Supporting the selection of value-driven performance measures in maintenance services – Comprehensive value assessment

Abstract: Maintenance measures, such as Key Performance Indicators should align with the strategic objectives. However, this is often not the case, as mainly the cost dimension of services is measured. The field of maintenance has evolved due to maintenance outsourcing and the rising interest of equipment providers to join the service business. There is a need for methods that improve communication between maintenance service customers and service providers to ensure that other value dimensions are recognized and measured. This paper proposes a preliminary framework for integrating comprehensive value assessment into strategic decision-making in maintenance service relationships. The empirical findings based on an online-survey emphasize the fact that several elements contribute to the value of maintenance services, but these elements are in many cases not measured. Based on the ranking of customers, a number of elements such as environmental safety, safety at work, operator knowledge, reliability, and reputation of the service provider should be included in the value assessments.

Key words: value creation, value elements, maintenance, maintenance services, value assessment, relationships, services, value, performance measurement, maintenance measures

1 Introduction

The field of maintenance has progressed together with the structural change of manufacturing and the expansion of the service sector. Due to maintenance outsourcing, and the rising interest of equipment providers to join the service business, the service aspect is now common also in maintenance (e.g. Al-Turki, 2011; Kindström and Kowalkowski, 2009). For example in the United Kingdom (UK) alone, manufacturers offering value from services increased by over 10 % during 2007-2011 (Foresight, 2013). Also for maintenance service customers, using external support of the original equipment manufacturers (OEM) and third party suppliers is currently popular (Bosch Rexroth, 2015). In addition, maintenance management has had a paradigm shift from being solely a cost factor to a service that can create additional value to companies (e.g. Liyanage and Kumar, 2003; Parida and Kumar, 2006). Value thinking has emerged, and maintenance is treated more and more as a strategic issue instead of just a technical one (Pintelon and Parodi-Herz, 2008). As Rosqvist et al. (2009) suggest, also maintenance objectives and measures should drive from the company's strategic objectives. Toossi et al. (2013) add that the full range of value elements need to be considered to identify the created

maintenance service value for an organization. However, this is too often not the case, as the measurement focuses mainly on the cost dimension of services instead of comprehensive value assessment aligned with the strategy.

The value of maintenance services comprises a wide range of different elements such as quality, reliability and pro-activeness; it is often case-specific and different for different companies (Toossi et al., 2013). This can make the identification of value creating elements quite complex, and therefore the cost is still in many cases the primary element emphasized and measured. However, to capture comprehensive service value, also other value elements, such as finance and non-finance, should be considered in strategic decision making (Liyanage and Kumar, 2003; Ojanen et al., 2012; Toossi et al., 2013). So far the strategic aspects have received less attention, as maintenance-related research has focused primarily on technical issues and improving the implementation aspect of the process with for example better planning, scheduling and controlling, which can result in "doing the wrong things right" as the solutions are not aligned with the strategy (Marquez, 2007; Pintelon and Parodi-Herz, 2008). Even though the subject area is rather unexplored, there is an increasing interest in the literature towards the strategic aspects of maintenance, and further research in the area is needed (Kans and Ingwald, 2016).

This paper aims to improve strategic decision-making in maintenance by supporting the selection of value-driven performance measures. The study examines what is valued by maintenance service customers and how maintenance service value is currently measured. The data for the study has been collected by using a detailed questionnaire distributed, via an online-survey, to a large number of maintenance service customers in the UK. The empirical findings emphasize that several elements (e.g. environmental safety, safety at work, operator knowledge, reliability and reputation of the service provider) contribute to the value of maintenance services, as the majority of the respondents highlighted three or more elements of a total of sixteen as important. However, these elements are in many cases not measured. To address this problem, this paper proposes a preliminary framework for integrating comprehensive value assessment into strategic decision-making in maintenance service relationships. The framework supports the selection of value-driven performance measures in order to ensure that the strategic objectives and performance measures are better aligned.

The paper is structured as follows. Section 2 outlines the theory surrounding maintenance value assessment and strategy. Section 3 provides a detailed description of the research methodology and data collection. Section 4 presents the results, and in section 5 conclusions and future research objectives are addressed.

2 Background

Maintenance is no longer seen as a cost-creating "necessary evil" but rather a service that "can be planned and controlled" (Liyanage and Kumar, 2003; Parida and Kumar, 2006). Through

improved understanding, maintenance has become an important support function that is valued in organizations. Maintenance is seen as a strategic issue instead of a purely technical one (Pintelon and Parodi-Herz, 2008). As Rosqvist et al. (2009) suggest, maintenance objectives and measures should derive from the company´s strategic objectives. However, even though the maintenance function is valued more, for many companies the optimization of maintenance still focuses on the minimizing of operational costs instead of maximizing the value by analysing what is important for the stakeholders (Marais and Saleh, 2008; Murthy et al., 2015). Focusing only on the cost-centric view can lead to sub-optimal maintenance strategies as the important dimension, value, is forgotten (Marais and Saleh, 2008). Pure cost-centric views can in addition lead to short-sighted decisions that will eventually add to the total cost. For example, the offshore oil production platform P-36 was heavily damaged by an explosion and completely submerged due to over-ambitious cost saving efforts (Liyanage and Kumar, 2003). Both sides should be assessed and measured when determining a maintenance strategy: assessment of the value creating elements and assessment of the costs (Marais and Saleh, 2008). This will allow for a more comprehensive view and elaborate the value-added processes (Liyanage and Kumar, 2003; Parida and Kumar, 2006). Moving from the cost-centric view towards more value-centric views also brings the focus on the long-term development aspects and benefits of appropriate maintenance (e.g. quality of work, availability, safety incidents) so that value creation can be optimized. Supporting the long-term development and profitability of the organization is one of the key functions of maintenance (Al-Sultan and Duffuaa, 1995; Parida and Kumar, 2006).

The value of maintenance services comprises a wide range of different elements, and it is often case-specific and different for different companies (Toossi et al., 2013). Value is also created in interaction between the customer and the service provider rather than unilaterally by one party, as service value is related to the solutions created at different relationship facets (Ballantyne and Varey, 2006; La Rocca and Snehota, 2014; Tuli et al., 2007). Value depends also on the perceptions of the customers and service providers, and although the companies may work together or as a part of a network, value is partly subjective, and the different parties have often very varying perceptions of the created value, accompanied by their own motivation and strategies (For and McDowell, 1999; Gummerus, 2013). Communication is necessary to unify the aims of the relationship. Well-functioning communication also helps in addressing possible problems and development targets quickly. The customer and the service provider need to understand what elements create and what destruct value for each party (Lapierre, 2000).

The diversity of service value can make the identification of the value creating elements complex and the measurement at the very least challenging, and therefore cost is still in many cases the primary element emphasized and measured. However, to capture the service value with regard to finance (e.g. price, cost) and non-finance (e.g. trained labour, cooperation ability, reputation), a more comprehensive list of value elements should be considered in strategic decision making (Liyanage and Kumar, 2003; Ojanen et al., 2012; Toossi et al., 2013). Especially in strategically important maintenance services organizations should not focus

solely on the financial elements, as this often results in transaction-based and short-term relationships. In transaction-based relationships an important element of value creation, relationship learning, is missing, and this can affect the possible returns from such services. Relationship learning (i.e. knowledge sharing, joint sense-making and knowledge integration) is enabled by long-term relationships and active feedback. It would be beneficial in many cases to change the financial and short-term view to a more comprehensive one with multiple decision elements developing in the long term (Kohtamäki and Partanen, 2016). To be able to examine and understand comprehensive value, value needs to be made more stable so that the different parties (e.g. the maintenance service customer, the maintenance service provider and/or the equipment provider) can communicate about the created service value. Representations where the value creating elements are identified help to create shared meanings and communicate the value faster between parties (Corsaro, 2014).

In interviews conducted by Toossi et al. (2013) and a survey conducted by Ali-Marttila et al. (2015), the complex nature of maintenance service value was supported, as multiple elements were considered as important by the customers and service providers. The entire scope is important when assessing the value, as Toossi et al. (2013, p. 355) emphasize "The diverse range of value dimensions shows the necessity of taking into account more comprehensive value-adding dimensions in order to meet customers' needs". Toossi et al. list 18 tangible values and 11 intangible values identified by the customers as important, grouped into "the need for specialist knowledge and control", "financial imperatives", understanding quality", "accessibility and responsiveness" and "the importance of intangible value". Soft values emerge especially through the interactional service setting, as also relationship-related aspects (e.g. administrative routines and communication) and other intangible elements affect the customer's perception of the service significantly (La Rocca and Snehota, 2014; Lindgreen and Wynstra, 2005; Toossi et al., 2013; Vargo and Lusch, 2008). The intangible and soft aspects form an important part of the service value, but they may be complex and difficult to measure through performance indicators. In the study conducted by Ali-Marttila et al. (2015), the parties described a number of important value elements, including the reliability of the relationship, safety at work, environmental safety, and operator knowledge. In addition, technical quality and price factors were seen as of high importance. The survey highlighted differences between the service customers' and service providers' preferred elements, and also case-specific factors, as the customers highlighted slightly different value elements with high and low critical items. This emphasizes the role of well-functioning communication so that shared meanings between the different parties can be created. For example, Smith et al. (2012) emphasize that value should always be considered from both sides, the derived value to the customers from the company, and also how much value can be derived by a company from its customers.

However, to select the correct or necessary measures can be challenging, as there are versatile measurement listings. The European Standard on Maintenance Key Performance Indicators (EN 15341) lists 75 different indicators including 24 financial measures, 21 technical measures and 26 organization-related measures (CEN, 2007). In addition, the standards can be

challenging to implement in an organization without previous experience in data collection and analysis (Stenström et al., 2013). To make this challenge easier, Stenström et al. (ibid.) have selected the most appropriate measures of standard EN 15341 based on four value drivers, namely economic, technical, organizational, and HSE (health, safety and environment) factors. However, the selected measures are cost-oriented as they are used to measure only the monetary value of maintenance by calculating discounted cash flows. Kumar and Parida (2005) acknowledge the complexity of maintenance performance measurement when defining indicators for monitoring and control. They present a multi-criteria maintenance measurement model (26 different indicators) with the focus on equipment, cost, maintenance task, learning and growth, customer satisfaction, health, safety and environment, and employee -related performance indicators. When selecting appropriate measures the role of the indicators should be forward-looking, and they should also provide feedback so that understanding and motivation can be encouraged (Marquez, 2007; Meekings 1995). In addition, it is important that there are not too many indicators and that the selected ones focus on organizational learning and structural change instead of meaningless target-setting (Marquez, 2007). A successful measurement framework is understood at all levels so that everyone can participate actively in the continuous improvement process.

The alignment of strategic objectives and measures is also important so that the right things supporting the continuous improvement process are assessed and developed. Marquez (2007) states that maintenance management should start with the definition of maintenance objectives and strategy. However, maintenance strategy and performance measures are too often misaligned with the company's overall business strategy (Gelders et al., 1994; Marquez, 2007). The focus is often on the implementation of the management processes (e.g. scheduling) instead of reaching a suitable maintenance strategy. This can result in too much focus on the wrong things (Marquez, 2007).

To avoid a biased focus, Marquez (2007) suggests the use of the Balanced Scorecard (BSC) introduced by Kaplan and Norton (1992). The Balanced Scorecard places the overall vision at the centre and provides a holistic framework when creating performance management systems. When using the Balanced Scorecard approach in maintenance management, Marquez (2007) lists the following steps to support decision-making:

1. Create a strategy for maintenance operation (e.g. development, outsourcing).
2. Translate the maintenance strategy into long-term objectives. Include relevant Key Performance Indicators (KPIs) and establish performance targets. Measures are designed towards the overall vision with financial, customer, internal processes and learning & growing perspectives.
3. Develop an action plan.
4. Review the performance and strategy periodically. Based on the review, new strategic objectives can be formulated, action plans modified and the scorecard revised.

An example of a Balanced Scorecard for maintenance can be seen in figure 1.

Mission & Strategy

Strategic Objectives	Measures (KPIs)	Targets	Action Plans	Perspective
Improve maintenance cost effectiveness	- Maintenance cost (%) per unit produced	- Current: 10% - Target: 7%	- Ensure proper data acquisition - Criticality analysis - PM compliance	**Financial**
Improve equipment availability	- MTBF - MTTR	- ↑ 20% MTBF - ↓ 10% MTTR	- RCM Program - Improve maintenance materials management	**Customer**
Improvement of maintenance process & documentation	- ISO 9001 compliance	Maintenance certification before 31.12.2007	- Develop all remaining procedures and technical specifications	**Internal Processes**
Ensure suitable training levels to fulfil the mission	- Training level per each maintenance level	Definition of the precise maintenance training level per maintenance level	- Definition of the training level per maintenance level - Training level assessment	**Learning & Growing**

Figure 1. An example of the Balanced Scorecard for maintenance (Marquez, 2007, p. 103)

Another approach to support the alignment of strategic objectives and maintenance measures is suggested by Rosqvist et al. (2009) with the value-driven maintenance planning approach (VDMP). To define the fundamental objective of a company, a value-tree approach is used. Based on the selected objectives, the key performance indicators and maintenance performance indicators can be selected. An example of a created value-tree is presented in figure 2.

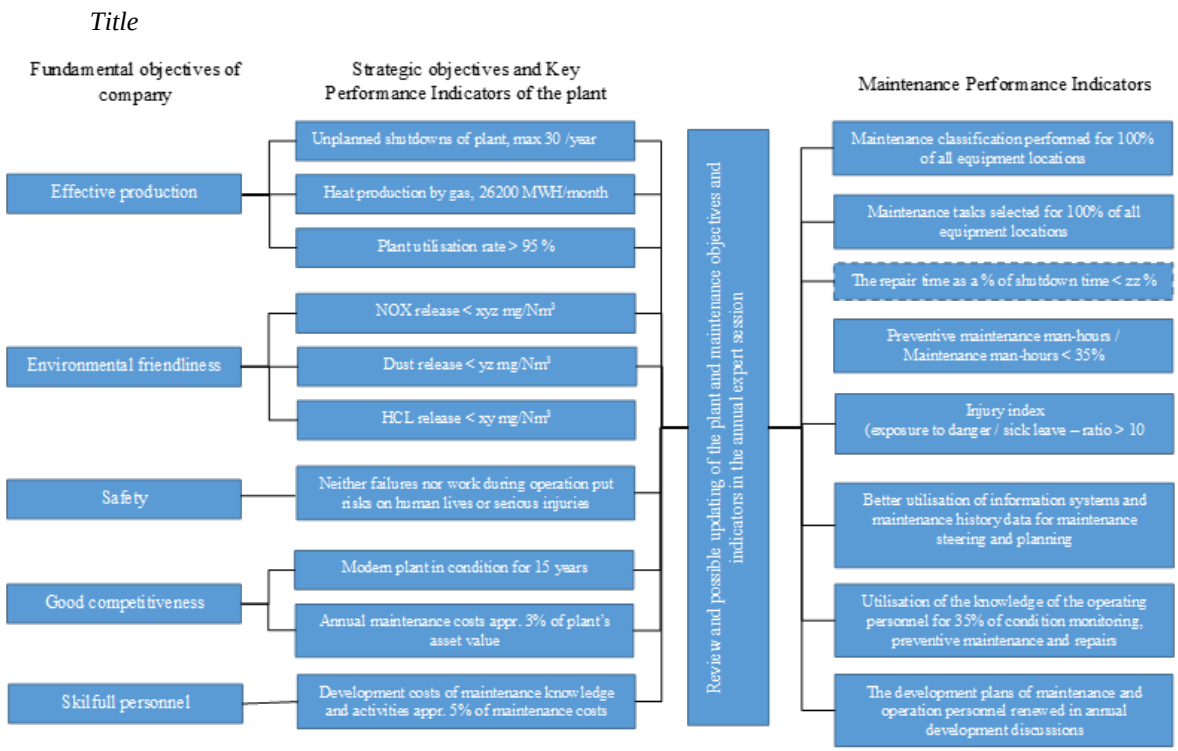

Figure 2. An example value-tree developed for a gasification plant in Finland (Rosqvist et al., 2009, p. 108)

Both frameworks presented above (BSC in the maintenance context and VDMP) are based on single case study examples. A recent literature review by Kans and Ingwald (2016) shows that there is an increasing interest for the strategic perspective around operations and maintenance services, but the area is still quite unexplored and generic models are rare. Further research is needed for a holistic view on the value creation process, relevant setup and metrics for performance-based business models, the bundling of products and services, and Information and Communications Technology (ICT) as an enabler for business model development. Overall, it is important that companies are able to adopt a holistic perspective regarding the service value to see why the service is used and what benefits it can offer.

3 Research methodology

3.1 Sample

The data for the study was collected with an online-survey from companies operating in the manufacturing field in the Northeast of England. The United Kingdom (UK) is a good testing ground as the manufacturing sector is one of the main drivers for the UK economy (Cholasuke et al., 2004). However, in recent years the relative share of manufacturing has declined compared to other developed economies (Foresight, 2013). Nevertheless, the manufacturing sector still contributes significantly to the UK GDP (£ 139 billion in 2012) and it has been

increasing over the long term (Foresight, 2013). Good maintenance practice is fundamental for success in manufacturing. The focus on maintenance management has increased in the past years, and it should become more productive and efficient to cope with the changing business environments (Cholasuke et al., 2004). The role of proactive maintenance has been increasing as a common maintenance strategy; but still 71% of maintenance activities are classed as reactive or planned, and so there is room for more productive maintenance (The Engineer, 2015). Descriptive statistics of the sample in this study is presented in table 1.

Table 1. Descriptive statistics of the sample

	Number (N=31)	*Percentage*
Number of employees		
under 10	10	32%
10-49	6	19%
50-249	10	32%
over 250	5	16%
Approximate turnover (£)		
under 1 million	7	23%
1-20 million	9	29%
21-100 million	14	45%
over 100 million	1	3%
Position of the respondent		
senior management	14	45%
middle management	14	45%
other	3	10%
Maintenance service performance		
no external maintenance service providers	5	16%
one external maintenance service provider	15	48%
many external maintenance service providers	11	35%

The primary source for contacts was the North East Maintenance Forum (http://www.northeastmaintenanceforum.org.uk/), which has a diverse network of companies operating in the manufacturing field. The survey was conducted between September-December 2015. 31 completed survey questionnaires were received from companies that considered themselves as maintenance service customers (or possible customers in the future). The

respondent companies operated in a range of different sectors (including e.g. engineering, process manufacturing, food and drink, and construction).

3.2 Survey instrument

The aim of the survey instrument was to study what is valued by maintenance service customers and how maintenance service value is measured. Therefore versatile value propositions (VP) were presented in the first part of the survey (shown in Appendix 1). The selected 32 value propositions were based on the research of Ali-Marttila et al. (2015), where the value elements and propositions were presented for the first time in a survey environment (minor improvements were made to the wording of the original propositions). The customers were asked to indicate their opinion on a five-point Likert scale with end points of 'strongly disagree' (1) to 'strongly agree' (5). The unit of analysis was a respondent's individual perception of what is valuable in maintenance services at the organizational level, as the respondents were not required to provide absolute values. The second part of the survey asked measurement and performance -related questions. The respondents were encouraged to answer from their own viewpoint, and also anonymous answering was allowed. When allowing anonymous responses, the respondents are less likely to edit their responses according to social desirability (Podsakoff et al., 2003). The questions were also pre-tested and revised by a group of researchers and maintenance experts to reduce the possibility of common method bias.

3.3 Data analysis

A value element consisted of two selected value propositions (see Appendix A for complete value element listing). The reliability of the value elements was tested by measuring the internal consistency with Cronbach's alpha. As can be seen in table 2, the values were mainly above the recommended 0.700 or close to it. This indicated that reliability could be considered sufficient and the sum variables could be used for further analysis (Cortina, 1993). The data was not normally distributed, and therefore non-parametric tests were used for further statistical analysis.

4 Results and discussion

4.1 What is valued in maintenance services

The majority of the respondents (83%) had at least one external maintenance service provider, and this supports the idea that the service aspect is nowadays common in maintenance. The most valued proposition by the UK maintenance service customers was VP6 "maintenance is performed according to environmental safety policies" (mean 4.26, on a scale from 1-5, see Appendix A). Also the safety propositions VP5 "the maintenance service performer recognizes the environmental safety hazards (mean 4.16), VP4 "maintenance is performed according to safety policies" (mean 4.10) and VP3 "the operational conditions and safety increase along the

service" (mean 3.58) were rated high. It seems that safety awareness is still rated high in organizations. Other highlighted propositions were VP12 "maintenance service cooperation is based on confidentiality" (mean 3.90), and VP14 "the maintenance service operators are professionally skilled and qualified" (mean 3.83). Overall, the highest ranked value elements (see Appendix A for the complete value element listing) by the UK maintenance service customers were environmental safety, safety at work, operator knowledge, reputation of the service provider, flexibility, and reliability of the relationship (table 2), which all had means above 3.50. When compared to Finnish customers' value element listing (also based on mean values, see Ali-Marttila et al., 2015 for detailed results), similar elements were highlighted, as safety, reliability and operator knowledge were likewise ranked on the top.

Interestingly, the UK maintenance service customers valued technical quality quite low (mean 3.28). Also price factors and orderliness were valued lower than by the Finnish customers (see Ali-Marttila et al., 2015). In the open-ended responses, 24h service, low cost and availability were emphasized. It seems that in the UK the maintenance approach is still quite reactive and focused on corrective maintenance strategies, and therefore elements with emphasis on orderliness and cooperation may not be considered important.

Table 2. UK maintenance service customers' value elements

Value element	Mean	Standard Deviation	Cronbach's alpha	Z score/sig. level when comparing the differences between small and large companies
Environmental safety (inc. VP5, VP6)	4.21	1.00	.961	-.725/ .468
Safety at work (inc. VP2, VP3)	3.84	1.02	.874	-1.066/ .286
Operator knowledge (inc. VP13, VP14)	3.73	0.94	.776	-.884/ .377
Reputation of the service provider (inc. VP17, VP18)	3.66	1.09	.899	-.933/ .351
Flexibility (inc. VP9, VP10)	3.55	1.05	.775	-.881/ .378
Reliability of the relationship (inc. VP11, VP12)	3.53	1.10	.633	-1.757/ .079
Relationship (inc. VP19, VP20)	3.37	1.13	.919	-.021/ .983
Technical quality (inc. VP7, VP8)	3.28	1.10	.871	-2.019/ .043*
Availability (inc. VP1, VP2)	3.22	1.10	.781	-1.026/ .305
Contracts (inc. VP21, VP22)	2.98	1.16	.774	-.063/ .950
Price factors (inc. VP27, VP28)	2.92	1.18	.661	-.274/ .784
Orderliness (inc. VP15, VP16)	2.86	1.15	.713	-.394/ .694
Total solutions (inc. VP23, VP24)	2.79	1.34	.624	-.468/ .640
R&D (inc. VP25, VP26)	2.33	1.45	.894	-1.736/ .083
Access to markets (inc. VP29, VP30)	2.00	1.48	.969	-.905/ .366
Asset mgmt. factors (inc. VP31, VP32)	1.92	1.27	.812	-1.719/ .086

2-tailed test *p < 0.05, ** p < 0.01, *** p < 0.001

When considering the comprehensive nature of maintenance service value, this was also supported by the UK maintenance service customers, as more than half of the respondents

evaluated propositions of three or more elements as important instead of highlighting a single element. The value of maintenance service cannot be compressed into one element, multiple factors need to be considered instead. This was also supported by the strong correlations between the highly ranked elements (Appendix B).

The size of the company did not seem to have significant influence on the element ranking, as technical quality was the only element where statistically significant ($p < 0.05$) differences were found between small and medium sized and large companies. The small sized customers considered it more important that the service outcome was as expected and sustained for the promised time, compared to their larger counterparts.

4.2 Measuring maintenance service value

In addition to the value elements, the respondents were asked about their views on maintenance, performance and measuring. The customers agreed that "maintenance can create value, not only cost" (mean 3.80) and interestingly, the claim correlated significantly ($p < 0.01$) with good financial performance of the company (table 3). However, only three of the respondents said that they identified the value of maintenance services systematically. The majority disagreed and claimed that they did not measure the value of maintenance services, as one respondent specified "we should but don't". In addition, it was asked if the units had measures/ KPIs to evaluate maintenance services. Again the majority disagreed, as the mean value was only 2.0 for the surveyed claim, and also here some respondents specified that "no but it should". Measurement information was used slightly more for the companies' own operations (2.12) than for the evaluation of partners (1.97). However, in both parts the mean values were low, as the scale was from 1-5. The respondents who claimed to be measuring value listed cost vs. downtime, costs vs. work done and rework, cost of downtime, planned against unplanned, cost to repair, and downtime against planned as measures used. When the companies had measures they were also used to developing their own operations and evaluating partners, as these correlated significantly ($p < 0.01$).

Table 3. Results regarding maintenance measurement

Claim	Mean	S.D	1	2	3	4	5	6	7
1 Maintenance can create value[1]	3.81	1.28							
2 Maintenance service value is identified[1]	2.03	1.45	.123						
3 My unit has measures to evaluate maintenance services[1]	2.00	1.19	.105	.498**					
4 Measurement information is used to develop our own operations[1]	2.13	1.41	.175	.339	.831**				
5 Measurement information is used to evaluate partners[1]	1.97	1.47	.264	.514**	.765**	.807**			
6 Financial performance (recent 5 years)[1]	3.00	0.73	.470**	.152	.005	.132	.051		
7 Operative performance (recent 5 years)[1]	3.26	0.68	.394*	.024	.055	.064	.014	.806**	

Notes: **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
[1] in claims 1-5 the scale has been from 1-5 and in claims 5-6 from 1-4
S.D = Standard deviation

The survey responses revealed the complexity of measuring maintenance service value and the fact that customers need support in the measurement process. In addition, the listed measures focused more on the technical and cost aspect. As also other elements were ranked high (see table 2), the measurement of other aspects (e.g. safety, knowledge and reputation) needs to be supported so that the comprehensive value of maintenance service can be captured.

4.3 Supporting the selection of value-based measures

According to the survey results, the maintenance service customers value elements like environmental safety, safety at work, operator knowledge, reputation, flexibility, and reliability of the relationship. However, on the basis of the results these are not the elements that are measured. Therefore, this paper suggests a simplified framework (figure 3) to support strategic decision-making and alignment of objectives and performance measures in general. In addition to cost and downtime, other measures should be included so that value is assessed more comprehensively. A preliminary framework is presented in figure 3. It uses the best elements of the frameworks of Rosqvist et al. (2009) and Marquez (2007), and in addition brings the selection of value elements as a new step to the decision-making process. The definitions of the value elements support the incorporation of non-financial measures on the scoreboard. Using value elements in the framework enhances and supports mutual understanding between the service partners.

Title

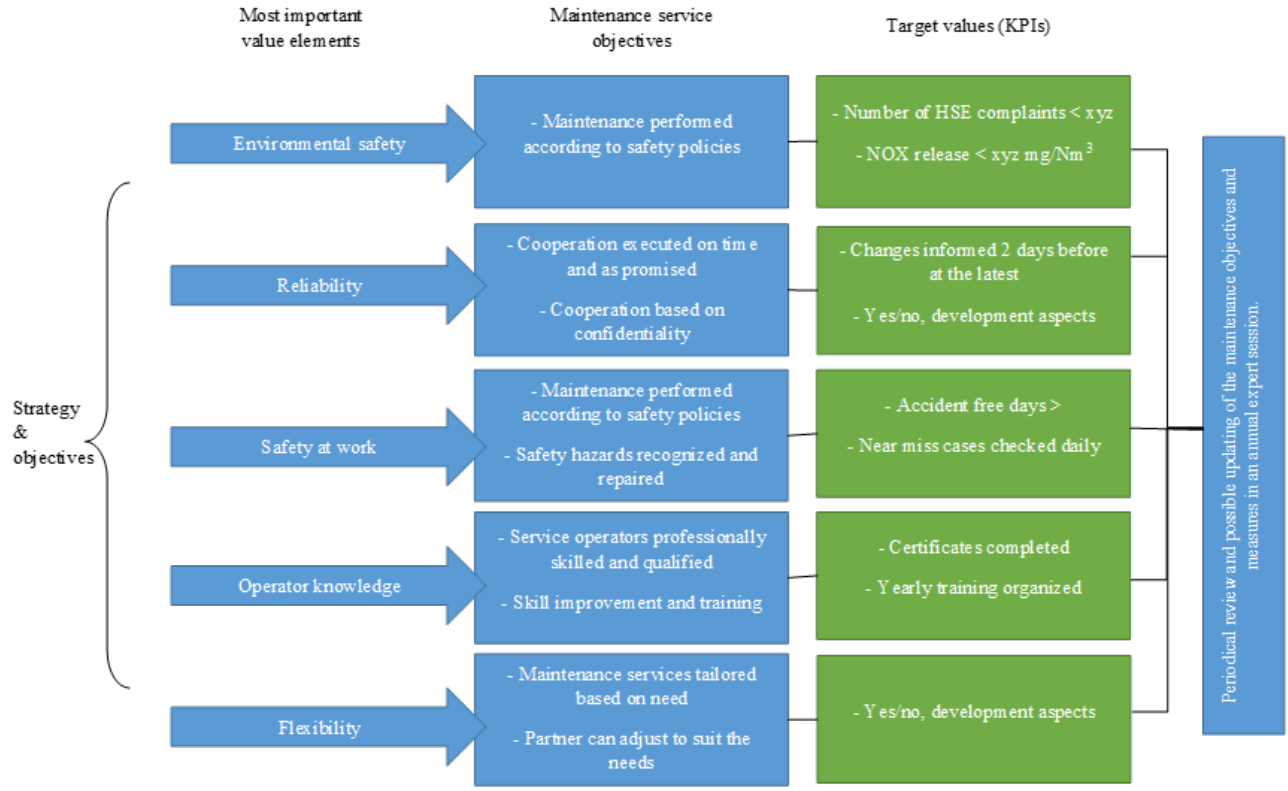

Figure 3. Preliminary framework to support the selection of value-based maintenance measures (value elements based on the survey results). The target values are examples and they should be tailored case by case.

The selection of appropriate maintenance measures should be aligned with the strategic objectives of the company, and this is the first step of the framework. Based on the strategic objectives, the most important value creating elements are selected and used to translate the maintenance strategy into long-term objectives. For the value elements several definitions are presented in this paper, and they could be used as a guide (see Appendix A). It is important to note that when selecting the objectives and measures they are seen as forward-looking and can provide appropriate feedback. Therefore, it is recommended to include also target values so that the actions can be guided to a certain direction. The target values should be tailored case by case. To make this a continuous improvement process, a periodical review and possible updating of the maintenance objectives and target values are recommended. This can be done for example in an annual expert session, as Rosqvist et al. (2009) suggest.

The framework and value elements can be used by the maintenance service customer to be able to align the strategic objectives and maintenance measures better. Also the maintenance service provider can use the framework to communicate better about the created service value with the customer. For the service providers it is important to address versatile value elements

in their service offerings (Toossi et al., 2013). In a 'best case scenario', the customers and service providers would use the framework for mutual representation so that they could create shared meanings and communicate actively about the value-related aspects with each other. With comprehensive value assessment, the parties will be able to evaluate and develop the value created in the service relationship and gain mutual understanding. When mutual understanding is achieved, it is more likely that appropriate and meaningful measures are selected on the scoreboard to measure the created value.

5 Conclusions and future work

The paper contributes to the value creation and maintenance performance literature by providing a preliminary framework for integrating comprehensive value assessment into strategic decision-making in maintenance service relationships. The survey results showed that maintenance service customers should measure the service value more comprehensively and include also measures that capture elements like environmental safety, safety at work, operator knowledge, and flexibility of the service. The respondents agreed that maintenance can create value (consisting of more than one element) and not just cost, but most of them still did not measure the value. Currently the measures are mainly focused around the cost aspect and possible downtime losses. However, the value elements in this paper can be used in decision-making to align the strategic objectives of the company and its maintenance measures better. With the presented framework, the selection of value-based maintenance measures and improved communication between the maintenance service customer and provider can be supported. Rather than sub-optimizing the cost aspects, a more comprehensive view at maintenance service value can be achieved.

The study was limited by a rather small sample, and this might restrict the generalizability of the survey results. Therefore, future research should focus on verifying the preliminary framework together with the service providers and other actors involved in the value creation process. Also the selection of appropriate measures for each value element needs further research. Despite the small sample, this study can be considered as a first step towards more comprehensive value assessment in maintenance services and maintenance service relationships.

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Title

Appendix A

Value propositions (VP) and their mean values (N=31). Value elements based on the propositions are presented in *italics*.

	Mean	**S.D**
Availability:		
VP1. The maintenance tasks are appropriate and maintainability and repair are easy.	3.45	1.21
VP2. The operators carry out their part of the in use maintenance operations and enhance the maintainability of the item.	3.03	1.25
Safety at work:		
VP3. The operational conditions and safety increase along the service.	3.58	1.06
VP4. The maintenance is performed according to safety policies.	4.10	1.11
Environmental safety:		
VP5. The maintenance service performer recognizes the environmental safety hazards.	4.16	1.07
VP6. The maintenance is performed according to environmental safety policies.	4.26	0.97
Technical quality:		
VP7. The maintenance service outcome is as expected.	3.37	1.10
VP8. The maintenance service outcome is sustained for the promised time.	3.13	1.28
Flexibility:		
VP9. The maintenance service partner can adjust to suit the needs of the company (e.g. . delivery time)	3.37	1.25
VP10. The maintenance services are tailored based on need.	3.68	1.11
Reliability (of the relationship):		
VP11. The maintenance service cooperation is executed on time and as promised.	3.21	1.24
VP12. The maintenance service cooperation is based on confidentiality.	3.90	1.35
Operator knowledge:		
VP13. The maintenance service provider has the knowledge to solve upcoming problems.	3.59	1.12
VP14. The maintenance service operators are professionally skilled and qualified.	3.83	0.93
Orderliness:		
VP15. The resources and timetable of the maintenance service can be planned well in advance.	2.69	1.29
VP16. The maintenance service operations are developed in cooperation.	3.14	1.24
Reputation of the service provider:		
VP17. The current reputation of the maintenance service partner is good.	3.66	1.05
VP18. The previous experiences with the maintenance service partner have been positive.	3.66	1.20
Relationship:		
VP19. The maintenance service cooperation works well considering the conditions of all partners.	3.37	1.22
VP20. The information exchange works between the maintenance service partners.	3.37	1.13
Contracts:		
VP21. The maintenance service warranty and terms of payment are kept and executed as promised.	3.00	1.15
VP22. The risks and responsibilities considering the maintenance services are shared between the customer and the service provider.	2.97	1.40
Total solutions:		
VP23. The maintenance service cooperation covers comprehensively the whole maintenance services (from management to execution)	3.04	1.70
VP24. The maintenance service covers the whole life span of the item.	2.63	1.38
R&D:		
VP25. Own research and development can be developed with the maintenance service partner.	2.30	1.47
VP26. The maintenance service partner can provide information and knowledge related to the development of R&D activities.	2.37	1.59
Price factors:		
VP27. The price paid for the maintenance service corresponds with the received service.	3.07	1.26
VP28. The price is negotiated in cooperation with the maintenance service partner.	2.77	1.46
Access to markets:		
VP29. The maintenance service cooperation enables contact with new customers.	2.07	1.53
VP30. The maintenance service cooperation enables starting a new type of business.	1.90	1.45
Asset management factors:		
VP31. The maintenance service partner is responsible for the spare part storage so that it does not tie your own resources and capital.	1.93	1.41
VP32. The maintenance service partner owns the fixed assets, for example the maintained items so that they do not stress your own balance sheet.	1.90	1.35

Appendix B

Value element	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 Availability															
2 Safety at work	.724**														
3 Environmental safety	.345	.749**													
4 Technical quality	.304	.221	.165												
5 Flexibility	.100	.410*	.332	.638**											
6 Reliability	.121	.240	.088	.302	.575**										
7 Operator knowledge	.177	.297	.075	.266	.399*	.803**									
8 Orderliness	.040	.135	-.061	.202	.327	.348	.517**								
9 Reputation	.409*	.537**	.193	.108	.444*	.293	.500**	.392*							
10 Relationship	.347	.336	.097	.182	.448*	.293	.396*	.331	.752**						
11 Contracts	.193	-.035	-.236	.219	.148	.230	.259	.210	.142	.461*					
12 Total solutions	-.160	-.372	-.346	.128	-.134	.130	.100	.175	-.326	-.194	.476*				
13 R&D	-.043	-.250	-.129	.449*	-.068	-.087	.081	.338	-.279	-.197	.071	.354			
14 Price	.134	.197	-.035	.466*	.476**	.529**	.603**	.488**	.139	.142	.422*	.307	.370*		
15 Access to markets	-.156	-.280	-.320	.438*	.226	.357	.284	.391*	-.291	.012	.314	.438*	.562**	.687**	
16 Asset management factors	-.340	-.245	-.266	.333	.247	.336	.269	.237	-.235	-.140	.151	.425*	.525**	.534**	.707**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).