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HIERARCHICAL RANKING AS BASIS FOR SHIP OUTFITTING PROCESS IMPROVEMENT

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Summary

Within the shipbuilding process, the outfitting activities are aimed to be deployed within stages before the ship's erection and ship launching as much as possible, where the cost of the working hour is lower and work quality higher. High level of ship outfitting before launching is one of the most important goals of today’s modern shipyards. In this work, within the ship equipment process, the most important criteria will be identified, evaluated and ranked according to their impact on the level of ship outfitting before launching. Expert approaches and hierarchical ranking is going to be used along with the creation of a computer application to support the solution which can be applied for different shipyards. The result of the evaluation is the sequence of criteria relevant to their impact on the level of outfitting before launching. Based on such results, the authors are proposing improvement of the ship outfitting process, which is expected to improve the ship's equipment level before launching and thus reduce the cost of the shipbuilding process. In the end, the authors will also indicate the guidelines for continuing the research for the purpose of further improving the ship outfitting process.

Keywords: *shipbuilding; outfitting; hierarchic ranking; shipbuilding costs*

Nomenclature

AHP	-	Analytic Hierarchy process
e_{jk}	-	grade of k expert for the j criterion
E_k	-	*k* expert
n	-	number of evaluated criterions
m	-	number of experts
p_j	-	overall weight factor of j criterion
p_jk	-	weight factor of j criterion based on k expert grade
Vj	-	the evaluated criterion
V_{kn}	-	*n* criterion at level 1
V_{sni}	-	*i* sub-criterion of *n* criterion at level 2
V_{fnij}	-	*j* sub-criterion of *i* sub-criterion of *n* criterion at level 3

1. Introduction

The ship outfitting process, within the ship design and building stage, involves significant financial, human and organizational resources, and as such significantly influences the time and cost of shipbuilding and is one of the key indicators of technological and technical development of a shipyard. In actual shipbuilding industry, however, the outfitting is concentrated more towards the earlier stages of shipbuilding production process, opposite to the ship outfitting on berth and in outfitting basin, [1]. Namely, the man-hours on the ship or after launching in the basin is several times more expensive than the same hour in earlier stages of production process within shipbuilding workshops. Mentioned is particularly apparent in special projects of high added value ships. Therefore, regarding the aim of modern shipbuilding industry to shift the focus of ship fitting jobs towards earlier, more efficient phases of production process authors main goal is to identify, evaluate and rank the most important criteria. Such criteria are ranked related to their influence on the level of ship's outfitting before launching, using expert approach methods and hierarchical rankings. Also a computer application to support a solution that can be applied to any other shipyard is developed. In the previous research and application of hierarchical modelling, [2,3,4] the authors have identified the applicability of the hierarchical approach to the ranking problem of the influential criteria on the ship outfitting level. Based on the results of the hierarchical ranking methodology applied, the authors propose processes whose improvement will most probably have an impact on raising the ship outfitting level and ultimately reducing shipbuilding costs. In the paper, within first chapters the basis of the manufacturing process of ship outfitting in modern shipyards is described. Furthermore, in the third chapter the general mathematical model of the hierarchical ranking method is presented. Chapter Four identifies significant influential criteria and their sub criterion by an expert approach and defines a real hierarchical model using three hierarchical levels. Such model is used as basis for the implementation of hierarchical ranking within established computer application. In addition, a hierarchical ranking method is applied on the case study for the selected shipyards of same technical level. Results, discussion, and suggestions for improvement are presented. Analysing obtained results and previous research and experience, [5, 6] the authors elaborate the planned directions for further development and research trough establishing a computer simulation model for optimization of ship outfitting process before ship launching.

2. Background

The ship outfitting process is usually divided into two mutually separate technological phases: pre-outfitting and on board outfitting. For the pre-outfitting process, it is characteristic that the timing takes place almost simultaneously with the construction of the hull and is further divided into two mutually independent technological phases: the on-block outfitting and modular outfitting, [7]. The modular outfitting concept of the ship in the assemblies, modules and block of equipment is the compilation of the ship's equipment in the assembly workshops before assembly to the site of construction, [8]. The on-board outfitting is also divided into two technologically separate phases: on berth outfitting and final outfitting in basin, [9, 10].

The primary purpose of work brake down structure is to reduce outfitting on the berth and after launching resulting in increased productivity and reduced process time and costs. Specifically, it often stated a ratio of 1: 3: 7: 11 for the allocation of working hours according to the stages of construction, [1]. This ratio speaks the following; if the outfitting is being done at an early stage of the block assembly, the cost of outfitting has factor one; for the same work performed in the closed block, the cost of the equipment is three times higher; when the outfitting is done on berth, for the same work the cost is seven times higher; while the cost of outfitting at the final stage after launching is eleven times higher. Therefore, modern shipbuilding is constantly working to improve the shipbuilding strategy, [11]. However, the authors argue that shipyards in general, in effort to shift the outfitting work load towards the earlier stages of production process, approach the issues by comparing them with other similar shipyards and partially within production processes. In doing so, the specific characteristics of particular shipyard are not adequately involved. Furthermore, the clear identification and systematization of relevant criteria and how their particular and mutual influence is impacting the entire production process, is not adequately covered. Therefore, the authors emphasize that shipyard management, for a more efficient implementation of the outfitting concept in the earlier phases of the production process, needs a better insight on the influential factors or areas to be considered towards better results and lower risk. For this purpose, the authors in this paper define the criteria and their detailed sub-criteria, and then rank them according to their impact on the ship's outfitting process before lunching. In addition, the detailed characteristics of certain criteria were further analysed and defined on the basis of the collected and systematized expert indicators that in the observed shipyards frequently led to disturbances in the design plan and the dynamics of outfitting. Furthermore, authors by using the expert approach define these significant criteria and their sub-criterions, and by applying the method of hierarchical ranking evaluate the influence on the outfitting process. The proposed methodology for outfitting process improvement based on expert approach and hierarchical ranking will be described below and further will be implemented on a real sample of five selected shipyards of same technological level, [12,13]. The authors are not familiar with the similar research that would identify and rank the selected shipbuilding process according to their impact on the outfitting process before ship launching by taking into account the interaction with the overall process.

3. Hierarchical ranking method

The authors suggest to evaluate the influential criteria on the outfitting level of before lunch using a hierarchical ranking method that identifies and classifies multi-level criteria 1, 2, ... r, as shown schematically in Figure 1, [2]. Criteria are defined based on collected and systematized expert indicators which frequently led to disturbances in the design plan and the dynamics of outfitting. Furthermore, their sub-criteria stem from the technological process of outfitting as factors directly affecting them at the second hierarchical level, and so on to the r-level.

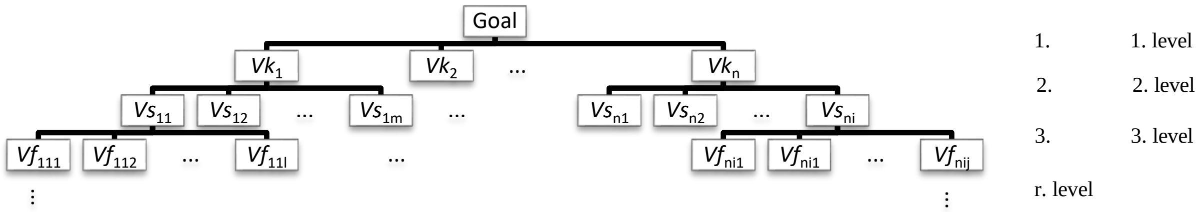

Fig. 1 Hierarchical ranking structure in *r*-levels

Where is:

V_{kn} – *n* criterion at level 1

V_{sni} – *i* sub criterion of *n* criterion at level 2
V_{fnij} – *j* sub criterion of *i* sub criterion of *n* criterion at level 3

For the evaluation and ranking of criteria, the ranking method is applied on the basis of third-level expert assessments awarded to selected shipyards of same technological level. The ratings are based on the evaluation of the interdependence of the criteria at the third hierarchical level, depending on the impact on the outfitting process. The ranking method based on expert ratings can be mathematically described as follows, which is applicable to each hierarchical level:

$$p_{jk} = \frac{e_{jk}}{\sum_{j=1}^{n} e_{jk}} \quad (1)$$

$$p_j = \frac{1}{m} \sum_{k=1}^{m} p_{jk} \quad (2)$$

where is:
m- number of experts
n- number of evaluated criterions
e_{jk} – grade of k expert for the *j* criterion
p_{jk} – weight factor of *j* criterion based on *k* expert grade
p_j – overall weight factor of *j* criterion

Based on the hierarchical model and ranking methods, authors have created a computer application that is reduced to a tabular approach to solving this problem on the basis of n criteria and m experts, as presented in table 1:

Table 1 Criterion grades

Ek (k:1-m) / *Vj*(j:1..n)	*E1*	.	.	.	*Em*
V1	$e_{jk=1}$	.	.	.	$e_{1k=m}$
.	.	.	.	.	.
Vn	.	.	.	.	.
	$\sum_{j=1}^{3} e_{jk=1}$	$\sum_{j=1}^{3} e_{jk=2}$	$\sum_{j=1}^{3} e_{jk=3}$	$\sum_{j=1}^{3} e_{jk=4}$	$\sum_{j=1}^{3} e_{jk=5}$

Where is:
Vj-graded criterion
Ek-expert

The weighted values of each criterion (*Vj*), as compared to the expert grade (*Ek*), are further calculated according to the expression (1), and the table solver is shown in Table 2.

Table 2 The weight factors of individual criteria in relation to expert grades

Ek (k:1-m) / *Vj*(j:1..n)	*E1*	.	.	.	*Em*	$\sum_{k=1}^{m} p_{jk}$

V1	$p_{jk} = \frac{e_{jk}}{\sum_{j=1}^{n} e_{jk}}$	.	.	.	.	$\sum_{k=1}^{m} p_{1k}$
.	.	.	.	.	.	$\sum_{k=1}^{m} p_{2k}$
Vn	.	.	.	.	.	$\sum_{k=1}^{m} p_{3k}$
$\sum_{j=1}^{n} p_{jk}$	$\sum_{j=1}^{n} p_{j1} = 1$	$\sum_{j=1}^{n} p_{j2}$	$\sum_{j=1}^{n} p_{j3}$	$\sum_{j=1}^{n} p_{j4}$	$\sum_{j=1}^{n} p_{j5}$	

The weight factors individual criterion, p_{jk}, are normalized according to expression (1), and the overall sum for each criterion. Furthermore, the total weight factors of the *j*-criteria are normalized and calculated according to (2) using the values in Table 2, as follows:

$$p_1 = \frac{1}{m}\sum_{k=1}^{m} p_{1k};$$

$$p_2 = \frac{1}{m}\sum_{k=1}^{m} p_{2k};$$

.

$$p_n = \frac{1}{m}\sum_{k=1}^{m} p_{nk};$$

In such way, the hierarchical ranking of the most influential criteria is defined so to further addressed with the aim of improving the ship's outfitting process most efficiently. In the next chapter, the analysis and definition of defined criteria and their sub-criteria is presented based on selected shipyards, as the foundation for the definition of a hierarchical ranking model structure and further a computer support solution application.

4. Criteria and Sub-Criteria Analysis as Input for Hieratical Ranking Model Definition

There are no completely defined activities and equipment that is installed in the prefabrication phase. With the expert approach [5, 8, 9, 14], the AHP [2,12] method, the empirical method, observation method and interview methodology, the criteria for evaluating the pre-outfitting process.

In order to improve the outfitting process, the authors emphasize the necessity of defining the criteria and their sub-criteria, and to rank them regarding the influence on outfitting process. The same will enable the management of the shipyard to have a clearer overview of the critical sites and to act with higher efficiency. For this purpose, an analysis of selected shipyards has been carried out with the aim of defining influential criteria and their sub-criterions as the basis for creating a model of hierarchical ranking supported by the corresponding computer application.

4.1 Impacting criteria and sub-criteria on outfitting process

Impacting criteria, and related sub-criteria are defined based on the analysis of collected and systematized expert indicators. Based on such an analysis, the following nine influential criteria on outfitting process before lunching were defined:

1. Criteria - Documentation adapted to pre-outfitting process
2. Criteria – Ship hull technological breakdown adapted to pre-outfitting
3. Criteria – Production planning adapted to pre-outfitting process
4. Criteria – Material supply adapted to pre-outfitting process
5. Criteria - Dimensional control
6. Criteria - The capacity and structure of the labour force adapted to pre-outfitting
7. Criteria – Workshops technological constraints for implementation of pre-outfitting
8. Criteria - Shipyard's layout
9. Criteria - Vertical and horizontal transport capacities

Further, conducted expert approach and detailed analysis of the identified criteria and their interaction with other processes in the shipyard are defined along their related sub-criteria as basis for hierarchical ranking method in three levels.

Criteria 1 - Documentation adapted to pre-outfitting; The documentation must first of all be technologically structured according to ship hull brake down structure and outfitting phases. The goal is to have a specific document with relevant information for every outfitting phase. Further, such documentation should be completed and ready for the assembly process at least one month before the start of outfitting, in order to prepare the process, material supply and work activities. In doing so, the authors for this criterion define significant sub-criteria as follows: Sub-criteria of criteria 1: Compliance with the technological process; Compliance with work phases; Information content; Deadline

Criterion 2 - Ship hull technological breakdown adapted to pre-outfitting; Geometry and volume of the ship hull blocks should be designed to accommodate the maximum ability for conducting block outfitting in such a way that boundaries of blocks follow as much as possible real space areas such as tanks, work areas on board, platform bulkheads, etc. If the outfitting is conducted within smaller block, assemblies and sub-assemblies in earlier phases of production, the similar approach applies in doing so, the authors for this criterion define significant sub-criteria as follows: Blocks; Ship hull block breakdown; Work breakdown.

Criterion 3 - Production planning adapted to pre-outfitting process; Planning and work preparation is a key prerequisite for an efficient ship outfitting process. It is important to recognize and monitor the key and interdependent activities, such as: deadlines for documentation, deadlines for ordering and delivery of materials in relation to the dynamics of ship outfitting, and planning and prediction of workload related to planning a sufficient number of labour force, own or subcontractor. In doing so, the authors for this criterion define significant sub-criteria as follows: Planning of documentation preparation; planning of material supply; Personnel planning; planning of works; financial resources planning.

Criterion 4- Material supply adapted to pre-outfitting process; Material supply should be organized according to technological phases and outfitting process dynamics. It is important to identify equipment that requires a longer delivery time so to be ordered in time. Financial resources should be accordingly provided. For this criterion significant sub-criteria are as follows: Deadlines; Compliance with work phases; Quality.

Criterion 5 - Dimensional control; To ensure the accuracy of outfitting process, high dimensional accuracy is required in order to reduce repair works in latter stages of production, after ship assembly on berth, or on ship. In doing so, the high level of ship outfitting before launching, generally implies a high level of accuracy [15, 16]. For this criterion significant sub-criteria are as follows: Accuracy; Quality.

Criterion 6 - The capacity and structure of the labour force adapted to pre-outfitting; In order to successfully implement the pre-outfitting concepts, it is necessary to provide adequate work force according to the degree of workload, the deadlines and the structure of the occupation in the different phases of the outfitting [17]. This should take into account peak loads, which should be anticipated in time, and also a need for possible co-operation. For this criterion, significant sub-criteria are as follows: Capacity; Structure.

Criterion 7 - Workshops technological constraints for implementation of pre-outfitting; The technological capabilities of the workshops, their size, the level of equipment with vertical and horizontal transport, and the energy supply directly affect the size of the ship blocks and the level of outfitting that can be applied. For this criterion significant sub-criteria are as follows: Size; Equipment.

Criterion 8 - Shipyard's layout; The application of the outfitting strategy in the earlier stages of production process, also requires the need for larger working surfaces for the disposal of ship blocks, assemblies, sub-assemblies, panels according to the stages of production. In this regard, the largest area should be provided for the disposal of large ship blocks waiting for final assembly prior to painting and assembly on the berth. Also, the equipment workshops should be brought closer to the earlier stage of the process [18]. For this criterion significant sub-criteria are as follows: Size; Equipment; Transport equipment.

Criterion 9 - Vertical and horizontal transport capacities; Vertical and horizontal transport capacities directly affect the technological ship breakdown structure and the level of ship outfitting through production stages. For this criterion significant sub-criteria are as follows: Load capacity; Reach; Overall capacity.

4.2 Hierarchical ranking model based on defined criteria and their sub-criteria

Based on the conducted analysis, defined criteria and their significant sub-criteria, a three-level hierarchical model is established (Figure 2). The established hierarchical model authors are using as a basis for implementing the hierarchical ranking method and basis for creating a computer application for supporting solution. In doing so, each of the identified sub-criteria for the corresponding criterion is ranked according to the criteria at the lower hierarchical level, thus evaluating the impact of the corresponding sub criterion on the criterion at an immediately higher level.

A case study of ranking defined criteria in the three hierarchical levels of criteria and their defined sub criteria will be presented below. In doing so, the criteria will be evaluated at the third hierarchical level, and according to their impact on the level of ship outfitting in the observed shipyard. The example is based on five selected shipyards with similar technological level.

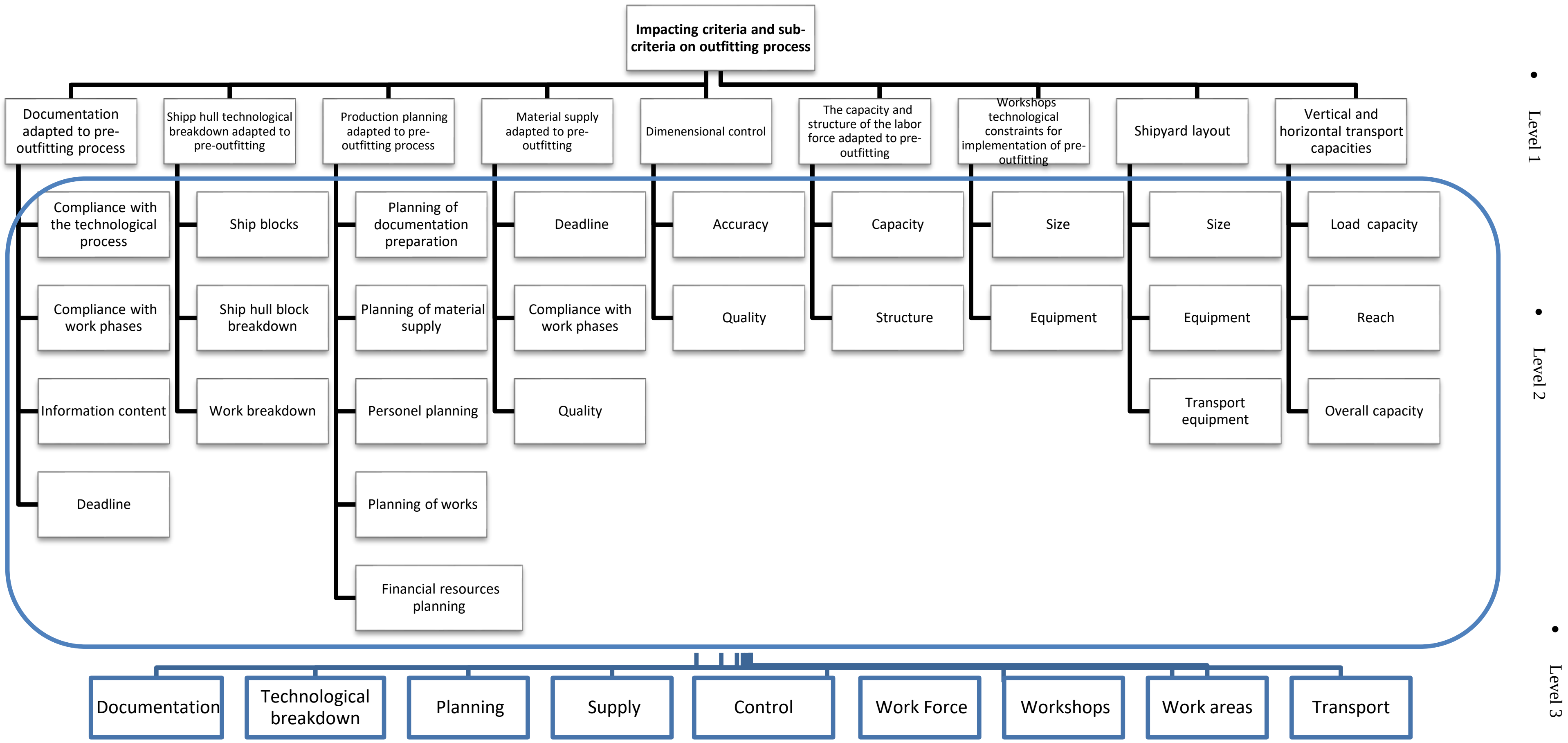

Fig. 2 Schematic representation of hierarchical ranking model at three levels

5. Criteria hierarchical ranking for selected shipyards – case study

As already emphasized, the authors have established a computer-based application based on the hierarchical ranking method supported by expert approach. Using expert approach, the authors evaluated the impact of each of the above criteria from the third hierarchical level on the previous 2-level criteria using the grades from 1 to 10. In this case, the small impact was evaluated by grades from 1 to 5, the average impact represents the grades from 5 to 8 and a large impact represents the grades from 9 to 10. An example of a filled score sheet using such approach for the first criterion is shown in Table 3. In the same way, for other main criteria within the established application such a table was created as following the hierarchical structure from Figure 2.

Table 3 Criteria evaluation for determining ship outfitting level prior to launching

V_k	V_s	V_f	E_1	E_2	E_3	E_4	E_5
CRITERIA	SUB-CRITERIA 2nd LEVEL	SUB-CRITERIA 3rd LEVEL	IMPACT GRADES				
			SHIPYARD 1	SHIPYARD 2	SHIPYARD 3	SHIPYARD 4	SHIPYARD 5
Documentation adapted to pre-outfitting process	Deadlines	Technological breakdown	3	5	3	3	2
		Planning	10	8	5	7	10
		Supply	9	10	8	8	8
		Control	1	3	1	2	2
		Work force	6	8	7	5	6
		Workshops	4	5	4	4	5
		Work areas	3	5	4	2	3
		Transport	2	1	1	3	1
	Information content	Technological breakdown	6	8	8	3	1
		Planning	8	8	7	7	6
		Supply	5	5	7	3	2
		Control	2	1	4	3	1
		Work force	6	7	9	5	2
		Workshops	6	10	9	4	3
		Work areas	3	1	2	3	2
		Transport	3	6	6	4	3
	Compliance with the work phases	Technological breakdown	8	8	7	6	5
		Planning	6	4	5	4	3
		Supply	2	6	5	3	3
		Control	2	2	1	2	1
		Work force	6	6	6	7	5
		Workshops	4	4	5	3	5
		Work areas	4	3	3	4	2
		Transport	2	4	5	3	3
	Compliance with the technological process	Technological breakdown	8	5	10	7	5
		Planning	7	5	5	4	6
		Supply	6	7	7	7	4
		Control	1	1	2	1	2
		Work force	6	6	6	7	8
		Workshops	4	5	6	7	4
		Work areas	4	4	3	2	2
		Transport	2	1	1	2	2

Using the proposed methodology for all nine selected criteria, a comprehensible assessment of the impact of each criterion on the other criteria was calculated and consequently the ranking of their impacts on the pre-outfitting level was calculated, as shown in Table 4.

Table 4 Criteria overall ranking related to impact on outfitting process before launching

CRITERIA	IMPACT STRENGHT	RANKING
Production planning adapted to pre-outfitting process	16%	1
Ship hull technological breakdown adapted to pre-outfitting	14%	2
Workshops technological constraints for implementation of pre-outfitting	13%	3
The capacity and structure of the labour force adapted to pre-outfitting	12%	4
Shipyard's layout	11%	5
Documentation adapted to pre-outfitting	10%	6
Material supply adapted to pre-outfitting process	9%	7
Vertical and horizontal transport capacities	8%	8
Dimensional control	7%	9

From the obtained results, it is possible to determine the level of impact of each observed criterion on the ship's outfitting process before launching. It is evident that on the greatest part of the criteria can be influenced with a successful planning of the entire technological process of ship outfitting, which does not require major financial resources other than the well-established plan and its strict monitoring and execution.

In the second place of defined criteria there is a ship hull technological breakdown and works that directly depends on the level of workshops equipment, work surfaces, structure and capacity of the workforce, which also effects on documentation preparation, process planning and materials supply. In doing so, the level of ship outfitting before launching, regarding using suitable ship hull technological breakdown and works, can be improved in two major directions:

a) Improvement by using existing shipyard resources, which do not require special investment funds, and is achieved by investing in the improvement of the supply process, designing and drafting of documentation, and planning and organization of ship hull construction and outfitting, more tailored to the process of outfitting.

b) Improvement with intervention in existing shipyard resources by investing certain financial resources. Investments are primarily concerned with investment in improving the performance of workshops, worksites of shipyards, and investments in vertical and horizontal transport.

In the third and fourth place of the criteria there are technological possibilities of the workshops and the associated structure of the workforce, [17] whose improvement also significantly increases the level of ship outfitting. For such, a certain level of investment is required to raise the level of equipment and the structure of the workforce.

In the fifth place of criteria ranking, there is the size and capacity of the work areas and shipyard layout in general. The layout and its size directly affects the strategy and the possibility of ship blocks outfitting within those areas.

In the sixth place of criteria ranking, there is documentation tailored to the required outfitting level. The volume and content of documentation is directly dependent on the technological process of outfitting, the features of the workshops, the shipyard layout, work areas and the transportable means. Improving the design of the documentation according to the above can also be seen from two aspects:

a) Improving documentation development that does not depend on investment in the resources of the shipyard, which is achieved by creating documentation in the required planning deadlines, in accordance with the technological process of outfitting and ship hull technological breakdown.

b) Improving documentation in relation to raising the level of technological capabilities of the shipyard, which requires the inclusion of new improved features in the content of the documentation.

At seventh place is the procurement and delivery of the material in line with the technological process and the phases of ship outfitting process, for which the improvement does not require additional financial resources, but disciplined compliance with the defined shipbuilding strategy in the planned framework.

At the eighth place of criteria, there are vertical and horizontal transport options, which directly affect the technological constraints and level of ship outfitting.

At the ninth place of criteria, there is a dimensional control, whose level of accuracy significantly increases the quality of the equipment's installation and outfitting process itself. Furthermore, such high dimensional accuracy of ship blocks, initially driven by the need of outfitting process, should ultimately lead to the elimination of the use of blocks over dimensioning on berth assembly, as well as elimination of very expensive reworks in later phases of ship production process, [15], [16], [19].

Ultimately, the authors suggest that the results of this research, which is the criteria definition and their ranking according to the strength of their impact on the ship outfitting process will enable the shipyard's management important ability to identify the critical elements in the ship outfitting process related to the level of ship outfitting before launching.

For that purpose, authors used expert approach to define major criteria influencing ship outfitting process. Further, such criteria were ranked, with the proposed hierarchical ranking method in three levels, according to their identified effect on ship outfitting level before launching. In that way, the most influential areas for the most effective action, with the aim of improving the ship outfitting level, are identified. In addition, the established computing application will allow practical application for different scenarios and various shipyards of similar technological levels.

Regarding financial requirements for improvements following obtained ranking in Table 4, the author would like to emphasise that majority of criteria’s are in the domain of organisation, work discipline and adequate management. Furthermore, in the author’s opinion such investments should not require significant financial resources and could be primarily manageable from shipyards potential. Others investments which could require significant financial allocation, such as equipment, facilities or shipyard layout modifications, should be critically analysed in cost benefit manner and, in authors opinion, most probably attended following the organisational ones. Although the financial aspects was not the major scope of this research, for such analysis authors propose to be one of the significant tasks of further development of this work. For that matter, within further research authors will work on developing the proposed methodology further in a way to conduct a detailed analysis of the outfitting process of selected ship type, with the aim of defining all the activities, working hours, resources and in particular the costs and financial effects of conducted improvements. Also, an attention will be attended to the decision making process analysis as to define critical points on the particular action implementation path, for improved control of partial results and evaluation of their influence on current shipbuilding process flow which must not be interrupted. A simulation model will also be developed with major purpose to monitor process performances and further optimize the ship outfitting process for selected but also for other ship types.

6. Conclusion

In this paper, the authors analysed the ship outfitting production process for selected shipyards of the same technological level in order to identify and evaluate the criteria according to their interaction and impact on the observed process. Based on the conducted expert analysis, the authors defined the significant criteria and relevant sub-criteria with their attributes related to ship outfitting process before launching. Further, such defined criteria and their sub-criteria, were ranked using the proposed hierarchical ranking method, and that how the critical points in outfitting process have been identified. With such ranking, it is pointed out on which criteria the action would result with most effect regarding outfitting process shifting to earlier production phase's strategy, which will ultimately result in lower shipbuilding costs. Also, the authors identified and highlighted the key prerequisites that must be met towards this goal, and they distinguish two major directions to improve the equipping process, the first one that does not involve significant financial resources and depends primarily on the organization, technology and production process planning, and other direction, which implies intervention in shipbuilding infrastructure, surfaces and equipment that requires large financial resources and should previously consist a thorough study of the feasibility and profitability of such an investment. Also, the authors have established a computer application to support the decision-making process solution, and in such way, this methodology can be applied efficiently to any shipyard of such or similar technological level. At the end of the paper, the authors also propose guidelines for future research that will primarily be reflected in a more detailed analysis of the ship's outfitting process related to the particular ship type. The aim will be to develop a relevant simulation model for tracking the performances of observed process, optimising the costs and improving the overall management capabilities regarding ship outfitting production process

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