vertical acceleration should be removed from the dynamic parameters to the background parameters by WP5 because they are related to the classification criteria the designer wants to use (BV normal, BV worst which are both defined in the HSC code).
- Sprinklers / Detectors quality: these parameters actually refer to the reliability of the sprinklers/detectors, as explained in Fire Risk and Cost Model User Guide. Thus, they should probably be renamed “reliability” instead of quality. If possible, a realistic range should be specified (the reliability can not be close to zero or to one). A standard method to assess the value of these parameters should also be detailed.

#### *4.4.2.3 Other comments / future improvements*

- Route loading parameters: these parameters are quite difficult to assess since they could not be directly found in Global Wave Statistics but have to be either derived, or assumed. The best improvement would be to have in the tool a database of different wave scatter diagrams (and other related information). In this way the user would only have to choose the sea area where the ship is intended to sail.
- The maintenance cost of main engine is not requested.
- Labour and maintenance costs are difficult to assess for all navigation or communication equipment, especially because some parameters are "function" rather than system (i.e. ARPA, ATA and identification system).
- The parameter input process is quite time consuming. The following areas could probably be improved, for instance by using simple excel cells instead of "boxes": Midship section, Compartment Details (Dynamic Parameters – preliminary) and Compartment / space data (Noise Parameters). Besides, the four models related to comfort (MSI-MII calculations, Hull Girder Vibrations, Indoor climate and Noise) are the most demanding in term of input parameters, whereas their impact on the global risk level is not critical.
- Noise parameters – indoor climate parameters: a lot of parameters are asked in these two areas. One improvement could be to ask only once the length, width and height of each room and to derive the other dimensional parameters (volume, surfaces, panel dimensions…).

## 4.5 Baseline ship safety results.

The safety level of the baseline ship can now be assessed. The values of all input parameters are those of the SuperSeaCat III, built by Fincantieri and operated by Sea Container. These values can be found in the list in Appendix 1.
It is considered that the route on which the ship is operated is Dublin-Liverpool, which was the route of the ship during 2002.

*Results concerning the comfort evaluation:*
Comfort level related to MSI: medium
Comfort level related to MII: high (for both crew and passengers)

Risk of resonance: low

Comfort level related to indoor climate: low (the ratio required air/supplied air is 1.2)

Noise level in different rooms:

| Compartment Name | Sound Limit (dBA) | Calculated Level (dBA) | Comfort level |
|---|---|---|---|
| Hall | 75 | 81 | Low |
| Bar | 75 | 138 | Low |
| Hot food area | 75 | 108 | Low |
| Shop | 75 | 102 | Low |
| pass. for | 70 | 40 | High |
| pass. Aft | 70 | 60 | Medium |
| pass. Upp | 70 | 49 | High |
| bridge | 65 | 40 | High |
| aft engine room | 110 | 117 | Low |
| for engine room | 110 | 112 | Low |
| auxiliary room | 110 | 81 | High |
| main car deck | 110 | 98 | High |
| lower car deck | 110 | 27 | High |
| upper car deck | 110 | 10 | High |

Overall comfort level: medium

*Results concerning the risk evaluation:*
Human factor: HFQ = 0.645

| Events | Frequency per year |
|---|---|
| Contravening traffic separation scheme | 1 |
| Impeded by other ship | 0.043 |
| Encountered environment condition | 0.016 |
| Too bad environment conditions for eye detection | 0.348 |
| Too bad environment conditions for radar detection | 0.193 |
| Tug or towing vessel unavailable in time | 0 |
| Failure to connect tug in time | 0 |
| Wind and/or current towards shore | 0.25 |
| Shore within max drift range | 0.5 |
| Failure to self repair in time | 0.5 |
| Poor seabed conditions | 0 |

| | |
|---|---|
| Length of anchor chain (too short) | 0 |
| Not mapped: ground or shallow water | 0 |
| VTS not present | 0 |
| VTS fails to alert | 0.101 |
| Alarm not active | 0.5 |
| No space to deviate from grounding route (only relevant for displacement vessels) | 0 |
| No space to deviate from striking route (only relevant for displacement vessels) | 0 |
| No space to deviate from collision route (only relevant for displacement vessels) | 0 |
| Other ship encountered in open sea | 0.172 |
| Other ship encountered in restricted water | 0.172 |
| Other ship fails to avoid close quarters | 1 |
| Other ship fails to avoid collision | 1 |
| Failure to make VHF contact | 0 |
| Fixed object encountered in restricted water | 1 |
| Not mapped fixed object in restricted water | 0.001 |
| Dangerous fixed object submerged in restricted water | 0.01 |
| Deliberate action of collision avoidance | 0 |
| Fixed object encountered in open water | 1 |
| Not mapped fixed object in open water | 1E-04 |
| Dangerous fixed object submerged in open water | 1E-04 |
| Floating object encountered | 8E-12 |
| Dangerous floating object submerged | 1 |
| Object detectable | 0.5 |

Mechanical and automation failures:

| Failures | Probability |
|---|---|
| Propulsion System failure | 1.00E-05 |
| Steering System failure | 1.00E-06 |
| Navigation Equipment failure | 6.80E-04 |
| Radar failure | 6.80E-05 |
| Int. Communication failure | 9.88E-02 |
| Ext. Communication failure | 2.60E-02 |
| Electric System failure | 1.00E-04 |

Manoeuvring error model:

The first version of this model was not properly working: a very short range of parameters had to be followed in order to perform the calculation. Since the SSC3 values were not within this range, no result has been found at this moment.
See chapter 5: Newcastle workshop and next steps.

Capsizing: probability of capsizing per year

| | |
|---|---|
| Dynamic Capsizing Probability | 0.007135982 |

## Long-term wave loading Weibull distribution:

| | |
|---|---|
| Linear Long Term Wave Loading Weibull Distribution: **Scale Parameter $\alpha_{wl}$** | 1.80E+01 |
| Linear Long Term Wave Loading Weibull Distribution: **Shape Parameter $\beta_{wl}$** | 1.28E+00 |
| Non Linear Long Term Wave Loading Weibull Distribution: **Scale Parameter $\alpha_{wnl}$** | 1.64E+01 |
| Non Linear Long Term Wave Loading Weibull Distribution: **Shape Parameter $\beta_{wnl}$** | 1.21E+00 |
| Total Number of Applied Cycles | 3.05E+07 |

## Foundering model:

### Risk level (frequency * severity) in a **lifetime**:

| | |
|---|---|
| Global Collapse Risk | 0.000010 |
| Panel Collapse Risk | 0.893631 |
| Fatigue Risk | 154.003638 |
| Fatigue Failure Index | 2.670892 |

### Probability of an event in a **lifetime**:

| | |
|---|---|
| Global Collapse Probability | 1.46E-06 |
| Fatigue Crack propagates | 1.07E-05 |
| Local Collapse Probability | 1.30E-01 |
| Lack of Maintenance Probability | 0 |
| Local Defects Probability | 0 |
| Risk Increasing Features Probabilities | 0 |
| Second Order Global Probability | 3.00E-07 |
| Second Order Local Probability | 0 |
| Uncontrolled Corrosion | 0 |
| Failure not detected or fixed in a timely fashion probability | 0.001 |
| Crack not detected or fixed in a timely fashion probability | 4.00E-06 |

## Fire containment:

| Scenario | Severity | IMO classification |
|---|---|---|
| E1 | 0 | No Effect |
| E2 | 0 | No Effect |
| E3 | 0 | No Effect |
| E4 | 2 | Significant |
| E5 | 3 | Severe |
| E6 | 0 | No Effect |
| E7 | 1 | Minor |
| E8 | 3 | Severe |
| E9 | 4 | Severe |
| E10 | 0 | No Effect |
| E11 | 1 | Minor |
| E12 | 3 | Severe |
| E13 | 4 | Severe |
| E14 | 1 | Minor |
| E15 | 2 | Significant |
| E16 | 4 | Severe |
| E17 | 5 | Catastrophic |
| E18 | 3 | Severe |
| E19 | 4 | Severe |
| E20 | 4 | Severe |
| E21 | 5 | Catastrophic |

Flooding containment:

Flooding due to collision, grounding and striking

| End events | Probability of event when flooding occurs |
|---|---|
| Remains afloat | 0.907067 |
| Slowly sinks | 0.069700 |
| Rapidly capsizes | 0.023233 |

Flooding: other causes.

| Events | Probabilities |
|---|---|
| Flooding through stern door due to wave damage | 3.00E-05 |
| Flooding through hull due to wave damage | 3.00E-05 |
| Flooding through bridge due to wave damage | 3.00E-04 |
| Failure of inner bow door | 5.00E-02 |
| Wave damage to outer bow door | 1.60E-03 |
| Failure of outer bow door | 6.00E-02 |
| Bow door left open at sea | 5.40E-04 |
| Bow door not closed on going to sea | 2.00E-06 |
| Flooding when bow door open | 1.88E-01 |
| Stern door left open at sea | 2.70E-04 |
| Stern door not closed on going to sea | 1.00E-06 |
| Flooding when stern door open | 7.50E-02 |
| Side door left open at sea | 9.00E-05 |
| Side door not closed on going to sea | 1.00E-06 |
| Flooding when side door open | 1.88E-01 |
| Flooding via down flooding openings | 2.90E-04 |
| Flooding below the vehicle deck | 8.60E-04 |

*Results after FaultTree+ analysis:*

**Effect on Property**

| Name | Weight (severity) | Frequency (per year) | Risk level |
|---|---|---|---|
| Minor effects on ship | 0.01 | 2.71E+00 | 2.71E-02 |
| Major effects on ship | 0.1 | 6.12E-04 | 6.12E-05 |
| Severe effects on ship | 1 | 8.36E-04 | 8.36E-04 |
| Catastrophic effects on ship | 10 | 7.41E-03 | 7.41E-02 |
| | | | 0.102140 |

**Effect on Human Safety**

| Name | Weight (severity) | Frequency (per year) | Risk level |
|---|---|---|---|
| Minor | 0.01 | 2.71E+00 | 2.71E-02 |
| Significant | 0.1 | 9.93E-04 | 9.93E-05 |
| Severe | 1 | 4.46E-04 | 4.46E-04 |
| Catastrophic | 10 | 7.34E-03 | 7.34E-02 |
| | | | 0.101097 |

*Cost evaluation:*

| | | | |
|---|---|---|---|
| Basis NPV | 10 000 000 | Change In NPV | -3 032 888 899 |

| | Procurement | Commissioning | Total Sales revenue | Voyage costs | Maintenance |
|---|---|---|---|---|---|
| Totals | 2 998 458 000 | 100 000 | 232 960 | 41 671 442 | 3 389 664 |

| Overheads | Decommissioning | Cash Flow | DCF | Cumulative |
|---|---|---|---|---|
| 9 056 022 | 100 000 | -3 052 542 168 | -3 022 888 899 | -3 022 888 899 |

## 4.6 Results analysis

The hereafter comments are derived from the 1st run of simulation and were proposed during the Newcastle workshop in order to give visibility on the main results and identify the critical design parameters.
The major points are summarised as below and the conclusions of Newcastle meeting are reported in section 5.

### 4.6.1 Indoor climate results:

The comfort level resulting from the indoor climate is found to be "low". It has to be underlined here that:

- firstly the ratio amount of air required/amount of air supplied is equal to 1.2, which is not far from a good comfort level
- secondly that the air required is calculated as the maximum of winter and summer values, which means that the comfort level is under estimated.

Besides, some of the input parameters were assumed, such as the supplied air temperature. The exhaust air flow was not directly found but was deduced from technical documentation. The infiltration air flow was not known and set to zero.
These assumptions may have an impact on the results.

### 4.6.2 Noise results:

The noise levels in both engine rooms and in auxiliary room, where all the noise sources are located, are realistic: in both engines rooms the noise level is quite high but this can be explained by the important number of noise source; in the auxiliary room, where much less sources can be found, the noise level is lower (81 dB).
However, in most of the other rooms, the noise levels are not accurate: in the bar it is even higher than in the engine rooms; in the accommodation rooms, it seems to be too low and it is far from being uniform in the car decks.
These errors may come from some input parameters. For instance the Sabine coefficient types have been assessed using approximation: the materials used in SSC3 are not all present in the proposed list and a surface is not always composed of one single material. However, the effect of Sabine coefficient on the results are not very significant (different configurations were tested).
Some refinement may also be needed concerning the bulkhead to deck connections and the airborne paths.
A part of the inaccuracy may come from the model itself.

### 4.6.3 Mechanical and automation failures

As shown by the results, the highest probabilities of failure are concerning the internal and external communication. The other systems have a very low probability of failure. According to Fincantieri, this statement could be quite realistic.

### 4.6.4 Dynamic capsizing

The model assesses that the probability of capsizing in one year is about 7E-3. This value is considered to be too high by experts. The model is probably too conservative. See chapter 5: Newcastle workshop and next steps.

### 4.6.5 Flooding containment model:

- Outcomes from collision, grounding and striking:

This model should be analysed in more detail to better understand the results. It seems that the model in itself aims at comparing two alternative designs, whereas the Tool should be made so that an assessment of the safety level of one single ship can be evaluated.
The input parameters "variation of transverse bulkheads" and "variation in height of bulkhead deck" was set to zero, in order to assess only the safety level of the basis vessel. Some more clarification were provided during the Newcastle workshop
See chapter 5: Newcastle workshop and next steps.

- Other causes:

The results of this model consist in probabilities of different events, among them "Flooding when bow door open", "Flooding when stern door open", "Flooding when side door open". What would be logical is that only one of these three events has a probability different from zero, depending on where the door is located in the ship in consideration. In the results of the model however, no one of all the events has a probability equal to zero.
Indeed, it is not possible in the input data process to specify which door is present on the ship. The parameter "bow door configuration" can be set only to "bow visor" or "bow doors".
It seems that the model as it is considers that all ships have one bow door, one side door AND one stern door.
Besides, the probability of flooding through bridge due to wave damage is quite high, whereas it should probably be lower than the probability of flooding through hull.
The necessary clarifications are on going and will be addressed in the 6.2 deliverable.

### 4.6.6 Cost model:

Some input parameters, as "Basis Net Present Value" needed some clarification. It seems that this parameter is of major importance when calculating the final results. It should then be explained by means of a User Guide. Besides, the results are difficult to understand, particularly when the risk and cost levels for a single ship are analysed (in that case, comparison between two designs is not possible and the ICAF is meaningless). The User Guide will be soon available and the results will be interpreted into task 6.2.
See chapter 5: Newcastle workshop and next steps.

### 4.6.7 Global results:

When no comments are made on the results of models, it means that the values were thought reasonable and realistic, given the input parameters.

The risk levels found after the use of FT+ seem to be reasonable values.
However, the use of the risk level as an absolute value has to be done carefully. It is probably more useful when interpreted as a relative value, when comparing two alternative designs. Indeed the weight given to each severity level is arbitrary and the overall risk level calculated is thus not very meaningful. When evaluating the safety level of a single ship, it is probably more interesting to look at the frequency of each severity class.

Indeed when looking at frequency of severity classes, interesting facts can be remark. The figures for frequencies of minor, major and severe effects are somehow lower than those usually found during Fincantieri safety studies.
On the contrary, the frequency of catastrophic effect is quite high (about ten times the frequency of major and severe effects). This result is caused by the frequency of dynamic capsizing which has already been noticed to be too high.
See also chapter 5: Newcastle workshop and next steps.

The fact that the risk is about the same for human safety and for ship was noticed and was considered as “possible” by Fincantieri. It was also noticed that the frequencies of minor effects and catastrophic effects are similar for both human and ship, whereas the frequency of major effects is higher for ship and the frequency of severe effects is higher for human. However these differences are not very significant and may come from the assessment on the correspondence of consequence levels (see part 2.4.1).

## 4.7 Preliminary analysis of Critical parameters

The aim of this analysis is not to conduct a sensitivity analysis (which will be done during task 6.2) but to check that the risk level is influenced by the modification of some important input parameters.

### 4.7.1 Assumptions and Preliminary results

In order to evaluate in a preliminary analysis how the global risk level changes depending on the input parameters, different configurations were identified and hence tested:

- **low_speed**: the service speed was changed from 35 kn to 25 kn and the maximum speed was changed from 40 kn to 30 kn. The operational profile was also modified;
- **draft**: the value of the draft was reduced to 2.03 m (default value: 2.63 m);
- **no-ECDIS:** the parameter “presence of ECDIS” was modified from YES to NO;
- **redundancy = 1**: the parameter “redundancy of safety information was modified from 2 to 1;
- **frame_spacing**: concerning the midship section, the frame spacing was set to 1200 mm instead of 600 mm;
- **floor material**: the material was chosen to be “sheet metal” instead of “carpet”;
- **steel**: the young modulus of the hull and of the midship section panels was changed in order to match to a ship in steel (instead of aluminium).

| | | low_speed | draft | No-ECDIS | Redund-ancy = 1 | Frame spacing | Floor material | Steel |
|---|---|---|---|---|---|---|---|---|
| risk increase / reduction compared to SSC3 | absolute value | -0.013364 | 0.028674 | 0.000000 | 0.000003 | 0.036398 | -0.000424 | -0.00121 |
| | percentage | **-13.23** | **28.39** | 0.000002 | 0.002526 | **36.03** | -0.42 | -1.20 |

Note: the complete results can be found in appendix 2.

The results show that the speed, the draft and the frame spacing are critical parameters. It is important to check that the Tool takes in account the fact that the safety level decreases when the speed increases (the low speed induces a risk reduction). Concerning the draft, it is logical that a decrease of the draft generates a lower stability and a risk increase. It is also important that the Tool considers the strength of the ship (which increases when the frame spacing decreases) in the overall safety level.
The risk decrease when considering a steel ship is also correct.
The use of a metal sheet for floor covering has a big impact on the fire containment results and thus has a significant impact on global risk level.

These preliminary results are very positive and show that the Tool is taking into account important parameters as it should.

With reference to some specific results associated to the presence of ECDIS and the redundancy of safety information it seems that nearly no impact on the global risk levels and it should be considered as a pending point. This can be explained by the analysis of the first draft of results (see chapter 5.1).

### 4.7.2 Foundering model:

For some values of the parameter "Fatigue axial SCF", the fatigue index can not be calculated which is correct. However, in order to help the user, a more specific range should be specified in the information button for this parameter, such as "1.15 – 1.65".

### 4.7.3 Noise model

*Noise sources:*
The noise model is adapted to ships propelled by conventional propellers. Thus information about propellers (diameter, cavitation level…) is required. The model is not able to take in account noise from water-jets. It should be interesting to implement a water-jets case, so that the model will be more flexible to different ship designs.

*Typical panels dimensions:*
It seems that in a very preliminary analysis the results are not sensitive to the modification of the width and length of panels. It will be useful to analyse this preliminary result during the sensitivity analysis foreseen for subtask 6.2.

### 4.7.4 Critical parameters missing

A possible improvement into the sensitivity analysis of the Tool was noticed in some areas of concern.

Some parameters that are taken in account in the design process in Fincantieri and that are safety related could be considered in a possible next update of the tool as input parameters: number, location and type of LSA (Life Safety Appliance), characteristics of stairs and exit alleys, parameters related to fire propagation.

Concerning the LSA, it was decided previously not to focus on this point, as said in deliverable D420: "It was then decided that the work on LSA's could not be taken any further at this point due to the financial constraints of the project and a higher perceived need to concentrate on fire related active systems."

# 5. NEWCASTLE WORKSHOP AND NEXT STEPS

Shortly after the end of task 6.1, a workshop was held in the University of Newcastle, the days preceding the PMC#12 meeting. The results were presented and discussed among the S@S partners. Few problems were solved during the workshop, which has provided new results; some decisions were also made concerning the results that had to be improved. It was decided to add these findings in this deliverable but not to wait for the future modifications of the models and the tool.

## 5.1 Problems solved during the workshop

- Concerning the manoeuvring model, the results presented above come from the first version of this model, which was not restricted to certain ranges of parameters and was not working for the SSC3 values. Here are the results found with the last version of the model (restrictions on the parameters range were removed).

| Events | Probabilities |
|---|---|
| Collision in open sea: last minute avoidance too late | 5.18E-01 |
| Collision in restricted water: remaining distance too short for crash stop | 0.00E+00 |
| Striking with a floating object: last minute avoidance too late | 6.67E-01 |
| Striking with a fixed object in open sea: last minute avoidance too late | 9.05E-01 |
| Striking with a fixed object in restricted water: remaining distance too short for crash stop | 1.19E-01 |
| Powered Grounding: Last minute avoidance too late | 1.00E+00 |
| Powered Grounding: Remaining distance too short for crash stop | 2.38E-01 |

- The results of the preliminary analysis of critical parameters (chapter 4.7) should be interpreted with care. Indeed it can be understood that some parameters (presence of ECDIS and redundancy of safety information), do not have a significant influence on the global risk level: the very high probability of capsizing has a major impact on the global risk level whereas the other probabilities have, relatively, a very small impact on it.

- Clarification was given concerning the meaning of the parameter "Basis Net Present Value". The right procedure is to set this parameter to zero for the baseline ship analysis. Then the cost model calculates the Net Present Value corresponding to the operation of this vessel. When an alternative design is evaluated, this value is then input as the basis NPV, for comparison with the alternative design NPV.

- Some errors were found and corrected in the cost model code and Excel sheet. The new results of the cost evaluation are the following:

| Basis NPV | 0 | Change In NPV | -9266463.8 |
|---|---|---|---|

| Time (years) | Procurement | Commissioning | Production No.s | | Total Sales Revenue | Voyage Costs | Maintenance | Overheads | Decommissioning | Cash Flow | DCF | Cumulative |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | | | | | | | | |
| 0 | 10 642 326 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -10 642 326 | -10 642 326 | -10 642 326 |
| 1 | 0 | 100 000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -100 000 | -90 909 | -10 733 235 |
| 2 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 168 942 | -10 564 293 |
| 3 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 153 583 | -10 410 710 |
| 4 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 139 621 | -10 271 089 |
| 5 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 126 928 | -10 144 161 |
| 6 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 115 389 | -10 028 771 |
| 7 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 104 899 | -9 923 872 |
| 8 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 95 363 | -9 828 509 |
| 9 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 86 694 | -9 741 815 |
| 10 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 78 812 | -9 663 003 |
| 11 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 71 648 | -9 591 355 |
| 12 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 65 134 | -9 526 221 |
| 13 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 59 213 | -9 467 008 |
| 14 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 53 830 | -9 413 178 |
| 15 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 418 318 | 566 001 | 0 | 204 419 | 48 936 | -9 364 241 |
| 16 | 0 | 0 | 78 500 | 17 250 | 3 640 000 | 2 451 261 | 81 340 | 566 001 | 13 242 | 528 156 | 114 942 | -9 249 299 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 86 758 | -86 758 | -17 165 | -9 266 464 |
| **Totals** | 10 642 326 | 100 000 | 0 | 0 | 54 600 000 | 36 768 919 | 5 937 792 | 8 490 021 | 100 000 | -7 439 058 | -9 266 464 | **-9 266 464** |

## 5.2 Decisions concerning future modifications

- The results of the noise model were considered as not accurate. Their influence on the overall results is quite limited. However, it was decided that it was important to check with the partner responsible for this model where the inaccuracies came from (either from the assumptions on input data or on the calculation itself or both) and to try to get better results.
When the check is completed a more comprehensive comment will be provided in 6.2/6.3 deliverable.

- The reason for the high probability of capsizing was investigated. It was found that the probability of being in a dangerous zone was properly evaluated, using IMO guidelines. However the probabilities of broaching while being in a dangerous zone and of capsizing when broaching were set to one, which seems not reasonable. Indeed the outcome of being in a dangerous zone is far from being each time catastrophic. IT was then decided that an event tree will be built after the event "being in a dangerous zone". The parameters that will be considered will be the presence of stabilisation system, the type of steering system (water-jets or rudder) and the operational time per year, in addition to the human factor quotient which is already considered in the probability calculation. The outputs of this model will be the probabilities of having no effect, minor effects, major effects, severe effects or catastrophic effects. It is expected that these modifications will have a significant impact on the overall frequency of catastrophic effects and on the overall risk level.

- The results of the flooding model were analysed. It was decided that both parts of the model had to be changed.
Concerning the first part, clarification was brought concerning the parameters "variation of number of bulkheads" and "variation in height of the bulkhead deck". They actually refer to the difference between the number of bulkhead (resp. the height of the bulkhead deck) in the design currently studied and in the SOLAS requirements. The model will be improved: the SOLAS requirements will be assessed by the model, while the user will only input the number of bulkhead (resp. the height of the bulkhead deck) of the ship studied.
The second model should be changed so that the probabilities of events related to bow door (resp. side door, stern door) will be zero when there is no bow door (resp. side door, stern door). The fault tree for flooding will also be changed in the Project Tool fault tree, so that only the frequencies of events will appeared (not the probabilities).

- The fire containment model needs to be updated so that the probabilities of each gate in the event tree will be related to (a) design parameter(s). The level of automation could be linked to one of the proposed parameters.

## 5.3 Next steps

The results presented in the section 4 of this report need to be reviewed taking into account the proposed actions of the Newcastle meeting. However taking into account that this results are very preparatory for the development of the whole task it was decided not to wait for the modifications of the models and the Tool before the final deliverable 6.1.

**Therefore the present results are not modified in this report but should be considered temporary**. Some modifications are shown in this report (section 5.1), some future modifications are described (section 5.2) but the new results will be presented as input data in the deliverable 6.2.0. The results of the following models will be different considering the proposed modifications: noise model, capsizing model, flooding containment model and fire containment model. These results, as well as the manoeuvring errors results and cost evaluation, will have a significant impact on the overall risk and cost assessment of the SuperSeaCat 3.

Some of the input parameters also need to be refined or checked after the delivering of a new version of the User Guide (including directions for the cost model):

- the costs related to the hull (labour, material, overhead and maintenance costs), which are in fact calculated by the structure model;
- the costs of general outfitting, which should include the fire protection costs;
- the basis NPV;
- the commissioning and decommissioning costs.

The final results for the baseline ship safety assessment will be presented, commented and taken as a starting point for the sensitivity analysis and for the comparison with alternative designs.

# 6. CONCLUSION

During the task 6.1, the Project Tool, developed by WP5 and based on WP1 to 4 models, has been used from a user point of view.
The values of the ship "SuperSeaCat 3" have been used as input parameters and a calculation was performed by means of the Project Tool and the software FaultTree+. In that way the safety level of the ship was assessed.

The results found were judged realistic and the run of few calculations allowed underlining the most important critical parameters. Among them, the speed, the draft and the frame spacing.

During the first part of the task, corrections were made to the models and to the integrated tool, both in the details of input process and in the code itself. After these corrections the Tool is entirely running and the input parameters are closer to a real design frame-work.

However, few points still need to be improved and are indicated in this deliverable. There are some minor items that should be modified within the end of the Project (error in the units, update of the information buttons…).
Some other comments have been pointed and were discussed during a specific workshop with other Work Packages leaders. The problems/doubts concerning the manoeuvring model and the cost evaluation were solved. It was also decided to try to improve the noise model results, to modify the fire and flooding models and to add an event tree to the capsizing model.

# 7. REFERENCES

1. S@S Project Tool User Guide
2. S@S Noise model User Guide
3. S@S Indoor Climate User Guide
4. S@S Hull Girder Vibrations User Guide
5. S@S Long Term Motion Sickness and Safety of Footing Model User Guide, ID Code: S102.32.07.058.001
6. S@S User Guide for the model for Human Error, Deliverable N° D1.3.1, ID Code: S101.31.01.052.002
7. S@S Risk and Cost Model for M&A failures, User Guide, ID Code: S101.13.03.058.001
8. S@S Manoeuvring Errors Model User Guide
9. S@S Long Term Dynamic Stability Risk Model User Guide
10. S@S Long Term Loading Model User Guide
11. S@S Structural Foundering Risk Cost Model User's Guide, ID Code: S103.30.13.060.004b
12. S@S Fire Risk and Cost Model: User Guide, ID Code: S101.43.03.058.001
13. S@S Risk/Cost Model for Flooding Containment User Guide
14. IMO HSC code
15. Ship Designers Guide "12, 16 and 20 cylinder RK270 Fast Ferry and Naval Marine Propulsion Engines"
16. Global wave statistics
17. ISO 7547 (temperature)
18. ISO 2923 (noise limits)
19. ISO 8861 (ventilation)

**Internal documentation, Fincantieri:**

20. Technical specification, AS 800G0009M
21. Midship section GG1010010M
22. General arrangement - upper decks GG8020201M
23. Body plan GG8020021M
24. Bus garage arrangement GG67300002
25. General arrangement windows GG6250001M
26. Technical specification and detail insulation GT63500002/01
27. Propulsion study GZ8350033M
28. Weight report GZ8330001M
29. Hydrostatic data GZ8350002M
30. Trim and stability for all loading condition-ship as built GZ8350079M
31. Ambient noise in the living spaces GZ8350060M
32. Sea-keeping study GZ8350023M

# 8. APPENDICES

## 8.1 Appendix 1: list of all parameters required in the tool, their description, their unit and their value.

Here is a list of all parameters required in the Project Tool. Their unit is specified as well as their value, corresponding to the SuperSeaCat 3.
The values which where assumed are written in red (reasonable assumptions).
The values that need to be refined in the later tasks are in yellow cells.

## Background cost data

| Parameter | unit | value | |
|---|---|---|---|
| Hull material | €/ship | 2 500 000 | |
| Hull build labour | € | 600 000 | |
| Hull build overhead | € | 200 000 | |
| Hull maintenance | € | 182 800 | |
| Active Stab equipment | € | 806 200 | |
| Active Stab labour | € | 120 000 | |
| Active Stab overhead | € | 60 000 | |
| Active Stab maintenance | € / year | 20 000 | |
| Fuel consumption electrical | gr/kWh | 300 | |
| Electrical engine relative power | % | | only one parameter is required |
| Electrical engine designer over ride | kW | 600 | |
| Main engine cost (Designer over ride) | € | | only one parameter is required |
| Main engine cost | €/kW | 81 | |
| Fuel price ME | €/tons | 226 | |
| Fuel price electrical | €/tons | 226 | |
| Basis net present value | € | 10 000 000 | |
| Required discount rate | 0 - 1 | 0.1 | |
| Commissioning costs | € | 100 000 | |
| Decommissioning costs | € | 100 000 | |

| | | equipment | labour (€) | **labour %** | maint (€) | **maint. %** |
|---|---|---|---|---|---|---|
| Diesel engines electrical | €/engine | 145 000 | 58 000 | 20.0 | 7 857.0 | 2.7 |
| Emergency engine | € | 145 000 | 29 000 | 20.0 | 3 928.0 | 2.7 |
| Water jets | € | 322 800 | 70 000 | 5.4 | 45 714.0 | 3.5 |
| 3 Ghz radar | € | 69 700 | 13 944 | 20.0 | 8 366.6 | 12.0 |
| emergency system for general alarm & PA | € | 48 000 | 20 000 | 41.7 | 2 112.0 | 4.4 |
| Talk back system | € | 18 000 | | 0.0 | 795.3 | 4.4 |
| VTS | € | 0 | 0 | 0.0 | 0.0 | 0.0 |
| ECDIS | € | 10 000 | 3 000 | 30.0 | 1 200.0 | 12.0 |
| DGPS | € | 15 000 | 2 000 | 13.3 | 1 800.0 | 12.0 |
| Paging system | € | 0 | 0 | 0.0 | 0.0 | 0.0 |
| Emergency system for the VHF | € | 72 000 | 15 000 | 20.8 | 3 168.0 | 4.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| ATA | € | 40 000 | Function of radar: 0 | 0.0 | 0.0 | 0.0 |
| ARPA | € | 35 000 | Function of radar: 0 | 0.0 | 4 200.0 | 12.0 |
| Identification system | € | 3 500 | function of ECDIS | 0.0 | 420.0 | 12.0 |

| | | | | |
|---|---|---|---|---|
| *Additional maintenance costs* | | | | |
| machinery | €/year | 55 700 | | |
| LSA | €/year | 71 400 | | |
| | | | | |
| *Additional annual overhead* | | | | |
| technical spares | €/year | 566 000 | | |
| | | | | |
| Crew costs | €/year | 2 353 000 | crew correction factor | 1.384 |

Sea Container information

| *Life Cycle Inputs* | | |
|---|---|---|
| Build time | Years | 1 |
| Trials Time | Months | 12 |
| Cycle Time | Days | 250 |
| Idle Time | Days | 85 |
| Maintenance Time | Days | 30 |
| Maint Frequency | Years | 1 |
| Decommission Time | Months | 6 |
| voyages per operational cycle | | 250 |

| *Fare prices* | | |
|---|---|---|
| Passengers fare price | € | 20 |
| Cars fare price | € | 120 |
| Coaches fare price | € | 0 |
| Lorries fare price | € | 0 |

| *Market data* | | |
|---|---|---|
| Passengers number | per day | 314 |
| Cars number | per day | 69 |
| Coaches number | per day | 0 |
| Lorries number | per day | 0 |

## Project specification

| Parameter | Unit | Values (Superseacat III) | Comments |
|---|---|---|---|
| Service Speed | Kn | 35 | |
| Maximum speed | Kn | 40 | |
| Main engine fuel consumption | gr/kWh | 200 | unit modified in the last version |
| Required deadweight | Tons | 340 | |
| Desired service life | Year | 15 | |
| Desired operation hours / year | Hour | 4000 | |
| Required availability | % | 95 | |
| Stillwater bending moment | kNm | 9800 | |
| Presence of ISM code (or other safety management code) | Y/N | Y | |
| 3 Ghz radar | Y/N | Y | |
| emergency system for general alarm & PA | Y/N | Y | |
| Tall back system | Y/N | Y | |
| Number of passengers | | 800 | |
| N° of cars | | 175 | |
| N° of coaches | | 0 | |
| N° of lorries | | 0 | |
| *Route and traffic parameters* | | | |
| traffic distribution index in restricted water | 1 - 2 - 3 | 2 | Sea Container information |
| traffic distribution index in open water | 1 - 2 - 3 | 2 | |
| Traffic density | L / M / H | M | |
| Traffic complexity | L / M / H | M | |
| Traffic separation scheme present at the route or at part | Y / N | Y | |
| Depth of water | m | 50 | |
| Route length | nm | 235 | |
| Sea Area | | mid north sea | |
| Turn around time in port | | less than 1 hour | |
| Port approaches deep enough to avoid squate | | both | |
| Sheltered Water Route | Y/N | N | |
| Outdoor air summer temperature | °C | 35 | |

| | | | |
|---|---|---|---|
| Outdoor air summer humidity | % | 70 | |
| Indoor air summer temperature | °C | 26 | |
| Indoor air summer humidity | % | 50 | |
| Outdoor air winter temperature | °C | -5 | |
| Outdoor air winter humidity | % | 25 | |
| Indoor air winter temperature | °C | 22 | |
| Indoor air winter humidity | % | 40 | |
| Sea-water summer temperature | °C | 27 | |
| Sea-water winter temperature | °C | 5 | |

## *Loading parameters*

**Operational diagram:**

| | | Hs | | |
|---|---|---|---|---|
| V (knots) | Heading | 1 - 3.5 m | 4 - 6 m | 7-11 m |
| 5 | 0 | 0 | 0.00 | 0.09 |
| 5 | 45 | 0 | 0.00 | 0.15 |
| 5 | 90 | 0 | 0.00 | 0.23 |
| 5 | 135 | 0 | 0.00 | 0.35 |
| 5 | 180 | 0 | 0.00 | 0.17 |
| 15 | 0 | 0 | 0.04689454 | 0 |
| 15 | 45 | 0 | 0.07371127 | 0 |
| 15 | 90 | 0 | 0.13630679 | 0 |
| 15 | 135 | 0 | 0.15193831 | 0 |
| 15 | 180 | 0 | 0.09114909 | 0 |
| 25 | 0 | 0 | 0.04689454 | 0 |
| 25 | 45 | 0 | 0.07371127 | 0 |
| 25 | 90 | 0 | 0.13630679 | 0 |
| 25 | 135 | 0 | 0.15193831 | 0 |
| 25 | 180 | 0 | 0.09114909 | 0 |
| 35 | 0 | 0.08932856 | 0 | 0 |
| 35 | 45 | 0.19447232 | 0 | 0 |
| 35 | 90 | 0.27024344 | 0 | 0 |
| 35 | 135 | 0.28784739 | 0 | 0 |
| 35 | 180 | 0.15810828 | 0 | 0 |
| Sum | | 1 | 1 | 1 |

| | |
|---|---|
| Rel number of peaks with whipping | 0.01 |
| Standard deviation whip/rho*g'B*L*Hs^2*Cf/Cb | 0.03 |

**Weather routing factor (0-1):**

| Hs (m) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 | 6 | 7 | 8 | 8 | 10 | 11 |
| 1 | 1 | 1 | 1 | 0.1 | 0.1 | 0.1 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 |

**Wave scatter diagram** wave scatter diagram north sea

| | | Hs (m) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Tz (s) | 1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 2 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 3 | 0.021 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 4 | 0.111 | 0.029 | 0.009 | 0.006 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 5 | 0.155 | 0.076 | 0.032 | 0.023 | 0.014 | 0.010 | 0.006 | 0.004 | 0.002 | 0.002 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 |
| | 6 | 0.091 | 0.068 | 0.037 | 0.028 | 0.020 | 0.015 | 0.010 | 0.007 | 0.005 | 0.004 | 0.003 | 0.002 | 0.001 | 0.001 | 0.000 |
| | 7 | 0.030 | 0.030 | 0.020 | 0.017 | 0.013 | 0.010 | 0.007 | 0.005 | 0.004 | 0.004 | 0.003 | 0.002 | 0.001 | 0.001 | 0.000 |
| | 8 | 0.007 | 0.008 | 0.007 | 0.006 | 0.005 | 0.004 | 0.003 | 0.002 | 0.002 | 0.002 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 |
| | 9 | 0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 10 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 11 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 12 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 13 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 14 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 15 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Wave incidence**

| | Wave incidence w.r.t ship (deg.)(180° = head sea) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 45 | 90 | 135 | 180 | 225 | 270 | 315 | **Sum** |
| **Probability** | 0.09 | 0.10 | 0.15 | 0.16 | 0.16 | 0.13 | 0.12 | 0.09 | 1.00 |
| | E | SE | S | SW | W | NW | N | NE | |

## Dynamic parameters_concept

| Parameter | Unit | Values (Superseacat III) | Comments |
|---|---|---|---|
| Length overall | m | 100 | |
| Length waterline of the vessel | m | 88 | |
| Breadth | m | 17.1 | |
| Breadth waterline of the vessel | m | 14.2 | |
| Depth | m | 10.7 | |
| Draft | m | 2.63 | |
| Displacement | tons | 1300 | |
| Number of propulsors | | 4 | |
| Bow door configuration | | NO | |
| Barriers arrangement | | NO | |
| Young's Modulus of hull material | kPa | 70000000 | |
| Vehicle deck arrangement | 1 to 5 | 3 | long side casings, no centre casing |
| Number of transverse bulkheads | | 8 | |
| Variation of transverse bulkheads | | 0 | |
| Vertical location of bulkhead deck | m | 6 | |
| Variation in vertical location of bulkhead deck | % | 0 | |

## Dynamic parameters_preliminary

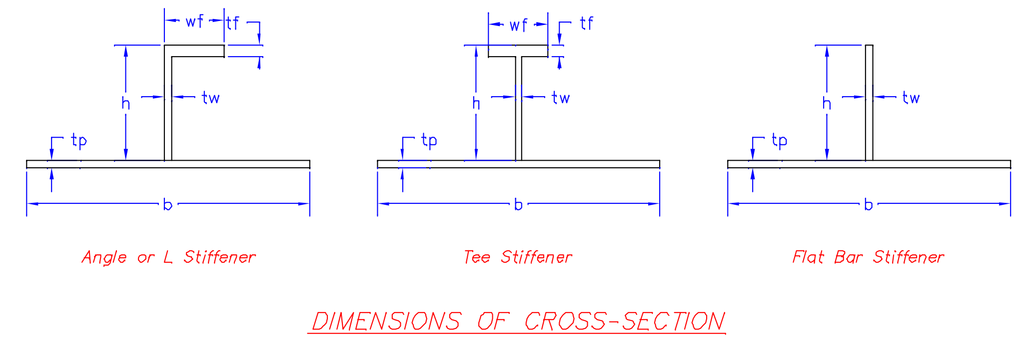
| **Parameter** | **Unit** | **Values (Superseacat III)** | **Comments** |
|---|---|---|---|
| Waterplane area coefficient | m2 | 0.7 | |
| Longitudinal centre of gravity | m | 35 | |
| Vertical centre of gravity | m | 5 | |
| Transverse metacentric height | m | 6 | not required (derived parameter) |
| Bow flare coefficient | | 0.25 | |

| | | | |
|---|---|---|---|
| Midship coefficient | | 0.5 | |
| Change in cm per 0.02m depth | cm | 0.002 | |
| Wetted Surface Area | m2 | 1400 | |
| Change in WSA per 0.02m depth | m2 | 2 | |
| Door closing reporting procedure | ISM code / positive / negative reporting | positive | |
| Bow door class rules | Current / pre-1982 IACS rules | current | |
| Bow door closures per ship | Per ship year | 0 | |
| Side door closures per ship | Per ship year | 0 | |
| Stern door closures per ship | Per ship year | 500 | |
| *Propulsion* | | | |
| No of Main Engines | | 4 | |
| No of gas turbines | | 0 | |
| No of Diesel Engines | | 4 | |
| No of Dedicated Engines for steering | | 4 | |
| No of Steering Water jets | | 4 | |
| No of Diesel Engines Electrical generation | | 2 | |
| No of Emergency Diesel Engines | | 1 | |
| Propeller diameter | m | 0 | |
| Cavitation level | % | 0 | |
| Distance from AP | m | 0 | |
| *Human factor* | | | |
| Amount of training and education | | Medium | |
| Quality of training and education | | Medium | |
| Number of well spoken working languages on board | | Medium | |
| Amount of experience | | Medium | |
| Amount of training and education | | Medium | |
| Overall quality of training and education | | Medium | |
| Ability to cope with boredom (e.g. due to routine work) | | Medium | |
| Amount of concern about safety | | Medium | |
| Amount of risk taking attitude | | Medium | |
| Level of confidence (in self, others, automation/technology) | | Medium | |
| Level of exposure to domestic issues | | Medium | |
| Level of overall medical and physical condition | | Medium | |
| Amount of daily time and/or scheduling pressure | | Medium | |

| | | | |
|---|---|---|---|
| Amount of commercial and/or organizational pressure | | Medium | |
| Amount of individual workload in the daily routine work | | Medium | |
| Amount of especially demanding planned situations (e.g. fire drills) | | Medium | |
| Amount of resources for maintenance, repair, retrofit, new equipment etc. (coeficient to be appiled to the maintenance value, delivered by D1.3.2) | | Medium | |
| Overall quality of working terms and conditions – long term (vacation, salary, promotion possibilities etc.) | | Medium | |
| Overall quality of working terms and conditions – daily basis (working hours, rest periods, working environment, accommodation etc.) | | Medium | |
| Level to which extend bridge discipline is regulated by procedures and/or practice | | Medium | |
| Level of automation | | Medium | |
| Level of transparency | | Medium | |
| Overall quality of interaction design and ergonomics | | Medium | |
| Availability of user manuals | | Medium | |
| Overall quality of user manuals | | Medium | |
| Availability of means for communication | | Medium | |
| Overall quality of means for communication | | Medium | |
| Level to which extend onboard communication is regulated by procedures and/or practice | | Medium | |
| *Navigation system* | | | |
| VTS Vessel Traffic System | Y / N | N | |
| ECDIS Electronic Chart Display & Information System | Y / N | Y | |
| DGPS Differential GPS | Y / N | Y | |
| Paging system | Y / N | N | |
| Redundancy of safety information | 1-2-3 | 2 | |
| Emergency system for the VHF | Y / N | Y | |
| Identification system | Y / N | Y | |
| Active stabilisation | Y / N | Y | |
| Class for availability criteria | | BV normal | |
| Reference period of availability criteria | s | 300 | default values for BV normal |
| Max horizontal acceleration of availability class criteria | g | 0.2 | |
| Max vertical acceleration of availability class criteria | g | 1 | |

## Midship section

| | | |
|---|---|---|
| frame spacing | 600 mm | for all panels |
| elastic modulus | 70000 Mpa | |
| Plate material | 1 | |
| Stiffener material | 1 | |
| Plate proof stress | 300 MPa | |
| Stiffener proof stress | 300 MPa | |
| Fatigue axial SCF | 1.5 | |
| Fatigue SN curve | 3 | |




| panel n° | panel name | start-point x1 | start-point y1 | end-point x2 | end-point y2 | tp | b | h | tw | wf | tf | plate type* | part of the deck flange | longitudinally effective |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | vertical | 0 | 0 | 0 | 1000 | 5 | 500 | 80 | 5 | 0 | 0 | 2 | Y | Y |
| 2 | bottom | 0 | 0 | 7400 | 2875 | 6 | 350 | 140 | 7 | 0 | 0 | 2 | Y | Y |
| 3 | lower_side | 7400 | 2875 | 8420 | 4675 | 5 | 400 | 80 | 5 | 0 | 0 | 2 | Y | Y |
| 4 | side | 8420 | 4675 | 8420 | 10600 | 5 | 300 | 60 | 5 | 30 | 5 | 2 | Y | Y |
| 5 | upper_side | 8420 | 10600 | 7970 | 13200 | 3 | 205 | 50 | 3 | 25 | 3 | 3 | N | Y |
| 6 | upper_deck | 7970 | 13200 | 0 | 13200 | 3 | 205 | 50 | 3 | 25 | 3 | 3 | N | Y |
| 7 | bridge_side | 5300 | 13200 | 4850 | 15700 | 3 | 205 | 50 | 3 | 25 | 3 | 3 | N | Y |
| 8 | bridge | 4850 | 15700 | 0 | 15800 | 3 | 205 | 50 | 3 | 25 | 3 | 3 | N | Y |
| 9 | car_deck | 0 | 4600 | 8400 | 4600 | 4 | 512 | 60 | 5 | 30 | 5 | 2 | Y | Y |
| 10 | main_deck | 0 | 10500 | 8500 | 10500 | 4 | 400 | 60 | 5 | 30 | 5 | 2 | Y | Y |

# Rooms data for use in the indoor climate model

*For all rooms:*

| | | *except bridge* |
|---|---|---|
| sensible gain from lightning | 10 | 0 |
| latent gain from lighting | 0 | 0 |
| HVAC system used | 1 | 1 |

| | Volume | Occupancy | surfaces | Av | Kv | Ag | Kg | DTw | DTs | DT2 | Gs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hall | 583 | 108 | after | 24.3 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | forward | 13.74 | 2.5 | 10.56 | 3.5 | 0 | 0 | 0 | 350 |
| | | | port | 62.03 | 2.5 | 2.77 | 3.5 | 0 | 0 | 0 | 350 |
| | | | starboard | 62.03 | 2.5 | 2.77 | 3.5 | 0 | 0 | 0 | 350 |
| | | | ceiling | 216 | 0.6 | | | 27 | 9 | 12 | |
| | | | floor | 216 | 0.8 | | | 17 | 18 | | |
| Bar | 36 | 6 | after | 15.15 | 0.9 | 0 | 0 | 27 | 9 | 16 | 0 |
| | | | forward | 12.15 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | port | 8.1 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | starboard | 8.1 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | ceiling | 13.5 | 0.6 | | | 27 | 9 | 12 | |
| | | | floor | 13.5 | 0.8 | | | 17 | 18 | | |
| Hot food area | 108 | 20 | after | 10.8 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | forward | 10.8 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | port | 27 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | starboard | 27 | 0.6 | 0 | 0 | 27 | 9 | 16 | 0 |
| | | | ceiling | 40 | 0.6 | | | 27 | 9 | 12 | |
| | | | floor | 40 | 0.8 | | | 17 | 18 | | |
| Shop | 108 | 20 | after | 10.8 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | forward | 10.8 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | port | 27 | 0.6 | 0 | 0 | 27 | 9 | 16 | 0 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | starboard | 27 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | ceiling | 40 | 0.6 | | | 27 | 9 | 12 | |
| | | | floor | 40 | 0.8 | | | 17 | 18 | | |
| pass. for | 688 | 250 | after | 45.9 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | forward | 45.9 | 2.5 | 0 | 0 | 0 | 6 | 0 | 0 |
| | | | port | 25.23 | 0.9 | 15.27 | 3.5 | 27 | 9 | 16 | 350 |
| | | | starboard | 25.23 | 0.9 | 15.27 | 3.5 | 27 | 9 | 16 | 350 |
| | | | ceiling | 255 | 2.5 | | | 0 | 0 | 0 | |
| | | | floor | 255 | 0.8 | | | 17 | 18 | | |
| pass. Aft | 688 | 250 | after | 45.9 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | forward | 45.9 | 2.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | port | 26.73 | 0.9 | 13.77 | 3.5 | 27 | 9 | 16 | 350 |
| | | | starboard | 26.73 | 0.9 | 13.77 | 3.5 | 27 | 9 | 16 | 350 |
| | | | ceiling | 255 | 2.5 | | | 0 | 0 | 0 | |
| | | | floor | 255 | 0.8 | | | 17 | 18 | | |
| pass. Upp | 540 | 150 | after | 27 | 2.5 | 0 | 0 | 0 | 6 | 0 | 0 |
| | | | forward | 27 | 2.5 | 0 | 0 | 0 | 6 | 0 | 0 |
| | | | port | 38.73 | 0.9 | 15.27 | 3.5 | 27 | 9 | 16 | 350 |
| | | | starboard | 38.73 | 0.9 | 15.27 | 3.5 | 27 | 9 | 16 | 350 |
| | | | ceiling | 200 | 0.6 | | | 27 | 9 | 12 | |
| | | | floor | 200 | 2.5 | | | 0 | 0 | | |
| bridge | 182 | 4 | after | 20.43 | 0.6 | 16.02 | 3.5 | 27 | 9 | 16 | 350 |
| | | | forward | 20.79 | 0.6 | 15.66 | 3.5 | 27 | 9 | 16 | 350 |
| | | | port | 9.88 | 0.6 | 3.62 | 3.5 | 27 | 9 | 16 | 350 |
| | | | starboard | 9.88 | 0.6 | 3.62 | 3.5 | 27 | 9 | 16 | 350 |
| | | | ceiling | 67.5 | 0.6 | | | 27 | 9 | 12 | |
| | | | floor | 67.5 | 2.5 | | | 0 | 0 | | |

**Climate System** *Only one system is present onboard*

| | winter | | | | | | | summer | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | Indoor temperature °C | Relative humidity % | Supplied Air Temp. °C | Infiltration $m^3/h$ | Ventilation $m^3/h$ | Exhaust $m^3/h$ | Winter humidification | Indoor temperature °C | Relative humidity % | Supplied Air Temp. °C | Infiltration $m^3/h$ | Ventilation $m^3/h$ | Exhaust $m^3/h$ | Duct thermal °C | Supplied Air $m^3/h$ |
| system 1 | 22 | 40 | 32 | 0 | **0** | 14500 | yes | 26 | 50 | 18 | 0 | **0** | 14500 | 2 | 32500 |

| | | |
|---|---|---|
| people heat emission | sensible | 55 |
| | latent | 80 |

## Dynamic parameters_detailed

| Parameter | Unit | Values (Superseacat III) | Comments |
|---|---|---|---|
| Workmanship level | | Medium | |
| Maintenance parameter | | Medium | |
| ATA (Automatic Tracking Aid for radar) | Y / N | Y | |
| ARPA (Automatic Radar Plotting Aid) | Y / N | N | |
| Propulsion point known | Y / N | Y | |
| Known Propulsion point speed | kn | 35 | |
| Known Propulsion point waterdepth | m | 50 | |
| Known Propulsion point Power PD | kW | 25000 | |
| *Fire fighting and detection:* | | | |
| N° of Detectors / Sprinklers | | Optimal | |
| Sprinkler quality | 0-1 | 0.96 | |
| Detector quality | 0-1 | 0.85 | |
| Seats Material | | Upholstery (Tign=450°C) | |
| Bulkhead panel and default structural material | | Marinite | |
| Secondary panel material | | Vynil Siding | |
| Floor material | | Carpet | |
| Ceiling panel material | | Non-Combustible ceiling | |
| *Hull girder vibrations*: | | | |
| Blade rate | RPM | 0 | |
| Main engine rate | RPM | 1000 | |
| Harmonics of ME | RPM | 2000 | |
| Other | RPM | 0 | |
| *For each hull section:* | | | |

| Hull section n° | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Weight | tons | 82 | 129 | 57 | 55 | 24 | 16 |
| Length | m | 19.3 | 25.7 | 9.6 | 12.8 | 9.6 | 10.9 |
| Hydrodynamic added mass | tons | 695 | 1090 | 482 | 468 | 204 | 139 |
| Bending 2nd Moment of area | m4 | 3.69 | 4.18 | 4.92 | 3.59 | 2.09 | 1.36 |

| | |
|---|---|
| *MSI & MII Calculation:* | |

| | | | |
|---|---|---|---|
| Calculation point for passengers: X | m | 37 | |
| Calculation point for passengers: Y | m | 0 | |
| Calculation point for passengers: Z | m | 7 | |
| Calculation point for crew: X | m | 37 | |
| Calculation point for crew: Y | m | 0 | |
| Calculation point for crew: Z | m | 7 | |
| Natural roll period | | Derived parameter | this parameter is automatically calculated when set to zero |

## Noise Rooms data

| | | | | | position of the center | | | | | | | Sabine Coeff Type | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | aft width | fwd width | length | height | longitudinal | transverse | vertical | deck n° * | sound pressure limit | Cfh corr. factor | Cfs corr. Factor | Aft Surf. | Fwd Surf. | Port Surf. | Stdb Surf. | Roof | Floor |
| Hall | 9 | 9 | 24 | 2.7 | 18.5 | 0 | 12.05 | 4 | 75 | 0.2 | 0.2 | 4 | 4 | 4 | 4 | 4 | 8 |
| Bar | 4.5 | 4.5 | 3 | 2.7 | 5 | 0 | 12.05 | 4 | 75 | 0.2 | 0.2 | 3 | 3 | 4 | 4 | 4 | 4 |
| Hot food area | 4 | 4 | 10 | 2.7 | 16 | -6.5 | 12.05 | 4 | 75 | 0.2 | 0.2 | 3 | 3 | 4 | 4 | 4 | 4 |
| Shop | 4 | 4 | 10 | 2.7 | 16 | 6.5 | 12.05 | 4 | 75 | 0.2 | 0.2 | 4 | 4 | 4 | 4 | 4 | 8 |
| pass. for | 17 | 17 | 15 | 2.7 | 52 | 0 | 12.05 | 4 | 70 | 0 | 0.2 | 4 | 4 | 6 | 6 | 4 | 8 |
| pass. Aft | 17 | 17 | 15 | 2.7 | 38 | 0 | 12.05 | 4 | 70 | 0 | 0.2 | 4 | 4 | 6 | 6 | 4 | 8 |
| pass. Upp | 10 | 10 | 20 | 2.7 | 36 | 0 | 14.75 | 5 | 70 | 0 | 0.2 | 4 | 4 | 6 | 6 | 4 | 8 |
| bridge | 12 | 15 | 5 | 2.7 | 49 | 0 | 17.45 | 6 | 65 | 0.2 | 0.2 | 4 | 4 | 6 | 6 | 4 | 7 |
| aft engine room | 17 | 17 | 10.5 | 5.5 | 12.5 | 0 | 2.75 | 1 | 110 | 0.5 | 0.2 | 14 | 14 | 14 | 14 | 14 | 3 |
| for engine room | 17 | 17 | 10.5 | 5.5 | 23 | 0 | 2.75 | 1 | 110 | 0.5 | 0.2 | 14 | 14 | 14 | 14 | 14 | 3 |
| auxiliary room | 6 | 6 | 10.5 | 5 | 50 | 0 | 2.5 | 1 | 110 | 0.4 | 0.2 | 14 | 14 | 14 | 14 | 14 | 3 |
| main car deck | 17 | 17 | 27 | 5.2 | 14.75 | 0 | 8.1 | 2 | 110 | 0.4 | 0.2 | 3 | 3 | 3 | 3 | 3 | 3 |
| lower car deck | 17 | 17 | 58.5 | 2.5 | 57.5 | 0 | 6.25 | 2 | 110 | 0.4 | 0.2 | 3 | 3 | 3 | 3 | 3 | 3 |
| upper car deck | 17 | 17 | 58.5 | 3.2 | 57.5 | 0 | 9.1 | 3 | 110 | 0.4 | 0.2 | 3 | 3 | 3 | 3 | 3 | 3 |

| *deck number | | |
|---|---|---|
| | 1 | baseline |
| | 2 | main car deck |
| | 3 | upper car deck |
| | 4 | main pass.deck |
| | 5 | upp.pass.deck |
| | 6 | bridge deck |

## Noise panels' dimensions

| | port surface | | | starboard surface | | | after surface | | | forward surface | | | floor surface | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | width | length | thickness | width | length | thickness | width | length | thickness | width | length | thickness | width | length | thickness |
| Hall | 2.7 | 24 | 6 | 2.7 | 24 | 6 | 2.7 | 9 | 6 | 2.7 | 9 | 6 | 9 | 24 | 6 |
| Bar | 2.7 | 3 | 6 | 2.7 | 3 | 6 | 2.7 | 4.5 | 6 | 2.7 | 4.5 | 6 | 4.5 | 3 | 6 |
| Hot food area | 2.7 | 10 | 6 | 2.7 | 10 | 6 | 2.7 | 4 | 6 | 2.7 | 4 | 6 | 4 | 10 | 6 |
| Shop | 2.7 | 10 | 6 | 2.7 | 10 | 6 | 2.7 | 4 | 6 | 2.7 | 4 | 6 | 4 | 10 | 6 |
| pass. for | 2.7 | 15 | 6 | 2.7 | 15 | 6 | 2.7 | 17 | 6 | 2.7 | 17 | 6 | 17 | 15 | 6 |
| pass. Aft | 2.7 | 15 | 6 | 2.7 | 15 | 6 | 2.7 | 17 | 6 | 2.7 | 17 | 6 | 17 | 15 | 6 |
| pass. Upp | 2.7 | 20 | 6 | 2.7 | 20 | 6 | 2.7 | 10 | 6 | 2.7 | 10 | 6 | 10 | 20 | 6 |
| bridge | 2.7 | 5 | 6 | 2.7 | 5 | 6 | 2.7 | 12 | 6 | 2.7 | 15 | 6 | 12 | 5 | 6 |
| aft engine room | 5.5 | 10.5 | 6 | 5.5 | 10.5 | 6 | 5.5 | 17 | 6 | 5.5 | 17 | 6 | 17 | 10.5 | 6 |
| for engine room | 5.5 | 10.5 | 6 | 5.5 | 10.5 | 6 | 5.5 | 17 | 6 | 5.5 | 17 | 6 | 17 | 10.5 | 6 |
| main car deck | 5 | 10.5 | 6 | 5 | 10.5 | 6 | 5 | 6 | 6 | 5 | 6 | 6 | 6 | 10.5 | 6 |
| upper car deck | 5.2 | 27 | 6 | 5.2 | 27 | 6 | 5.2 | 17 | 6 | 5.2 | 17 | 6 | 17 | 27 | 6 |
| auxiliary room | 2.5 | 58.5 | 6 | 2.5 | 58.5 | 6 | 2.5 | 17 | 6 | 2.5 | 17 | 6 | 17 | 58.5 | 6 |

## Bulkhead-deck transmission losses

| bulkhead n° | deck n° * | bhd position | loss |
|---|---|---|---|
| 1 | 1 | 0 | 10 dB |
| 2 | 1 | 14.5 | 10 dB |
| 3 | 2 | 0 | 10 dB |
| 4 | 2 | 14.5 | 10 dB |
| 5 | 2 | 25.2 | 10 dB |
| 6 | 3 | 17.5 | 10 dB |
| 7 | 3 | 30 | 10 dB |

## Airborne paths

| path n° | from | to | transmission loss type * | transmission loss increment type * |
|---|---|---|---|---|
| | (room name) | (room name) | 1 to 89 | 89 to 116 |
| 1 | for engine room | pass. for | 9 | 104 |
| 2 | aft engine room | pass. Aft | 9 | 104 |
| 3 | for engine room | pass. Upp | 9 | 104 |
| 4 | aft engine room | Hot food area | 9 | 104 |
| 5 | aft engine room | Hall | 9 | 95 |
| 6 | aft engine room | Bar | 9 | 97 |
| 7 | aft engine room | Shop | 9 | 97 |
| 8 | for engine room | Bridge | 9 | 89 |

* see noise model for more explanation

## Noise sources

| Group 1 : diesel engines | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Description** | Main engine 1 | ME 2 | ME 3 | ME 4 |
| | Room where the source is located | aft engine | aft engine | fwd engine | fwd engine |
| 1 | Engine power (HP) | 6378 kW | 6378 kW | 6378 kW | 6378 kW |
| 2 | Nominal RPM | 900 | 900 | 900 | 900 |
| 3 | Type of the octave band adjustment appropriate for the engine Applicable types 1-6 | 3 | 3 | 3 | 3 |
| 4 | Type of the adjustment for the engine unmuffled exhaust noise source level.Applicable types 7 or 8 | 7 | 7 | 7 | 7 |
| 5 | Type of source adjustment for the diesel engine casing airborne noise. Applicable types 9 to 14 | 11 | 11 | 11 | 11 |
| 6 | Type of source adjustment for the transmission loss due to air intake pipes. Applicable types 74 to 94 | 80 | 80 | 80 | 80 |
| 7 | Type of source adjustment for the transmission loss due to the exhaust pipes. Applicable types 74 to 94 | 80 | 80 | 80 | 80 |
| 8 | Length to diameter ratio for circular air intake pipes or external surface to cross section for rectangular air intake pipes | 55 | 55 | 55 | 55 |

| | | | | | |
|---|---|---|---|---|---|
| 9 | Length to diameter ratio for the exhaust pipes or external surface to cross section for rectangular exhaust pipes | 60 | 60 | 60 | 60 |
| 10 | Engine weight in lb | 73854 | 73854 | 73854 | 73854 |
| 11 | Max RPM: | 1000 | 1000 | 1000 | 1000 |
| 12 | Type of Structureborne noise level adjustment. Applicable type 60 | 60 | 60 | 60 | 60 |
| 13 | Type of transfer function for mounting attachment. Applicable types 95 to 114. | 106 | 106 | 106 | 106 |
| 14 | Type of transmission loss due to foundation. Applicable types 115, 116 | 115 | 115 | 115 | 115 |

**Table 3.3.3 : Parameters for noise source Group 3 : Other equipment**

Note: this approach is not perfect since it does not take in account the number of units present in each room

| **Parameter** | **source name** | Gears 1 | Gears 2 | Pumps 1 | Pumps 2 | Generators | HVAC Units 1 | HVAC Units 2 | HVAC Units 3 | Compressors 1 | Compressors 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Category number (1 to 9) | 1 | 1 | 3 | 3 | 5 | 8 | 8 | 8 | 9 | 9 |
| *parameter not required in tool* | number of units | 4 | | 30 | | 3 | 20 | | | 3 | |
| | room where the source is located | aft engine room | for engine room | aft engine room | for engine room | auxiliary room | aft engine room | for engine room | auxiliary room | aft engine room | for engine room |
| 2 | Type of airborne noise source levels. | 32 | 32 | 35 | 35 | 47 | 59 | 59 | 59 | 45 | 45 |
| 3 | Type of structureborne noise source levels. | 64 | 64 | 65 | 65 | 71 | 64 | 64 | 64 | 69 | 69 |
| 4 | Type of transfer function for mounting attachment. | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 |
| 5 | Type of transmission loss due to foundation. | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 | 115 |
| 6 | Power (HP) | 6378 | 6378 | 30 | 30 | 0 | 0 | 0 | 0 | 10 | 10 |
| 7 | Nominal RPM | 1000 | 1000 | 1200 | 1200 | 1500 | 0 | 0 | 0 | 0 | 0 |
| 8 | Power in kW | 0 | 0 | 0 | 0 | 300 | 0 | 0 | 0 | 0 | 0 |
| 9 | Air flow (CFM) | 0 | 0 | 0 | 0 | 0 | 5700 | 5700 | 5700 | 0 | 0 |
| 10 | Pump pressure height (psi) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | Static pressure of fun unit (inches of water) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 8.2 Appendix 2: results for critical parameters analysis.

# SSC3_0804

## Effect on Property

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor effects on ship | 0.01 | 2.71E+00 | 2.71E-02 |
| Major effects on ship | 0.1 | 6.12E-04 | 6.12E-05 |
| Severe effects on ship | 1 | 8.36E-04 | 8.36E-04 |
| Catastrophic effects on ship | 10 | 7.40E-03 | 7.40E-02 |
| | | | 0.102053 |

## Effect on Human Safety

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor | 0.01 | 2.71E+00 | 2.71E-02 |
| Significant | 0.1 | 9.93E-04 | 9.93E-05 |
| Severe | 1 | 4.46E-04 | 4.46E-04 |
| Catastrophic | 10 | 7.33E-03 | 7.33E-02 |
| | | | 0.101009 |

# LOW SPEED_0904

| Modified parameters | SSC3 value | alternative design value |
|---|---|---|
| service speed | 35 | 25 |
| maximum speed | 40 | 30 |
| operational profile | speed between 5 and 35 | no speed above 25 |

**Effect on Property**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor effects on ship | 0.01 | 2.71E+00 | 2.71E-02 |
| Major effects on ship | 0.1 | 6.12E-04 | 6.12E-05 |
| Severe effects on ship | 1 | 8.36E-04 | 8.36E-04 |
| Catastrophic effects on ship | 10 | 6.06E-03 | 6.06E-02 |
| | | | 0.088689 |

**Effect on Human Safety**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor | 0.01 | 2.71E+00 | 2.71E-02 |
| Significant | 0.1 | 9.93E-04 | 9.93E-05 |
| Severe | 1 | 4.46E-04 | 4.46E-04 |
| Catastrophic | 10 | 6.00E-03 | 6.00E-02 |
| | | | 0.087646 |

| modified models | modified outputs |
|---|---|
| capsizing | probability |
| foundering | weibull distribution |
| | collapse risk |

## Short_draft

| Modified parameters | SSC3 value | alternative design value |
|---|---|---|
| draft | 2.63 | 2.03 |

**Effect on Property**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor effects on ship | 0.01 | 2.71E+00 | 2.71E-02 |
| Major effects on ship | 0.1 | 6.12E-04 | 6.12E-05 |
| Severe effects on ship | 1 | 8.36E-04 | 8.36E-04 |
| Catastrophic effects on ship | 10 | 1.03E-02 | 1.03E-01 |
| | | | 0.130727 |

**Effect on Human Safety**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor | 0.01 | 2.71E+00 | 2.71E-02 |
| Significant | 0.1 | 9.93E-04 | 9.93E-05 |
| Severe | 1 | 4.46E-04 | 4.46E-04 |
| Catastrophic | 10 | 1.02E-02 | 1.02E-01 |
| | | | 0.129684 |

| modified models | modified outputs |
|---|---|
| capsizing | probability |
| foundering | weibull distribution |
| | collapse risk |

## No-ECDIS

| Modified parameters | SSC3 value | alternative design value |
|---|---|---|
| presence of ECDIS | YES | NO |

**Effect on Property**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor effects on ship | 0.01 | 2.71E+00 | 2.71E-02 |
| Major effects on ship | 0.1 | 6.12E-04 | 6.12E-05 |
| Severe effects on ship | 1 | 8.36E-04 | 8.36E-04 |
| Catastrophic effects on ship | 10 | 7.40E-03 | 7.40E-02 |
| | | | 0.102053 |

| modified models | modified outputs |
|---|---|
| M&A failures | navigation equipment failure |
| | |
| | |

**Effect on Human Safety**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor | 0.01 | 2.71E+00 | 2.71E-02 |
| Significant | 0.1 | 9.93E-04 | 9.93E-05 |
| Severe | 1 | 4.46E-04 | 4.46E-04 |
| Catastrophic | 10 | 7.33E-03 | 7.33E-02 |
| | | | 0.101009 |

# Redundancy=1

| Modified parameters | SSC3 value | alternative design value |
|---|---|---|
| redundancy of safety information | 2 | 1 |

**Effect on Property**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor effects on ship | 0.01 | 2.71E+00 | 2.71E-02 |
| Major effects on ship | 0.1 | 6.12E-04 | 6.12E-05 |
| Severe effects on ship | 1 | 8.36E-04 | 8.36E-04 |
| Catastrophic effects on ship | 10 | 7.40E-03 | 7.40E-02 |
| | | | 0.102055 |

**Effect on Human Safety**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor | 0.01 | 2.71E+00 | 2.71E-02 |
| Significant | 0.1 | 9.93E-04 | 9.93E-05 |
| Severe | 1 | 4.46E-04 | 4.46E-04 |
| Catastrophic | 10 | 7.33E-03 | 7.33E-02 |
| | | | 0.101012 |

| modified models | modified outputs |
|---|---|
| M&A failures | ext. Communication failure |
| | |
| | |

# Frame spacing

| Modified parameters | SSC3 value | alternative design value |
|---|---|---|
| frame spacing (midship section) | 600 for all panels | 1200 for all panels |

**Effect on Property**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor effects on ship | 0.01 | 2.71E+00 | 2.71E-02 |
| Major effects on ship | 0.1 | 6.12E-04 | 6.12E-05 |
| Severe effects on ship | 1 | 8.36E-04 | 8.36E-04 |
| Catastrophic effects on ship | 10 | 1.10E-02 | 1.10E-01 |
| | | | 0.138451 |

**Effect on Human Safety**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor | 0.01 | 2.71E+00 | 2.71E-02 |
| Significant | 0.1 | 9.93E-04 | 9.93E-05 |
| Severe | 1 | 4.46E-04 | 4.46E-04 |
| Catastrophic | 10 | 1.10E-02 | 1.10E-01 |
| | | | 0.137408 |

| modified models | modified outputs |
|---|---|
| foudering | collapse risk |
| | |
| | |

# Floor material

| Modified parameters | SSC3 value | alternative design value |
|---|---|---|
| floor material (firefighting) | carpet | sheet metal |

**Effect on Property**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor effects on ship | 0.01 | 2.71E+00 | 2.71E-02 |
| Major effects on ship | 0.1 | 5.99E-04 | 5.99E-05 |
| Severe effects on ship | 1 | 7.87E-04 | 7.87E-04 |
| Catastrophic effects on ship | 10 | 7.36E-03 | 7.36E-02 |
| | | | 0.101629 |

**Effect on Human Safety**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor | 0.01 | 2.71E+00 | 2.71E-02 |
| Significant | 0.1 | 1.03E-03 | 1.03E-04 |
| Severe | 1 | 3.84E-04 | 3.84E-04 |
| Catastrophic | 10 | 7.29E-03 | 7.29E-02 |
| | | | 0.100578 |

| modified models | modified outputs |
|---|---|
| fire containment | consequences of events 1 to 21 |
| | |
| | |

## Steel

| Modified parameters | SSC3 value | alternative design value |
|---|---|---|
| young modulus of hulll material | 7.0E+07 kPa | 2.10E+08 kPa |
| young modulus of midhsip section panels | 70000 Mpa | 210000 Mpa |

**Effect on Property**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor effects on ship | 0.01 | 2.71E+00 | 2.71E-02 |
| Major effects on ship | 0.1 | 6.12E-04 | 6.12E-05 |
| Severe effects on ship | 1 | 8.36E-04 | 8.36E-04 |
| Catastrophic effects on ship | 10 | 7.28E-03 | 7.28E-02 |
| | | | 0.100837 |

**Effect on Human Safety**

| Name | Weight | Frequency | Risk |
|---|---|---|---|
| Minor | 0.01 | 2.71E+00 | 2.71E-02 |
| Significant | 0.1 | 9.93E-04 | 9.93E-05 |
| Severe | 1 | 4.46E-04 | 4.46E-04 |
| Catastrophic | 10 | 7.21E-03 | 7.21E-02 |
| | | | 0.099793 |

| modified models | modified outputs |
|---|---|
| hull girder vibrations | risk of resonance level |
| foundering | collapse risks |
| | |

## Comparison between configurations

| | SSC3 | low_speed | Short_draft | No-ECDIS | Redundancy=1 | Frame spacing | Floor material | Steel |
|---|---|---|---|---|---|---|---|---|
| risk on ship | 0.102053 | 0.088689 | 0.130727 | 0.102053 | 0.102055 | 0.138451 | 0.101629 | 0.100837 |
| risk on human safety | 0.101009 | 0.087646 | 0.129684 | 0.101009 | 0.101012 | 0.137408 | 0.100578 | 0.099793 |
| risk increase/reduction compared to SSC3 | absolute value | -0.013364 | 0.028674 | 0.000000 | 0.000003 | 0.036398 | -0.000424 | -0.001216 |
| | percentage | **-13.23** | **28.39** | 0.000002 | 0.002526 | **36.03** | -0.42 | -1.20 |