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RISK BASED DESIGN CONCEPT IMPLEMENTATION IN SHIP RETROFITTING PROCESS

Dan IOACHIM*

Prof.Univ.Dr.Eng.Adrian GHEORGHE**

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Ship design;

Ballast water treatment;

Multicriterial hierarchy;

Ship–System compatibility

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Abstract

The financial crisis had a bad influence for the shipbuiding together with the new technology development, which should have been provided to the ship from the design. An alternative solution is to maintain the actual ships for an extra period of time. The problem is that this ships are outdated, being compulsory a retrofitting in order to install the nedeed systems.

This kind of job needs inovative technologies, that has not been used until now onboard, being possible to appear a large sort of operational or technical risks.

The final target and also the inovative part of these studies is represented by the methodology that helps the development of new solutions, regarding old ships retrofitting. These solutions must give realistic answers to the new International Maritime Organisation standards, together with economical efficiency and operational safety maintain.

Taking into consideration that the methodology not to be a local or restrictive one, it was selected a reasonable number of 100 cases. The hierachy process of the systems, for each type of the ten ships, is based on AHP methodology. In order to establish if the improvements has also some side effects, I developed a risk analysis, based on HiP-HOPS software model.

* **Doctorate Program, POLITEHNICA University of Bucharest, Romania**

** **Old Dominion University, Norfolk, USA**

1. Introduction in the analysis of Risk Methodologies in Ship Design

Risk management represents the collecting data process and information synthesizing, focusing the development of an obvious understanding, regarding the risks existing in a certain system. It supose probabilities and consequences maximization for positive events and minimization for the adverse ones.[1]

Risk analysis process in naval and aerospace field is developed at the highest performance level due to the huge costs, involved in the specific systems. Some of the usual analysis used are: PHA (preliminary hazard analysis), Risk trees and Fault trees, FMEA (Failure modes and effect analysis).

Failure tree analysis for BWTS operating

Failure tree is a graphical model which represents the connetions between the failure events and the simultaneous human errors that can happen in the system. The calculation of the main event probability is possible only evaluating the failure probabilities for each basic component. [2]

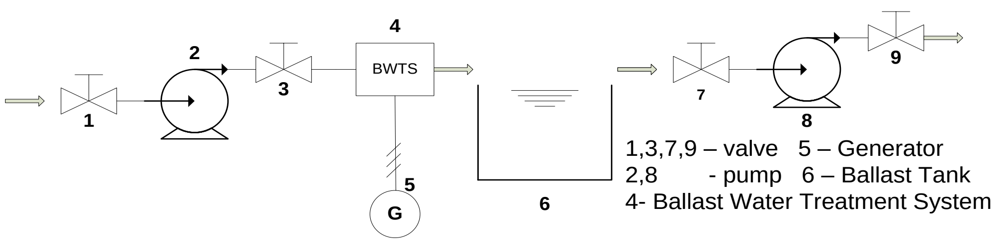

Fig. 1.1 Elementary design for a Ballast Water Management System

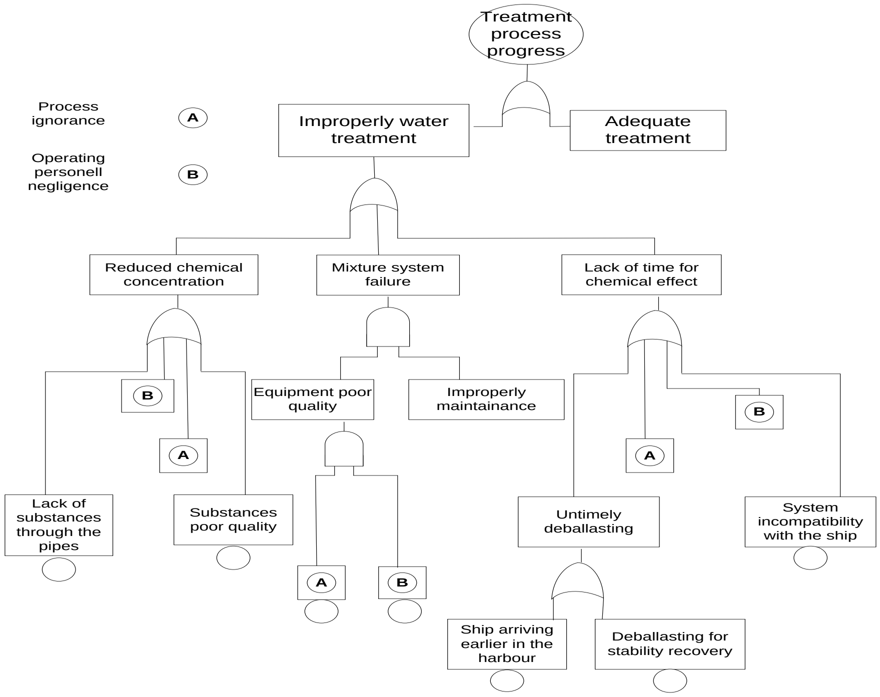

Fig. 1.2 Failure tree coresponding with the BWMS

2. Research Method

2.1 Different ways of analysing Risk Based Design Methodology

Risk management integration in design process leads to "Risk Based Design" concept. Science and technical improvements gave the opportunity for inovation in the naval field. The main targets are: bigger, faster and more economical ships. Also, an other interest regards the environmental pollution decrease.

The fact is that, together with this technological improvements, risk level is rising. Obviously it is not enough any more only to follow the actual standards an reglementation. That is why, it is compulsory to adopt some predictive analysis, to be integrated in design process. This risk analysis must be considered at the same level of importance with economic efficiency or environmental pollution. [3]

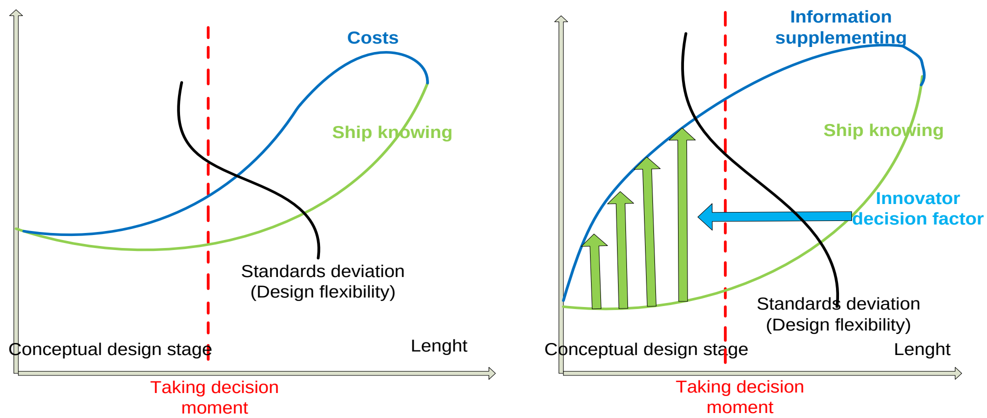

Fig. 2.1 Classic Design vs. Risk Based Design

One of the most important features of RBD is the implementation of safety measures at a high level, with a low cost.

In order to reach the safety level, it is compulsory the implementation of some procedures for measuring the risk analysis. It must be take into consideration the fact that, due to analysis complexity, some clues must be followed, as: historical data from previous major accidents, experts opinions, software simulations. This kind of instruments (clues) must be integrated into the design process to facilitate the conections between safety and other factors (economic, performance, environmental).

Risk Based Design concept way of implementation

Safety management or risk management is a process that can be achieved through a multitude of ways. The steps are represented in the below graphic.

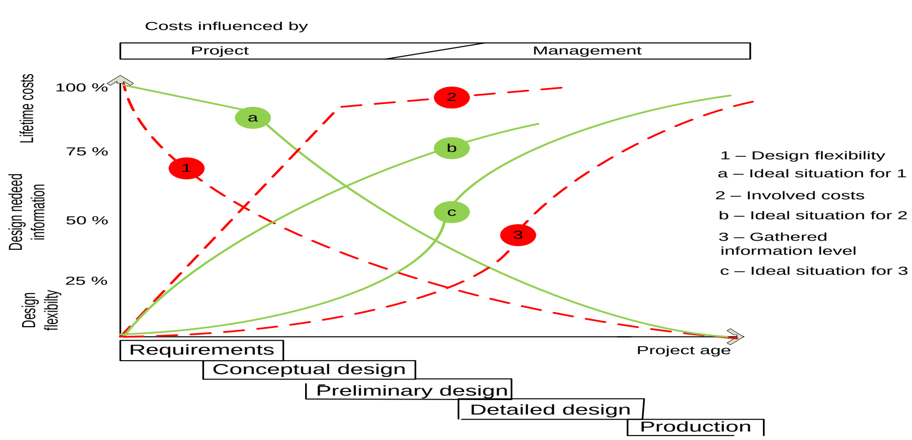

Fig. 2.2 Design process factors[4]

Instruments used in Risk Based Design concept

RBD requires advanced instruments for developing Risk Management analysis in a certain project. This instruments facilitates consequences analysis for a variety of hazards: technical failures, conflagrations, explosions, floodings, capesize, and so on.

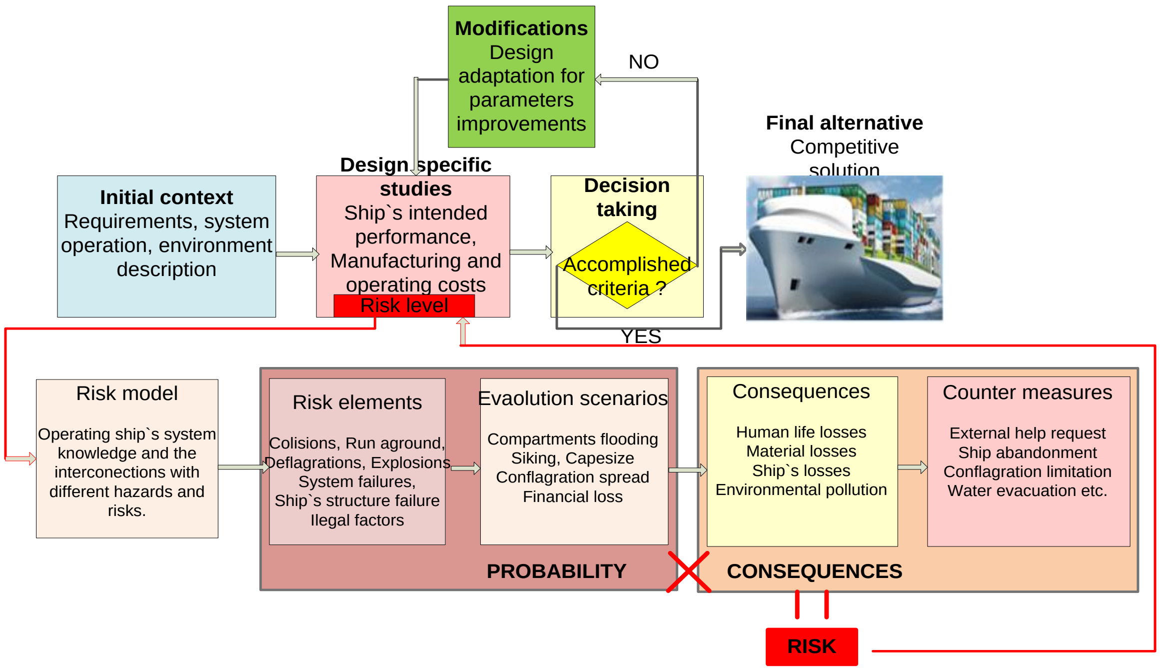

Fig. 2.3 RBD algorithm implementation

3. Results and Analysis

3.1 Treatment Systems Compatibility with the selected ships and Hierarchical Process

To verify any system compatibility with the counted ships, will be taken into consideration the percent that represents the nedeed power supply for system operation, from the gen-set available power.

An important criteria for removing from potential to be used system list, is the fact that the nedeed power supply exceeds 10 % from the gen-set available power.

To obtain all possible combinations between the systems and the selected ships (10 examples of each), was realised the below matrix:

Tab. 3.1 Possible combinations matrix, between the systems and selected ships ballast pump flow, preliminary phase (represented only 6 out of 10 ship cases)

3.2 Analytic Hierarchy Process Methodology for Rising Systems Performance

BWMS Name	kW/500 m3/h	kW/1,000 m3/h	kW/1,500 m3/h	kW/2,000 m3/h	kW/2500 m3/h	kW/3,000 m3/h
Aquarius EC	40	70	110	150	185	220
HiBallast	110	200	285	370	450	480
BalPure BWMS	30	60	90	120	150	180
Ecochlor BWT	10	19	28	36	44	50
Hyde GUARDIAN	50	75	114	150	190	235
Aquarius UV	90	110				
Crystal Ballast	83	165	250	330	415	500
Mitsui	6	10	16	20	26	
NK-O3 Blue	60	100	144	190	240	290
ClearBallast	40	80	120	155	190	230

Multicriterial ranking

In the following there is made an analyse of the systems, in order to select the compatible ones with the choosen ten ships.Due to the fact that the diferences regarding oil consumption, operating or aquisition costs, installing area, are pretty small, theoreticaly, any of the ten systems can be installed onboard of any ship.

That is why will be required a ranking, based on criterial hierarchy, the criteria being the represented by the previous calculated parameters.

In the following I will mention the choosen parameters (criteria) to be followed in the analysis, for each ship separately, and, at the end, will be proposed the best treatment system, according to the selected ship. Fig.3.1:

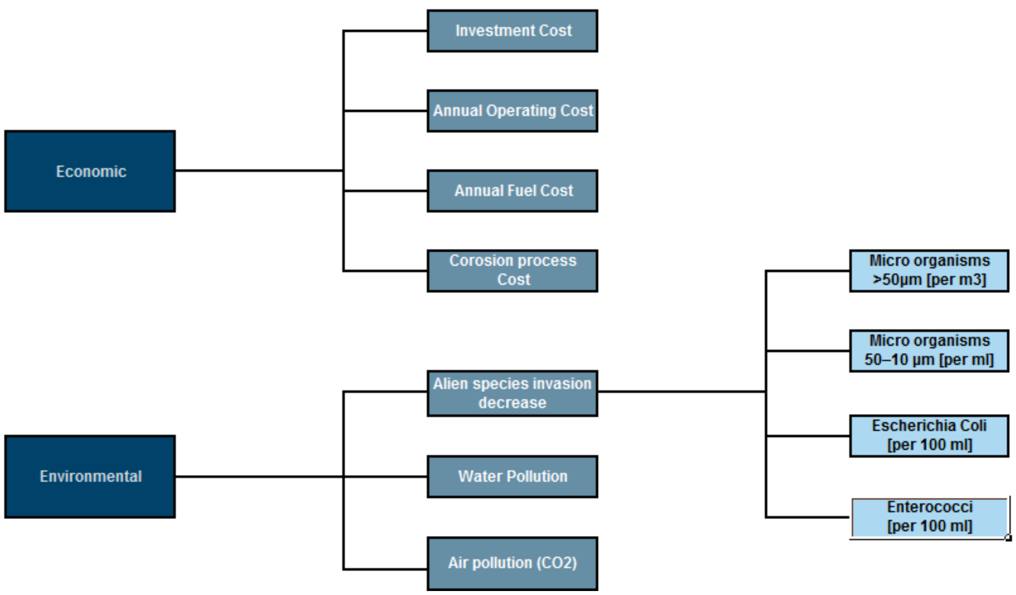

Fig. 3.1 Criteria parameters clasification

Weights calculation

In the following diagrams there are represented the rankings for each of the four main criteria. The specific values are based on the literature [5] [6].

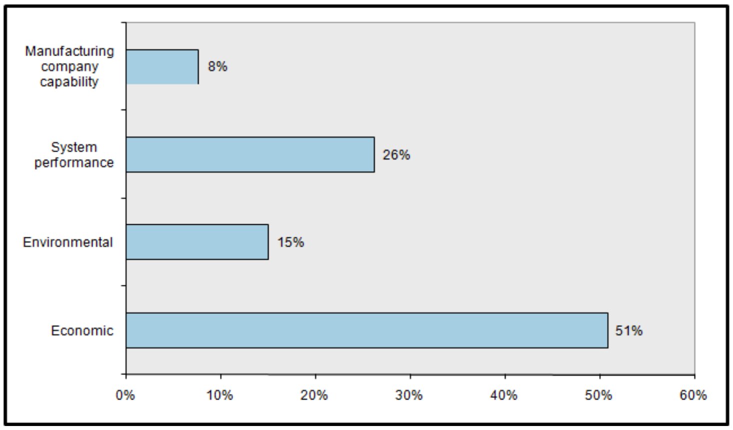

Fig. 3.2 Systems specific criteria ranking

Hierachical criteria analysis

Table 3.2 Aquisition cost parameter from Economical criteria

BWMS Name	Tanker 9200 ($x1000)	Rates	Rates	Tanker 24000 ($x1000)	Rates	Rates	Tanker 95000 ($x1000)	Rates	Rates
Aquarius EC	650	2.03	1	1100	1.69	1	1500	2.31	1
HiBallast	650	2.03	1		0.00			0.00	
BalPure BWMS	350	1.09	10	650	1.00	10	1200	1.85	1
Ecochlor BWT	350	1.09	10	650	1.00	10	1200	1.85	1
Hyde GUARDIAN	400	1.25	8	950	1.46	4		0.00	
Aquarius UV	400	1.25	8	950	1.46	4		0.00	
Crystal Ballast	350	1.09	10	720	1.11	9		0.00	
Mitsui	320	1.00	10	800	1.23	7	1200	1.85	1
NK-O3 Blue		0.00			0.00			0.00	
ClearBallast		0.00			0.00			0.00	

The values from this table are calculated in Excel. As an example, the chosen hierarchical parameter was Aquisition cost. It can be observed that the marks are given in disproportion with the aquisition values. In this way, the system that has the lowest price will get 10. With red were marked the unsuitable systems.

Table 3.3 Hierarchical analysis for selecting the best treatment system, suitable for 9200 TDW Tanker

BWMS Name	BWMS Process	Capex	Opex	cost	Air emiss	species invasion	duration	Area	cons
Aquarius EC	Filtr+Electrochlorin	1	1	9	9	10	5	1	7
HiBallast	Filtr+Electrochlorin	1	1	5	5	5	5	7	1
BalPure BWMS	Filtr+Electrochlorin	10	2	9	9	10	8	10	8
Ecochlor BWT	Filtr+Electrochlorin	10	2	10	10	8	3	8	10
Mitsui	Ozonation	10	10	10	10	3	6	8	10
NK-O3 Blue	Ozonation	-	-	8	8	6	6	5	5
ClearBallast	Filtration + precoagul	-	-	9	9	3	8	4	7
Parameter weight at global level		28%	7%	13%	9%	9%	4%	10%	7%

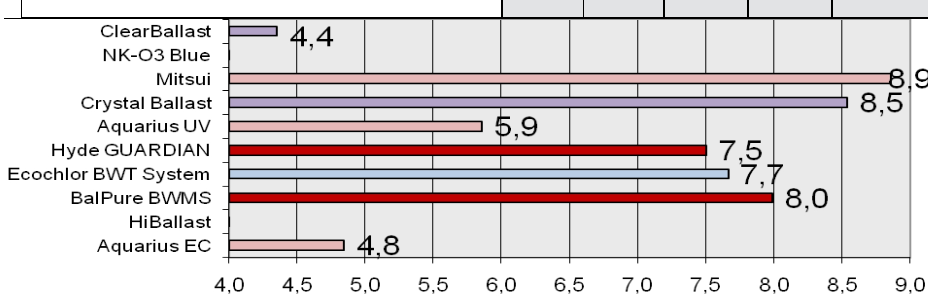

Fig. 3.3 Hierarchical analysis for selecting the best treatment system, suitable for 9200 TDW Tanker

3.3 Lifetime Risks Identification for Treatment Systems

Treatment system selection and aquisition specific risks

There is the risk that the shipyards to be overcrowded, being unable to achieve installing operation in time, causing high financial loss.

Also, is expected a rise of the costs, both for the systems and for the installing operations. An other reason would be the one that a slow management in the environmental protection could turn in a bad light the entire company.[7]

Onboard installing risks

The previous mentioned stages, are taken from the project "Eco innovative refitting technologies and processes for shipbuilding industry promoted by European Repair Shipyards", EcoREFITEC-D-4.1-2012-12-01-SSA, in partnership with Constanta Shipyard.

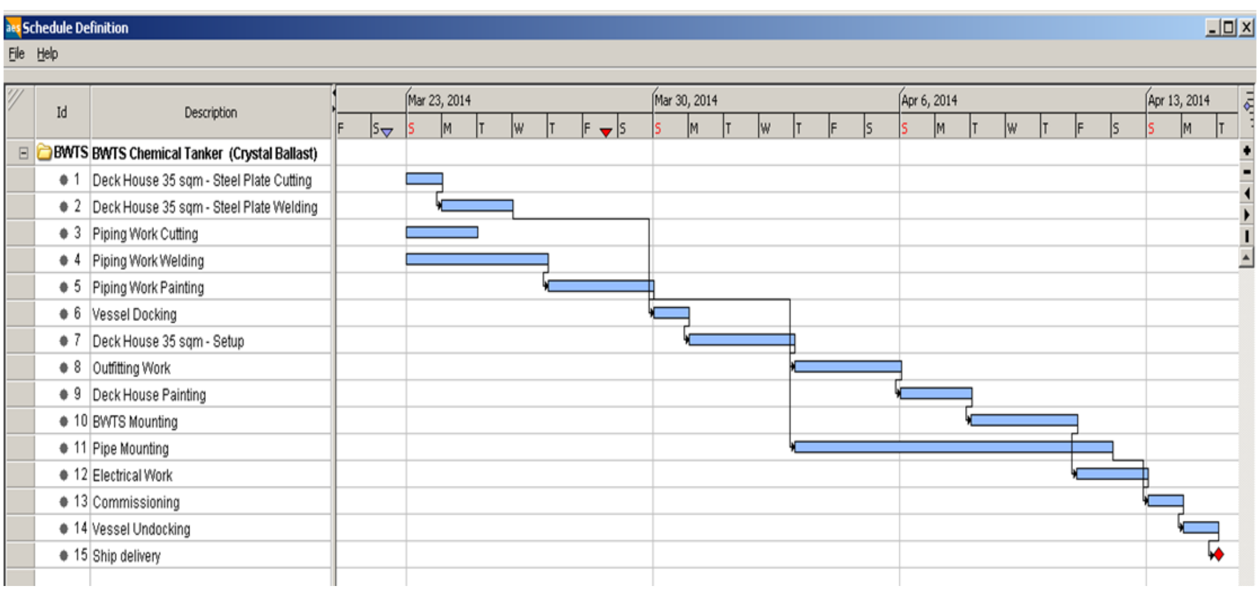

Figure 3.4 Gant graphic for the system onboard installing operations

Specific risks for system operating

Chemical treatment risks [8]

- the ones with short delay effect (due to strong oxidants ballasted to sea)
- the ones with long delay (due to by-products)

Ozonation treatment risks

Ozone decomposition in sea water creates a strong oxidants that neutralize the aquatic invasive organismes. The risk is that this oxidants (hypo-bromic acid) is poisonous also for the operators.

UV treatment risks [9]

UV treatment efficiency depends on the water turbidity and solid suspensions, that makes harder the radiation propagation.

Sediments management risks

Solid wastes after treatment, representing the remains of the aquatic organismes, is forbidden to be overboard discharged. That is why is compulsory that all the systems to be fitted with rough preliminary filter, retaining the over 50 μm particles

3.4 Risk Based Design Analysis for a Ballast Water Treatment System

Possible improvements for a BWTS [10]

This chapter analyses the incompatibilities between some treatment systems with the considered ships, by following RBD methodology. There are proposed a series of solutions, some of them already implemented, and others not even in design phase. This analysis intend to avoid, or at least to reduce the potential risks, that can appear when is about to implement an incompatible system with a certain ship.

At the end there will be indicated how much the proposed solutions can be take into profit regarding financial, environmental or safety, compared with the previous solutions, specific for the classical analysis.

Reducing the incompatibilities number regarding de power demand

Aproximately 50% of the 100 possible ship-system combinations, can not be considered because of the power demand incompatibility. That is because the available gen-set power is lower than the treatment system power demand.

In the literature there are some possible solutions:

1. Suplementary gen-set installing, called Power-Pack, that is able either to supplement ship`s power system, either to feed independently the treatment system

2. Treatment system feed from emergency diesel-generator

Figure 3.5 corresponds to a 40700 TDW tanker. In the initial phase, Aquarius UV system did not figured in the compatible systems list. After reevaluating the situation through RBD methodology, the ranking value for this system is 4.1. Although is the last one in the list, represents however a viable solution for the ones that prefers it against of other systems.

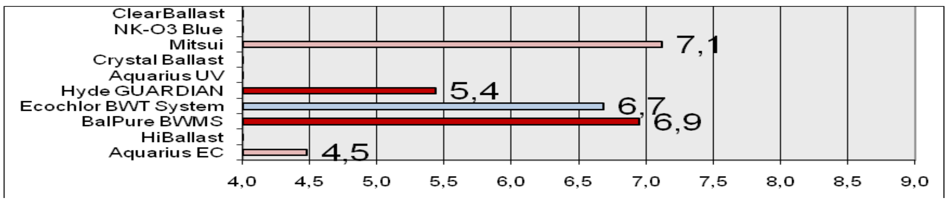

Fig. 3.5 Ranking values before improvements

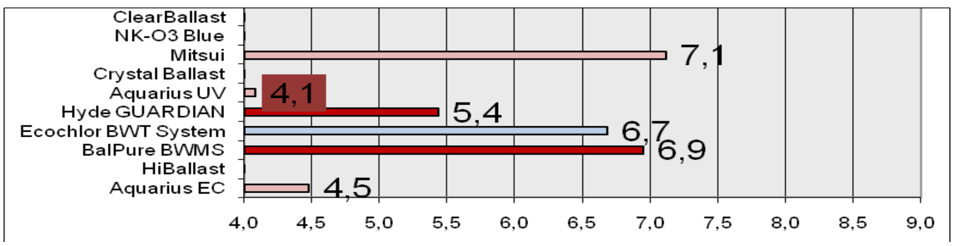

Fig. 3.6 Ranking values after improvements

3.5 Redesigning Modeling by using the Risk Analysis Hip-Hops Software Model

In order to decide if the proposed improving system solutions are viable (can be applied without side effects), I used HiP-HOPS instrument for Risk analysis software modeling.

The sollution I chosed to analyse by risk analysis is the BWTS feed from Emergency Generator.

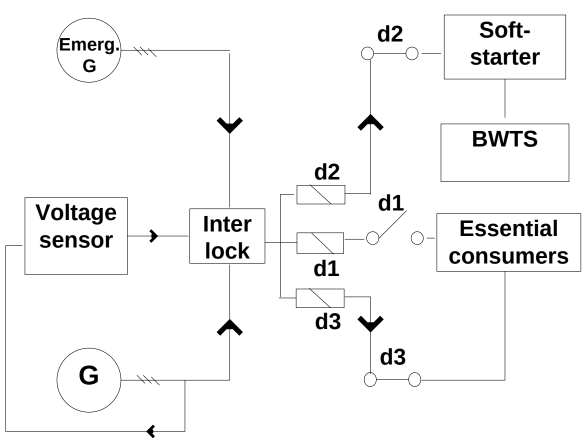

Fig.3.7 BWTS power system feeding

The major risk element from this analysis is the failure of power feeding for the essential consumers, in case of blackout. This can happen if the emergency generator does not starts due to the BWTS interconnection or other various deficiencies (that had been took into consideration).

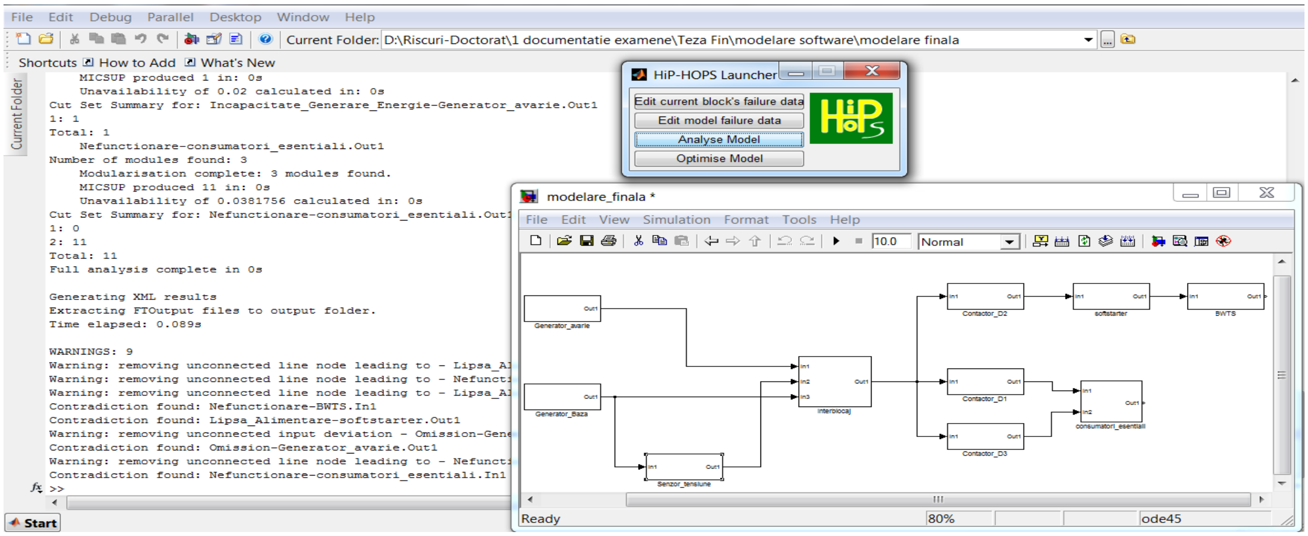

Fig. 3.8 Simulink design for BWTS power system feed

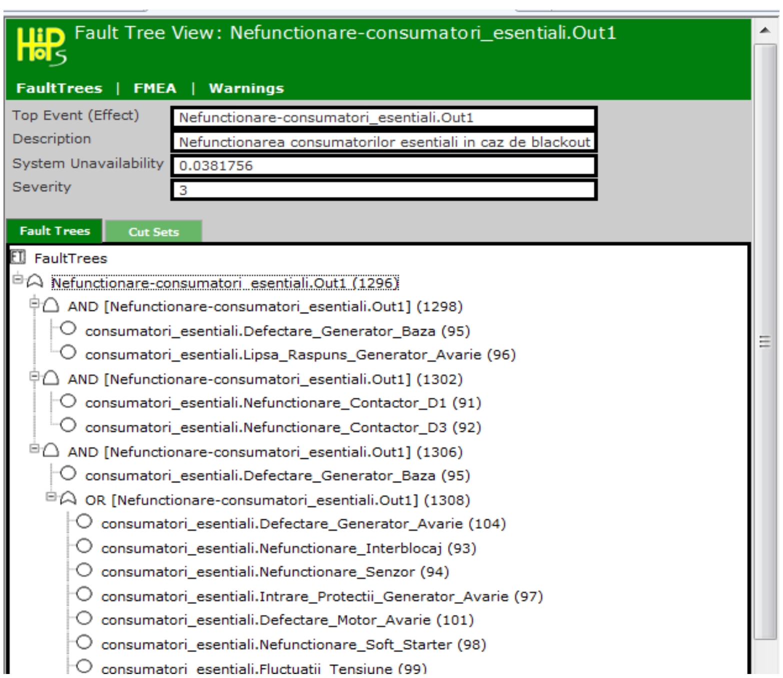

Fig. 3.9 Failure tree corresponding to the BWTS power system feed

In figure 3.9 it is represented the failure tree, resulted after running the software model. This was created based on the manual designed failure tree. It can be identified the resulting value for the main failure probability (0,038). Also, it is represented the severity value (3), on a scale from 1 to 7.

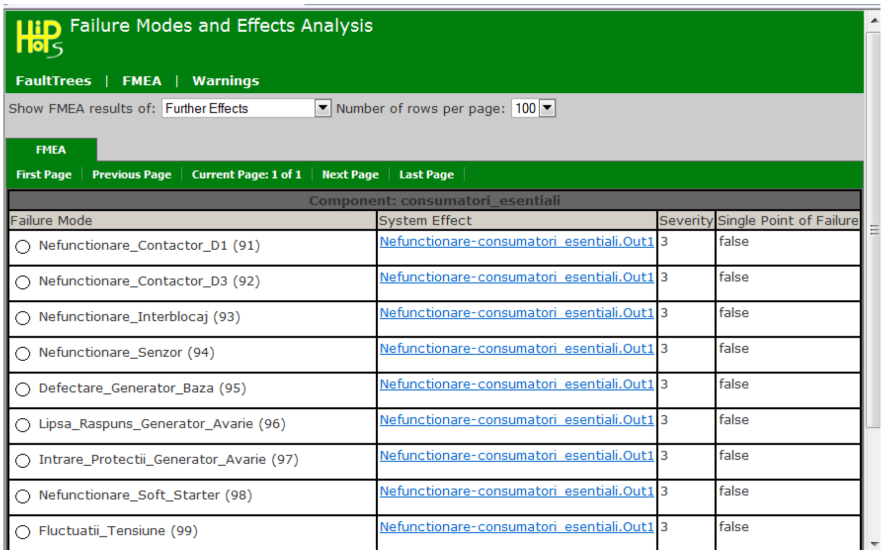

Fig.3.10 Basic elements FMEA structure

In figure 3.10 is represented the FMEA structure, corresponding to the BWTS power system. For each of the basic element from this structure is represented the final effect on the analysed system (the failure of the ssential consumers).

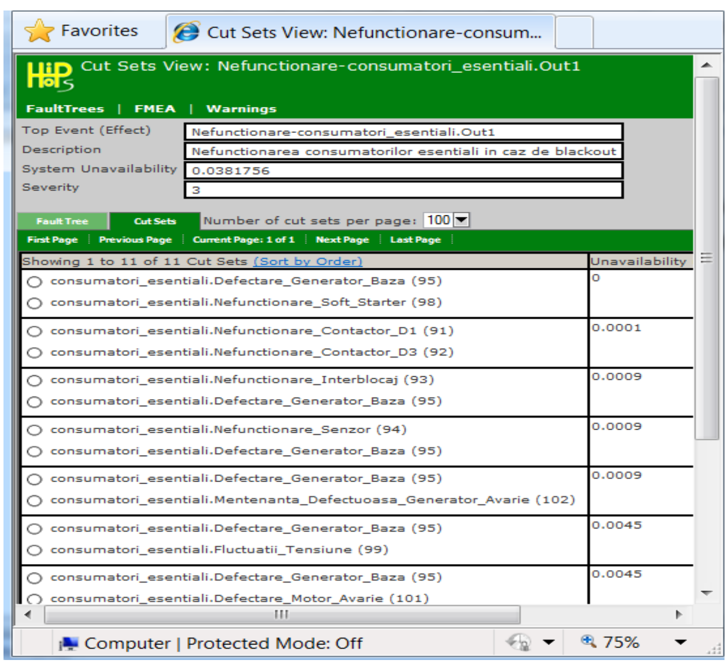

Fig.3.11 Failure tree basic elements and the specific failure probability

The final remark for this software modeling, using HiP-HOPS instrument, is that, due to low value of the risk probability (0,038), correlated with a 3 level severity, indicates a low risk value. That is why, the improving solution of feeding the BWTS by Emergency generator, is a viable one, the potential risk (ship sinking, capsize, colission or run aground), having a low level.

4. Conclusions

This study is based on the activities developed in colaboration with Constanta Shipyard, Ship Design departament, in the ECOREFITEC Project. The project referes to the BWTS instalation onboard of a 41000 TDW tanker.

The originality elements obtained through this studies is the methodology that helps new solutions developing, regarding water ballast management, for the ships that has not been provided with this kind of system, so to fit to the new standards, together with economical efficiency and safety operation.

I tried to define a number of alternatives, as big as possible, in order to obtain a global feature, so that the methodology not to be a narrow one.

I used an AHP software model in order to rank all the treatment system.

Although there were searched many directions, the most feasible solutions for improving the system are reffering to: Treatment process (filtration), Treatment duration minimizing, Ex-proof standard comply, Power demand optimum level.

After offering this solutions, all the systems were ranked again, in order to highlight the benefits.

Using RBD methodology, it was developed HiP-HOPS software model in order to establish if through the improvements does appear major drawbacks, that can compromise the whole activity.

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