TESTING OF THE EVALUATION METHODOLOGY FOR SHIP'S PLANNED MAINTENANCE SYSTEM DATABASE

Ladislav Stazić[1]*, Tatjana Stanivuk[1], Vice Mihanović[2]
[1]University of Split, Faculty of Maritime Studies, Croatia
[2]Port Authority Split, Croatia

Ship's Planned Maintenance Systems are in use for a long period of time, but database quality, configuration and content are still not standardized. Factors affecting the database quality, configuration and content are the quality of raw data, experience and knowledge of database creation team, importance given to computerized PMS and care assigned to evaluation of finished product. Evaluation of finished product, i.e. ship's Planned Maintenance System Database is an action requiring specified knowledge and qualifications, as well as experience in performing the task. Even when evaluators fulfill all needed requirements, credibility of the obtained results is questionable due to their subjectivity. One of the tools to decrease that problem is the Evaluation Methodology for Ship's Planned Maintenance System Database. A research, described in the paper, has been performed to test that aspect of the Methodology. Three Ships Planned Maintenance System Databases were evaluated by four different evaluators, first using only their experience, then using the Methodology. Results of the research are presented in the paper together with comparison of findings. All presented points that usage of the Methodology is a necessity during evaluations of ship's Planned Maintenance System Databases.

Key words: database, planned maintenance, questionnaire, quality evaluation, evaluation methodology, planning

INTRODUCTION

Database creation for ship's Planned Maintenance System (Gašpar et al 2018) is a complex operation which involves several persons and specific knowledge of ship and its systems. During any Planned Maintenance System Database creation process it is necessary to establish DQ procedures (Blakeslee and Rumble 2003), which in the case of Ship's Planned Maintenance System Database is rechecking and analyzing the data. The process serves to discover deficiencies which may appear during data entry (Wang and Strong 1996), (Rabin 2002). ''Deficiencies depend upon database development team, their expertise, knowledge, abilities, etc.'' (Stazić et al 2018). Although it is said that performing DQ analysis tasks manually, in many cases, is infeasible (McKenna 2011), most of the rechecking and analyzing of Ship's Planned Maintenance System Database is performed manually. Considering above, the rechecking and analyzing of the entered data into Ship's Planned Maintenance System Database requires specific knowledge, proper qualifications and experience in performing those tasks, as well as good and verified tool and method (Woodal et al 2014) which has to be adjusted to the specific circumstances (Granke 2013). Final result of the evaluation is questionable even when fulfilling all those requirements, there will always be a certain dose of the subjectivity of the evaluator (researcher) included into the evaluation results (Ratner 2002).

To enable easier Evaluation of ship's Planned Maintenance Databases, a tool has been created. It is named The Evaluation Methodology for Ship's Planned Maintenance System Database (Stazić et al 2017). The tool

has been created with intention to give a strict guideline during the Evaluation of Ship's Planned Maintenance System databases, and by enforcing some rules to decrease the subjectivity (Hû et al 1999) of the evaluator (researcher).

The Methodology has been tested in operation on several databases and the functionality of the Methodology has been established, as well as reliability of obtained results (Stazić et al 2017). Verification of the functioning of the Methodology has been performed and published (Mišuraet al 2019) and obtained results were similar to the results during development of the Methodology.

The decrease of the subjectivity of the evaluator should be a side effect of the usage of the Methodology. A research has been performed by the authors of the paper to establish how much evaluator's subjectivity (Hû et al 1999) affects the evaluation of ship's Planned Maintenance System databases and to establish how much the Evaluation Methodology for Ship's Planned Maintenance System Database (Stazić et al 2017) is helping to decrease that subjectivity and consequently creating evaluation results more credible. The research has been arranged using real Shipping Company Planned Maintenance System databases. Evaluation of databases was performed at the end of 2018 and beginning of 2019 at the Company premises and remotely through computer connection. As the Shipping Company allowed access to their databases and real data strictly under no disclosure condition, all data which can lead to identification of the company or vessels has been withheld.

The research was divided into two separate events or evaluations (Rossi et al 2018). The first evaluation was

performed by evaluators after short briefing and it is based only on experience and knowledge of the evaluators, without any specialized tools or instructions. Therefore, obtained results will be fully influenced by evaluator's opinion and view. Second evaluation was performed immediately after the first one, using the Evaluation Methodology for Ship's Planned Maintenance System Database and its Questionnaire (Table 1). All evaluators were briefed how to use the Questionnaire and what the grades should represent. The expected results of the second evaluation should contain subjectivity of the evaluator shown during the first evaluation, reduced by the Methodology.

Results of both evaluations are presented in the paper, grouped by the evaluation to allow easier insight on difference of the evaluation results. Comparison of results, presented in discussion served to show that the evaluation without strict guide is greately influenced by personal point of view (or interest) and that a firm guideline (The Methodology) decreases that impact, creating evaluation results more reliable.

THE FIRST EVALUATION

The evaluation of ship's databases is performed by four evaluators meeting the criteria for performing the evaluation. Two of the evaluators (in paper are named A and B) are the shipping company Technical Superintendents, involved in everyday maintenance of the ships and using the PMS daily. The third evaluator (named C) is member of a database construction team (the team which constructed one of the analyzed databases) and the fourth (named D) is independent PMS consultant, familiar with (and sometimes employed by) the company and its PMS.

Before the first evaluation, evaluators were briefed about expected outcome of the evaluation, which was:

- To give average grade for the quality of each database (1 to 5, using one decimal place, 5 is the highest grade),
- To discover and describe database deficiencies (as precise as possible),
- To grade the importance of each deficiency (low, medium, high),
- To investigate possible cause for the database deficiencies.

Investigation of the possible or probable cause of the deficiencies is performed only during the first evaluation. That part of the task is added only as a bait to all evaluators to demonstrate the subjectivity by assigning the cause of the deficiency to somebody else.

Database 1 evaluation results

Evaluator A:
- Average grade: 4.0
- Deficiencies and their importance:
1. Jobs required by Classification Society are not in-

cluded (High importance).
2. Alarm testing program is not present (High importance).
3. Critical equipment is not marked (High importance).
4. There is no list of critical spares (High importance).
- Probable cause of the deficiency: The database factory did not request the data.

Evaluator B:
- Average grade: 4.0
- Deficiencies and their importance:
1. Jobs required by Classification Society are not included (High importance).
2. Jobs required by Company SMS are partially included (High importance).
3. Critical equipment is not marked (High importance).
4. There is no list of critical spares (Medium importance).
- Probable cause of the deficiency: The data was not inserted into database.

Evaluator C:
- Average grade: 4.7
- Deficiencies and their importance:
1. Critical equipment is not marked (High importance).
2. There is no list of critical spares (Medium importance).
3. Alarm testing program is not present (High importance).
- Probable cause of the deficiency: Shipowner or his representative did not produce the data, therefore, it was not entered into database.

Evaluator D:
- Average grade: 3.8
- Deficiencies and their importance:
1. Jobs required by Classification Society are not included (High importance).
2. Jobs required by Company SMS are partially included (High importance).
3. Critical equipment is not marked (High importance).
4. There is no list of critical spares (High importance).
5. There is no fire system testing program in DB (High importance).
- Probable cause of the deficiency: Data not delivered by shipowner, and not requested by data factory, insufficient control during the construction and at the delivery.

Database 2 evaluation results

Evaluator A:
- Average grade: 3.8
- Deficiencies and their importance:

1. Jobs required by Classification Society are not included (High importance).
2. Alarm testing program is not present (High importance).
3. Critical equipment is not marked (High importance).
4. There is no list of critical spares (High importance).
5. A number of spares is missing (High importance).
- Probable cause of the deficiency: The database factory did not request the data.

Evaluator B:
- Average grade: 3.5
- Deficiencies and their importance:
1. Jobs required by Classification Society are not included (High importance).
2. Jobs required by Company SMS are partially included (High importance).
3. Critical equipment is not marked (High importance).
4. There is no list of critical spares (Medium importance).
5. A number of spares is missing (High importance).
- Probable cause of the deficiency: Unknown, missing spares cannot be explained!

Evaluator C:
- Average grade: 4.5
- Deficiencies and their importance:
1. Critical equipment is not marked (High importance).
2. There is no list of critical spares (Medium importance).
3. Alarm testing program is not present (High importance).
4. A number of spares is missing (High importance).
- Probable cause of the deficiency: Shipowner or his representative did not produce the data, therefore, it was not entered into database.

Evaluator D:
- Average grade: 3.5
- Deficiencies and their importance:
1. Jobs required by Classification Society are not included (High importance).
2. Jobs required by Company SMS are partially included (High importance).
3. Critical equipment is not marked (High importance).
4. There is no list of critical spares (High importance).
5. There is no fire system testing program in DB (High importance).
6. A number of spares is missing (High importance).
- Probable cause of the deficiency: Data not delivered by shipowner, and not requested by data factory, insufficient control during the construction and at the delivery, lack of interest by personnel using PMS.

Database 3 evaluation results

Evaluator A:
- Average grade: 4.0
- Deficiencies and their importance:
1. Jobs required by Classification Society are not included (High importance).
2. Alarm testing program is not present (High importance).
3. Critical equipment is not marked (High importance).
4. There is no list of critical spares (High importance).
- Probable cause of the deficiency: The database factory did not request the data.

Evaluator B:
- Average grade: 4.0
- Deficiencies and their importance:
1. Jobs required by Classification Society are not included (High importance).
2. Jobs required by Company SMS are partially included (High importance).
3. Critical equipment is not marked (High importance).
4. There is no list of critical spares (Medium importance).
- Probable cause of the deficiency: The data was not inserted into database.

Evaluator C:
- Average grade: 4.7
- Deficiencies and their importance:
1. Critical equipment is not marked (High importance).
2. There is no list of critical spares (Medium importance).
3. Alarm testing program is not present (High importance).
- Probable cause of the deficiency: Shipowner or his representative did not produce the data, therefore, it was not entered into database.

Evaluator D:
- Average grade: 3.8
- Deficiencies and their importance:
1. Jobs required by Classification Society are not included (High importance).
2. Jobs required by Company SMS are partially included (High importance).
3. Critical equipment is not marked (High importance).
4. There is no list of critical spares (High importance).
5. There is no fire system testing program in DB (High importance).
- Probable cause of the deficiency: Data not delivered by shipowner, and not requested by data factory, insufficient control during the construction and at the delivery.

THE SECOND EVALUATION

The second evaluation of the same databases was performed after the first one. This time all evaluators were using the Methodology, going through databases and answering to previously prepared questions (the Questionnaire) about the database. The Questionnaire is main part of the Evaluation Methodology for Ship's Planned Maintenance System Database and it is intended to *''be simple and useful tool for the evaluation of all ships Planned Maintenance System databases''* (Stazić et al 2017).

The Questionnaire

The Questionnaire (Table 1) should be used for the Evaluation of databases. For each question a grade should be given after inspection of the database and rechecking needed details.

Table 1: Computerized PMS database evaluation questionnaire (Stazić et al 2017)

Area	No.	Question	Gr.
Machinery and equipment	01	Is all machinery and equipment included in the database?	
	02	Is all included equipment marked properly and uniquely, according to their shipboard location and markings?	
	03	Is all necessary machinery divided to subcomponents (to smaller subsystems) in logical manner?	
	04	Does machinery or equipment have larger number of subcomponents then necessary?	
	05	Is there equipment or machinery listed in the database more than once, or do they have same markings or names?	
	06	Is the data about the manufacturer, the type and the serial number entered to all relevant items?	
	07	Do all equipment and machinery entries have the same style, abbreviations, and markings?	
Jobs inside DB	08	Do all devices in the DB have linked maintenance plan according to manufacturer's recommendation?	
	09	Are manufacturer's recommendations grouped according to devices, periods and company maintenance rules?	
	10	Are all jobs required by company policy included in the DB? (e.g. SSM – Safety Management System)?	
	11	Are all jobs based on manufacturer's recommendation changed due to the company policy (if exists)?	
	12	Are all jobs required by flag state rules and regulations included in the DB?	
	13	Are all jobs required by class society included in the DB?	
	14	Is there a number of smaller jobs which can be grouped together?	
Special jobs and rules - DB jobs general	15	Is fire detection sensor list inserted into the DB together with the testing plan?	
	16	Is the alarm system and its testing program entered in the DB?	
	17	Is PMS self-improvement program inserted into the DB, and is there control mechanism for PMS DB self-improvement program?	
	18	Is critical equipment marked according to company SMS?	
	19	Are job descriptions written clearly and straightforward?	
	20	Are jobs created and grouped according to multiplier principle?	
	21	Are all the same type jobs, coming from different sources, synchronized?	
	22	Are all the same jobs, resulting from different requirements (sources), merged?	
Spare parts	23	Are all required spare parts included in the database?	
	24	Are spare parts distributed to proper equipment and machinery?	
	25	Are all spare parts properly marked, do they have sufficient data for ordering?	
	26	Is company critical spare parts list inserted in the DB?	
	27	Do all spare parts have the same style, abbreviations, markings, etc.?	
		Are there spare parts entered several times?	
Miscellaneous	29	Are all users inserted in the DB, and are all access rights defined in order?	
	30	Is there any other deficiency noted in computerized PMS database?	

Grades should be given as follows:

Grade 1 – Fully negative evaluation result, very few positive findings,

Grade 2 – Mostly negative evaluation with a minor number of positive findings,

Grade 3 – Mostly positive evaluation with a significant amount of irregularities,

Grade 4 – Mostly positive evaluation with a minor amount of irregularities,

Grade 5 – Fully positive evaluation with a neglectable amount of irregularities

The questions awarded the grade 5 are considered in order and no modifications are needed in the database. The questions with the grade 4 are also considered in order, although there is improvement possibility. For questions with the grades 4 and 5 changes in DB are not recommended. The questions graded 3, 2 or 1 are showing that there are significant deficiencies in that area and changes in the database should be performed. The color of the question represents its importance, colors are based on traffic light principle. Questions colored red have high importance, colored yellow have medium importance and colored green have low importance.

In line with the above, during the second part of the research all questions which received grades 1, 2 and 3 are considered as deficiency in the database.

The second evaluation results

The second evaluation results are presented in Table 2. Results are grouped by the database; each database is divided by thicker line. Average grade for the database is calculated and shown at the bottom of the table.

DISCUSSION

Table 3 presents comparison of grades awarded during the first and the second evaluation (without and with the Questionnaire). Grade(s) awarded to the database is basic indication of the quality of the database, and should be given with intention to be objective.

From the Table 3 following is visible:

- Average grade value for the second evaluation is significantly lower than the first evaluation, applicable to all evaluators.

- Decrease of average grade between evaluations is highest for the database constructor, his first evaluations were high above all other evaluators.

- Average grade value is affected by the occupation of the evaluator, database constructor evaluated databases higher than both superintendents while independent PMS consultant gave the lowest grades.

- Average grade value difference between evaluators is halved at the second evaluation, showing that strict guidelines that the Methodology imposed are decreasing subjectivity of evaluators, but not suppressing it completely.

Detected deficiencies in databases during the first evaluation are presented in chapters 2.1, 2.2 and 2.3. Overall number of those deficiencies is just a part of deficiencies detected using the Methodology. Table 4 presents comparison of number of deficiency detections without and with the Questionnaire.

Although all four evaluators are very experienced and qualified, number of detected deficiencies without the Methodology was confined to areas where they are most familiar. High increase of number of detected deficiencies during the second evaluation (using the Methodology) indicates that usage of the Methodology greatly promotes detection of deficiencies and consequently helps to increase the quality of the database.

Differences of the number of detected deficiencies during the second evaluation, mostly noted at database 2, are attributed to subjectivity of evaluators. More than half of those differences is derived by small difference of opinions, which are visible in Table 2.

CONCLUSION

The Evaluation Methodology for Ship's Planned Maintenance System Database has been created with intention to serve as a tool to enable users to examine data in the database to discover deficiencies and to allow improvement of the database and consequently, the maintenance. This research showed that database evaluation is a process highly affected by the subjectivity of evaluators. The difference of the first evaluation was one or close to one grade (in percentage 20%), depending of the database. Best grades were awarded by database constructor, person who participated in construction of the database, and lowest grades are given by person who was not involved in database construction process (independent PMS consultant). Investigation of causes of deficiencies showed the subjectivity in full extent. Superintendent A points to database construction team as a cause for the deficiencies, while database constructor is pointing towards the Shipping Company. Superintendent B did not give exact answers, while PMS consultant (Evaluator D) pointed to both sides and highlighted that control (again subjectivity, this should be his role in the process of database construction) was missing. Subjectivity of evaluators was still present in the second evaluation although the use of the Methodology halved the difference of the grades, i.e. decreased the subjectivity by almost 50%.

List of discovered deficiencies during the second evaluation was much larger, indicating that use of the Methodology propagates easier discovery of database deficiencies, and creates initial condition for the improvement of the database and consequently, the maintenance.

Considering all listed, the Evaluation Methodology for Ship's Planned Maintenance System Database proved to be a tool which decreases subjectivity of the evaluator and makes evaluation of databases easier and much more detailed. Detection of deficiencies is much better,

Table 2: Results of the second evaluation

No.	A1	B1	C1	D1	A2	B2	C2	D2	A3	B3	C3	D3
01	4	4	5	4	4	4	4	4	4	4	5	4
02	5	5	5	4	4	5	5	3	5	5	5	4
03	5	5	5	5	5	5	5	5	5	5	5	5
04	5	4	5	4	5	4	5	4	3	3	3	2
05	5	5	5	5	5	5	5	5	5	5	5	5
06	5	5	5	4	4	4	4	4	5	4	5	4
07	5	5	5	5	5	5	5	5	5	5	5	5
08	5	5	5	4	4	3	4	3	5	5	5	4
09	5	4	5	4	4	4	4	3	4	4	5	4
10	3	3	4	2	2	2	2	2	3	3	4	2
11	3	2	3	2	3	2	2	2	3	2	3	2
12	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1
14	2	2	3	2	2	2	2	2	2	2	3	2
15	2	2	3	2	2	2	2	2	2	2	3	2
16	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1
19	5	5	5	5	5	5	5	4	5	5	5	4
20	5	5	5	4	3	3	4	3	4	4	4	3
21	5	5	5	4	4	4	4	3	5	5	5	4
22	5	5	5	5	5	5	5	5	5	5	5	5
23	5	5	5	5	2	2	2	2	5	5	5	4
24	5	5	5	5	2	2	2	2	5	5	5	4
25	5	5	5	5	2	2	2	2	5	5	5	4
26	1	1	1	1	1	1	1	1	1	1	1	1
27	5	5	5	5	5	5	5	5	5	5	5	5
28	5	5	5	5	5	5	5	5	5	5	5	5
29	5	5	5	5	5	5	5	5	5	5	5	5
30	5	5	5	5	2	2	3	3	5	5	5	5
Av.	3.83	3.73	3.97	3.53	3.17	3.10	3.23	2.97	3.70	3.63	3,87	3.30

Table 3: Comparison of grades of both evaluations

	Database 1				Database 2				Database 3			
Evaluator	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
The First evaluation	4.0	4.0	4.7	3.8	3.8	3.5	4.5	3.5	4.0	4.0	4.7	3.8
The Second evaluation	3.83	3.73	3.97	3.53	3.17	3.10	3.23	2.97	3.70	3.63	3,87	3.30

Table 4: Comparison of number of detected deficiencies

	Database 1				Database 2				Database 3			
Evaluator	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
First evaluation	4	4	3	5	5	5	4	6	4	4	3	5
Second evaluation	10	10	9	10	14	16	15	19	11	10	10	12

that can boost improvments of databases and the maintenance.

Remaining subjectivity which is still present during the use of the Methodology can be further decreased either with firmer andstricter rules of use of the Methodology or with the use of several evaluators, which will increase the cost of the Evaluation.

REFERENCES

1. Blakeslee, D.M.; Rumble, Jr. J. 2003. The essentials of a database quality process. Data Science Journal, Vol 12, pp.35-46.

2. Gašpar, G.; Poljak, I.; Orović, J. 2018. Computerized Planned Maintenance System Software Models, Pomorstvo: Scientific Journal of Maritime Research 32: 141-145.

3. Granke, O. 2013. Methods for Database Quality Assessment, Forest Monitoring, Developments in Environmental Science Book 12, Chapter 23. Elsevier, Dordrecht, pp 455-467, 10.1016/B978-0-08-098222-9.00023-6.

4. Hû, O., Trigano, P., & Crozat, S. (1999). Considerating Subjectivity in Softwares Evaluation. In J. Vanderdonckt & A. Puerta (Eds.), Computer-Aided Design of User Interfaces II. (pp. 331-336). Dordrecht: Springer Science and Business Media LLC. doi:10.1007/978-94-011-4295-3_29.

5. Mišura, A.; Stazić, L.; Stanivuk, T.; Komar, I. 2019. Verification of the Evaluation Methodology for Ship's Planned Maintenance System Database, Book of Proceedings, 8th International Maritime Science Conference / Ivošević, Špiro; Vidan, Pero - Kotor: CIP - Nacionalna biblioteka Crne Gore, 2019, 441-445.

6. McKenna, B. 2011. Data Quality Improvement Impeded by Lack of Automation, Computer-Weekly.com:https://www.computerweekly.com/news/2240039405/Data-quality-improvement-impeded-by-lack-of-automation (accessed 21.08.2019).

7. Rabin, M. 2002. Inference by believers in the law of small numbers. Quarterly Journal of Economics 117: 775–816.

8. Ratner, C. 2002. Subjectivity and Objectivity in Qualitative Methodology, Forum: Qualitative Social Research, 3(3), Art. 16, http://nbn-resolving.de/urn:nbn:de:0114-fqs0203160

9. Rossi, P.H., Lipsey, M.W., & Henry, G.T. (2018). Evaluation: A Systematic Approach. USA: SAGE Publications Inc.

10. Stazić, L.; Komar, I.; Mihanović, L.; Mišura, A. 2018. Shipowner's Impact on Planned Maintenance System Database Quality Grades Resemblance Equalization, Transactions on Maritime Science, 07(01), 5 - 22. https://doi.org/10.7225/toms.v07.n01.001.

11. Stazić, L.; Komar, I.; Račić, N. 2017. Evaluation Methodology for Ship's Planned Maintenance System Database, Transactions on Maritime Science, 06(02): 109 – 116, https://doi.org/10.7225/toms.v06.n02.002.

12. Woodal, P.; Oberhofer, M.; Borek, A. 2014. A Classification of Data Quality Assessment and Improvement Methods, International Journal of Management Information Systems, 12(4): 5-33

13. Wang, R. Y.; Strong, D. M. 1996. Beyond Accuracy: What Data Quality Means to Data Consumers, Journal of Management Information Systems, 12(4): 5–33.