Presenting Software Metrics Indicators: A Case Study

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ABSTRACT
Industrial measurement systems in software projects can generate a large number of indicators (main measurements). Having a large number of indicators might result in failing to present an overview of the status of measured entities. In consequence, managers might experience problems when making decisions based on indicators. In essence, visualizing indicators and their dependencies can communicate the information to the stakeholders efficiently if done correctly, or mislead them if not done properly. In this paper we present results of a case study conducted in a unit of Ericsson. During the case study we identified the main requirements for methods for visualizing the indicators, developed these visualizations and conducted a series of interviews evaluating them. The results show that the dashboard presentation is the best solution, but that the simple, tabular visualizations are next best suited for communicating the information to the managers.

Categories and Subject Descriptors
D.2 [**Software Engineering**]: Software/Program Measurement – visualization techniques.

General Terms
Measurement, Management, Design.

Keywords
Software metrics, Information Visualization, Indicators, Case study.

1. INTRODUCTION
Following the statement "If you can't measure it, you can't manage it" [1], companies use metrics and measurement systems to monitor and control the status of their projects and products. A successful measurement system must be designed and developed based on company policies and strategies in order to overcome the challenges with overwhelming information generated by software applications for supporting decision making [2].

One of the possible solutions is to use indicators which can turn the attention of stakeholders to the most important information. The indicators are usually a few and their goal is to provide the stakeholder with the basic information – whether the status requires attention or not. If it is the case that attention is indeed required, the stakeholder should be provided with additional information to help him/her to make decisions. However, in the daily work the amount of information should be minimal. The attention should be drawn rather quickly, which means that the interpretation of the indicator cannot be complex – using a red color for the status of indicator when problems occur draws an attention effectively to the problem area. In its essence an indicator is a variable that communicates information to a stakeholder about the state or trend of one or more attributes of the system, expressing a specific value at a required time [4, 18].

Burkhard et al. [6] researched in the use of indicators and found that although the indicators are presented visually, people are surrounded by overwhelming information and miss the big picture [6]. Furthermore, the authors [6] argue that companies should focus on presenting the collected data in a way that communicates the "big picture" rather than presenting raw data in decorative tables. However, it is not a straightforward task to select the most relevant visualization technique for a particular goal or application, as no specific technique is suitable for all the problems [7-9]. In this paper we present a case study of how indicators are visualized at Ericsson and what principles underlay this particular way of presentation. During the study we evaluated several metaphors for presenting information and compared these with established ways of presenting indicators in other fields – e.g. sustainable development of countries.

The results of this paper show that using a well-known metaphor yields the highest understanding of the information presented in the indicators and using standard tools like MS Excel vastly increases the adoption of presenting indicators this way.

The remainder of the paper is structured into the following sections. Section 2 provides a summary of the previous related research in the field. Section 3 contains the description of the design of the case study and section 4 presents the empirical data collected during our research. Section 5 discusses the validity of the case study. Section 6 presents the conclusions drawn from the research followed by future work.

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2. RELATED WORK

Information visualization is the process of presenting abstract and huge amount of data in a communicative way to the users [23-24]. The study of Voinea and Telea [16] shows how techniques promoted by the field of information visualization can be integrated into the configuration management process for software systems, whereas Amar and Stasko [25] present a design and evaluation framework for narrowing the analytic gaps and limitations of information visualization systems. Moreover, a meta-analysis of empirical studies on information visualization presented by Chen and Yu in [26] showed that users with the same level of cognitive abilities have tendency to perform better with interfaces that contained simple real life objects.

Regarding software measurements, the ISO standard ISO/IEC 15939 supports the composition of a software measurement process in a standardized way [3]. It involves the identification of appropriate measures that concentrate on the information needs of the stakeholder [3]. Nonetheless, although the ISO standard ISO/IEC 15939 provides companies with a structured way to define, create, use and profit from the software measurement process, it does not include how to communicate the information needs to the users using visualization. Our study helps adopters of this standard with presentation techniques.

A recent study on visualizing dependencies between measures in measurement systems was conducted by Johansson et al. [33] at Ericsson. According to Johansson et al. [33], the indicators that are on the top of the measurement system model, should fulfill the stakeholder's needs in a fast, effortless and understandable way. We used that study as an input for our work and extended their results.

A significant aspect that should be considered when presenting information in measurement systems is the quality of the information. Lee et al [12] conducted a study on how quality attributes of information can be prioritized to increase the quality of knowledge. In our work we select eight quality attributes based on the information quality attributes defined on [12]. We identify and prioritize the importance of those attributes in the context of our research through interviews.

In the area of software engineering the research on visualization techniques focuses more on code comprehension and understanding activities, for example [13-16], rather than on visualizing software metrics indicators. However, Burkhard et al. [6] discuss an innovative approach to present indicators. In their study a framework for visualizing strategies is used to communicate a number of indicators to different stakeholders in a way that motivates them and lead them to make decisions. Although the results are interesting, it is not feasible to use the framework as the whole measurement system should be changed, which is out of the scope of this study.

Outside the area of software engineering there are several papers [17-20] on how to present sustainability development indicators for countries. The sustainable development is one of the goals that each country tries to achieve [21]. The sustainable development of a country is controlled and measured by using indicators. Because the phenomenon of sustainable development is complex and many parameters should be measured, a dashboard of sustainable development was created which summarizes the most important measures (indicators) in a single figure. The idea behind the concept of the sustainable development dashboard is to present information from various areas to non-expert users [22]. The dashboard software uses the metaphor of a vehicle dashboard and is created in a way that enables comparison of indicators between countries [17]. This dashboard model was adapted and evaluated in our paper.

3. CASE STUDY DESIGN

This section presents the case study performed at the company. The purpose of the study was to evaluate the presentation techniques for indicators in their natural context and understand the principles that underlay the best suited visualization. The holistic single-case study design [35] was applied to investigate one single case: the presentation of indicators in measurement systems at a unit of Ericsson. The study was conducted at one of the departments of Ericsson. Our proposition in this case study was that presenting limited information in a simple manner helps the managers more than presenting a full set of details in an intuitive way. The rationale behind this proposition was a set of observations from our previous case studies that managers require a limited number of data for their daily work and only access details when problems occur. An alternative proposition was that using more details in presenting information (e.g. dependencies between indicators) would blur the overview picture for the managers and result in their unwillingness to use the indicators in their daily work.

The study design comprises of four distinct phases which are described below.

3.1 Phase 1: Current Presentation Techniques at the Company

In this phase we investigated how the information is presented by current measurement systems at the company. The objective of this phase was to identify and assess managers' requirements and expectations for presenting indicators. More specifically, the focus was on two main research questions:

- *What are the main requirements for presenting information in measurement systems?* , and
- *Which is the most important quality attribute for the presentation methods?*

In order to address these questions we performed an interview with a quality manager with a number of years' experience in the field. The manager was largely involved in the design and development process of the current ways of presenting indicators from measurement systems. A semi-structured interview was selected in order to collect the information. Table 1 shows areas which were used as a guide for posing questions during the interview.

We ensured that the presentation methods complied with the quality information attributes of the system identified in the interviews based on Lee et. al.'s 20 quality attributes [12]. Eight attributes, presented in Table 2, were selected from the quality manager, and included in the later research (phase 3 and 4). Identification and prioritization of the importance of those attributes in the context of our research was done using the $100 technique [10].

Table 1. Interview areas

Interview areas	Expected outcomes
Measurement systems: Concept	Experience of the stakeholders with measurement systems
Measurement systems: Use	Scenarios of everyday use of measurement systems
Information presentation	Basic requirements for presenting indicators information in the organization
Information quality	Identify and prioritize the most important information quality attributes for the stakeholders.
Technical details	Differences between the measurement systems at the company and visualization tools in the market.
Potential improvement needs for the current presentation methods	Improvement opportunities and requirements for information presentation.

Documentation study [35] was applied in order to gain insights into the organization‘s current measurement processes and to triangulate the data sources with interviews.

We used grounded theory and coding for analyzing data from interviews. The final set of categories of the results codes is presented in Table 1.

We studied the measurement systems in the organization, which are described in [32]. Our interview subjects were experienced quality managers and project managers working with measurement systems.

3.2 Phase 2: Identifying Non-standard Visualization Methods

The purpose of this phase was to assist in establishing how the information is presented in previous studies and existing tools in the market. In this phase non-standard visualization techniques were identified from the literature review and a market scoop. The criteria elicited in phase one served as a reference point for selecting the relevant techniques. Consequently, a comparison between the results and the current presentation methods at the company could be drawn. In this phase we concentrated on two research questions:

1. *What are the existing visualization techniques identified previously in the literature?* and
2. *Which visualization techniques are used in commercial and open-source measurement systems?*

The literature review was conducted through the search of keywords like “measurement system”, “indicator”, or “information visualization”. Content analysis [36] was used as a method to collect and analyze the data from existing and relevant literature (i.e. published papers, books, etc.). An internet-based market search was conducted to identify different visualization applications currently on the market.

3.3 Phase 3: Prototype Development

After eliciting the requirements for presenting indicators in phase 1 and identifying non-standard visualization techniques in phase 2, we developed three prototypes of MS Excel add-ins which use the techniques to present the indicators used in an example measurement system at Ericsson. The prototypes were developed in Visual Basic for Applications in MS Excel 2003 at the IT University of Göteborg. MS Excel 2003 was selected due to the fact that the current measurement system at the company was developed in MS Excel 2003.

In this phase, the iterative development process was chosen because it allowed us to make modifications and improvements on the prototypes during the development. Our contact person at the company was involved during the development of prototypes (one meeting) before the prototypes were evaluated in phase 4.

3.4 Phase 4: Evaluating Prototypes through Interviews at the Company

After developing the prototypes and using them in a number of weeks we prepared printouts of the measurement systems to use during the evaluation interviews. The main scope of these interviews was to assess whether the new ways of presentation are better than the current ones in the company. In this phase we addressed two research questions:

1. *What are the advantages and disadvantages of each presentation?*, and
2. *Which of the proposed prototypes is the best and why?*

Three interviewees (one Project Manager and two Quality Managers) participated in the evaluation process of the prototypes developed in phase 3. The interviewees were asked to evaluate the presentations using:

- the 5 point Likert scale, used in most of the questions:

  1 – Very difficult; 2 – Difficult; 3 – Normal; 4 – Easy; 5 – Very easy,

- the 10 point scale, used in one question:

  1 – Totally insufficient; … 10 – Completely fulfils all information needs.

- open-ended questions allowing the interviewees to express unconstrained opinion about the prototypes.

To conduct the interview and analyze the data, the same methods are used as in phase 1, i.e. grounded theory.

4. RESULTS

This section summarizes the results of our case study designed in Section 3.

4.1 Current Presentation Techniques

Measurement systems are used to collect, calculate and present software metrics. At Ericsson each measurement system was built for a particular purpose (information need according to ISO/IEC 15939:2007 [5]), which was done according to the standards. The information was presented in MS Excel files which were in turn available from internal web pages. The stakeholders had direct access to the indicators worksheet, as it is the first worksheet shown to them by the measurement system. In this worksheet the indicators are presented in a plain table with colored cells (see Figure 1). This table is separated in different areas (i.e. time, budget etc.), where each area has a corresponding indicator (i.e. development time, testing time, etc.). Also, the users have access to more detailed information which is presented by the measurement system in other worksheets.

For each indicator, in parallel with the color, the actual value of the indicator is displayed. To communicate the status of the indicators to the users, the responsible team for the measurement systems had focused on identifying metaphors that are familiar to the users. Consequently, the traffic-light model is used for the color-coding of the indicators. The traffic light model contains three colors, green-yellow-red, to show the three different statuses of the indicator: ok, warning, not ok. The interviewee stated that the color-coding technique by itself has some limitations. The users are not informed if the value is closed to the boundary of a color definition in the analysis model (i.e. "how green is green for a specific indicator"). Figure 1 shows an example of how this traffic-light model is used in the organization on a fictitious example.

Figure 1. Current presentation at Ericsson

After describing the structure and design of a measurement system we focus on the functionality part of this system. According to the interviewee, the measurement system in principle fulfilled the following user needs:

1. Displays the status of the project for different areas,
2. Compares historical data,
3. Automates the presentation of information, and
4. The information is succinct and precise.

In principles the users could interact with the presented information by viewing the underlying data, filtering the information, and displaying details of the underlying information.

One of the main problems in the organization, however, was the summing-up of the colors of different areas – e.g. all indicators related to budget or quality. In the current measurement systems the indicators were categorized in different areas. The status of each indicator was presented in the corresponding area; however the status of the whole area was not presented in one single indicator.

4.2 Requirements for Information Quality

The results are presented in Table 2 and they show that the interviewee considered accuracy as a prerequisite quality attribute of the measurement system. While all the other quality attributes were considered with quite the same level of importance.

Table 2. Prioritized quality attributes

Priority	Quality attribute	Question
51$	Accuracy	Is the information reliable and error-free?
8$	Accessibility	Can the information be accessed in any time?
8$	Value-added	Is the information helpful for the user and the organization?
8$	Timeliness	Is the current information required?
5$	Understandability	Is the information clear, unambiguous and simple?
4$	Objectivity	Does the information show a minimum of a bias?
4$	Completeness	How in depth is the information, does it cover all the levels?
3$	Variety	Is the information presented in different ways?

The following list presents the requirements that indicators' presentation should fulfill elicited by the first round of interviews.

1. Overview solution: The user should be able to view the status of all indicators.
2. Sum-up areas: The indicators' status of a category should be aggregated in a single indicator.
3. The presentation should present the color boundaries defined in the analysis model. Moreover, the user should be able to distinguish the value of the indicator and the defined analysis model.
4. Familiar and intuitive visualization metaphors should be identified to present the data.
5. The user should be able to view more detailed data under his/her request.
6. The user should be able to present the indicators using a various number of colors according to their needs.
7. The presentation of information should be space efficient in order to fit in presentation slides when reporting the results from measurement systems to managers.

4.3 Identifying Non-standard Visualization Techniques

From the research of existing tools in the market we identified the following applications which can be used to visualize the data:

1. Tableau [38],
2. Visokio Omniscope [39],
3. Spotfire [40],
4. TychoMetrics [41],
5. Inxight [42],

6. Ilog Jviews Charts[43],
7. Data Drill Integrated [30],
8. Microsoft Excel 2003 [31],
9. Dashboard of sustainability [29], and
10. Crystal Xcelsius Profesional 4.5 [28].

These tools were explored in terms of visualization and interaction techniques they use. Based on the criteria obtained from phase one, the following visualization techniques were selected.

4.3.1 Dashboard Overview

The dashboard of sustainability presentation shows the current status of development indicators of a country [29]. Figure 2 illustrates an example of the dashboard of sustainability. This presentation is based on a hierarchal structure with a number of levels. The first level – the circle in the center (labeled PPI) – shows the country's development status. The country's development status is defined by aggregating the indicators of each subarea (Environment, Economy and Social Care) of the country which are presented in the second level - the bigger circle. Each indicator illustrated in the second level is calculated summing-up the corresponding indicators of each subarea which are shown in the third level –the biggest circle.

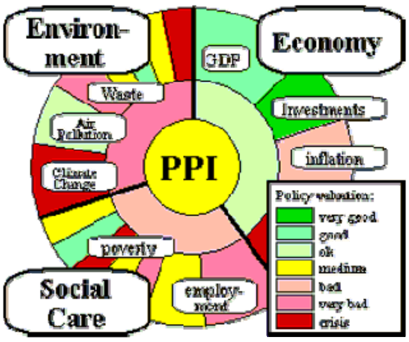

Figure 2. Dashboard of sustainability [27]

This presentation corresponds to the disk-based visualization technique [44]. According to Diehl [44] this visualization technique uses efficiently the screen space and can present a larger number of details in a compact manner.

4.3.2 Thermometer Model

Another way of presenting indicators is the thermometer model [30]. This model is inspired from a real life object, the thermometer and is therefore intuitive to understand – the bar's size shows the status of the indicator. This intuitive interpretation was the reason for choosing this model.

4.3.3 Speedometer Model

Crystal Xcelsius Professional 4.5 [28] uses the speedometer model to present data. The arrow shows the current value of the indicator while the colors alert the users of the status of the indicator. The speedometer model is another example of an intuitive way of presenting information.

4.4 Prototype Development

The three models of presentation were realized in practice and integrated with a measurement system in the studied organization. After the integration of these methods in phase 4 of our study, the measurement system was used for ca. 10 weeks in order to gather the opinions of the users about its usability and conformance to the expectations.

4.4.1 Prototype 1: Dashboard Overview

The dashboard overview illustrated in Figure 3 presents the status of each indicator using color-coding. The dashboard view contained three circles (levels) in our realization. Each level contains one or more indicators. The first level, the smallest circle, displays the status of the whole project. Each project is divided in different main areas, for instance Time, Cost or Budget etc., which are presented as indicators in the level 2, the bigger circle. Each main area is divided in a number of more specific indicators, such as Testing Time or Developing Time for the Time area. All these indicators are presented in the third level, the biggest circle.

The dashboard overview provides the user with the possibility to utilize a large number of indicators in level 2 and 3 consistent with user's needs. Moreover, the user is not restricted to a predefined number of colors, indicating that the user can define the range of colors according to their needs.

Furthermore, implementing the details-on-demand technique the user can view the underlying data by clicking on each indicator. In the Indicators details view, the user is provided with the name of the indicators, the current value and the decision criteria. Also, the arc view is embedded in the details view to inform the users if the value is closed to the boundary of a color definition in the analysis model (i.e. "how green is green for a specific indicator").

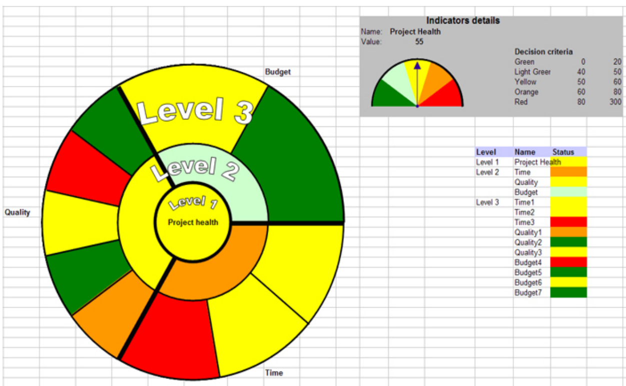

Figure 3. Dashboard overview

4.4.2 Prototype 2: Thermometer View

The presentation shown in Figure 4, based on the thermometer model, presents the status of every indicator in the project.

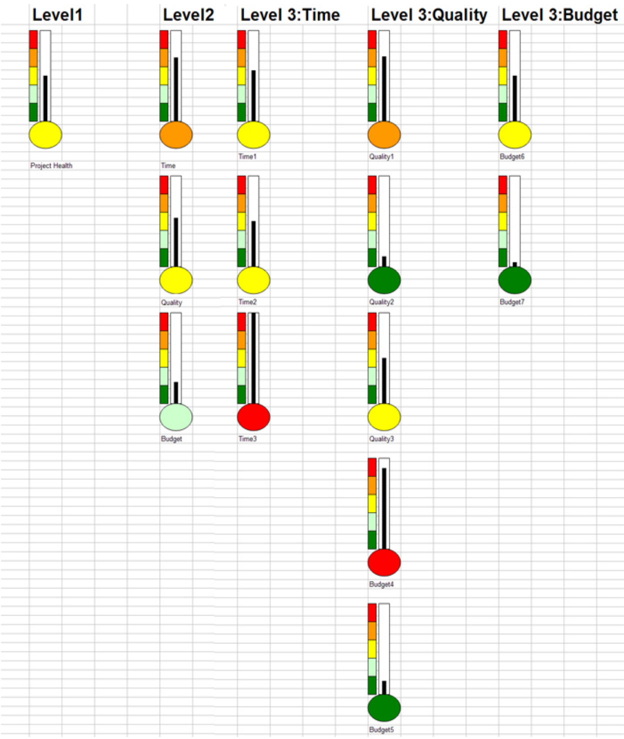

Figure 4. Thermometer view

According to the decision criteria, the thermometer scale is separated in different colored parts. The bulb of the thermometer present the current status of the indicator and the "mercury line" presents the level of the current status.

This presentation, using the "mercury line", answers the question: how green is green for a specific indicator. Furthermore, the user is not limited in using a constant number of indicators or colors for each indicator.

4.4.3 Prototype 3: Arc View

The Arc View presentation illustrated in Figure 5 displays the status of each indicator using the speedometer model.

Each arc is divided in different colored parts according to the decision criteria for each indicator. The user is able to present a various number of indicators with different decision criteria and for each indicator an undefined number of colors can be set.

The status of the indicator is displayed by an arrow. The position of the arrow in the arc shows not only the current value of the indicator, but also informs the users if the value is closed to the boundary of a color definition in the analysis model (i.e. "how green is green for a specific indicator").

Figure 5. Arc view

4.5 Evaluation of the Prototypes after their Use in Interviews

The following paragraphs present a summary of the advantages and disadvantages for each presentation as resulted from the interviews. The overall suitability of each presentation technique is presented in Table 3.

4.5.1 Current Presentation at the Company

The main advantages of the current presentation were that it was easy to interpret the results (thanks to the color-coding). Using only one metaphor, i.e. color-coding, instead of several, e.g. color and size coding, made it much easier to understand the indicators. Simple interactive features like clicking on the indicators which opened detailed information for the indicators was appreciated by the stakeholders.

The main disadvantages of this solution were related to its simplicity. No dependencies between indicators were visualized which made more advanced status analyses harder (e.g. interpreting the situation when budget was "red" and resource allocation was "green"). The lack of aggregation of the indicators was initially perceived as a disadvantage, but was later disregarded as such. Overviewing the indicators might lead to over-interpretation of the information by the measurement system. It was found that it was not possible to summarize the status of a project or a product in only one indicator.

Finally an important disadvantage was the fact that the stakeholders were not informed if the value is closed to the boundary of a color definition in the analysis model or in the middle of it. In other words if the indicators showed status "green" denoting no-problems or ok situation, then the stakeholder was not informed if this is green, but close to red or not. Neither was the stakeholder informed whether the status is about to change or on its way to change based on historical data.

4.5.2 Dashboard Overview

The dashboard presentation offered the best overview of the indicators providing an easy and intuitive way to capture the 'big picture' of the project. The evaluation revealed the dashboard overview as a convenient way to present indicators to the others, due to its space efficient property. An additional advantage was the potential of aggregating indicators. In this way we overcame one of the limitations of the current presentation: summarizing different indicators in a higher level indicator.

The detail-on-demand technique presented detailed information when the user clicked an indicator. This interaction feature informed the user about the exact value, the color boundaries defined in the analysis model, and the position of the indicator in relation to these boundaries. This was realized by embedding the arc view presentation. Associating the detailed-on-demand with the color-coding technique facilitated the interpretation of the results.

On the other hand, two disadvantages were identified during this evaluation. First, the lack of the indicators name and value in the overview was considered as a weakness of this presentation. Second, while the interaction feature of details-on-demand was clearly a plus, the fact that it was not visible which indicator was selected in the overview presentation, counted as a drawback.

4.5.3 Thermometer View

The advantages of this presentation were the indicators' aggregation capability and the visibility of color boundaries. The later, for example, answered the question "How much green is green?" for all indicators.

Despite the familiarity of this metaphor, the thermometer view was rated as the most difficult technique to read and perceive the information. This disadvantage was also reinforced by the absence of the indicators' numerical value and the need of a scale in the bar of the thermometer.

4.5.4 Arc View

From all the evaluated presentations, the arc view was the most understandable and familiar metaphor - the stakeholders found it easy to get an overview of the status of the indicators. The status was illustrated through color-coding technique which assisted in alerting the user concerning important changes or problems. Moreover, distinguishing the value of the indicator between the color boundaries was a straightforward task. This approach improved the presentation of the indicators; supplying the stakeholder with a more precise indication of the value. Thus, the stakeholder could interpret easier the information and derive better results.

In addition, the indicators' aggregation feature was integrated in this presentation too. Delivering summarized indicators facilitated the interpretation process of the data and minimized the time and effort. The stakeholder would have to rely only in one indicator to control and verify the progress of the project. However, defining the decision criteria to aggregate the indicators is not an easy task and out of the scope of this paper. On the other hand, the arc view re-encountered one of the disadvantages of the previous presentations – the missing numerical value. Numerical value in the arc was required as well.

4.5.5 Summary

Table 3 presents the mean values for the questions where 5 point Likert scale and 10 point scale where used.

These results show that the dashboard overview presentation is the most highly graded from the innovative non-standard presentations. A three-fold reason exists for this outcome: the space-efficient overview, the easy way to interpret the data and a familiar metaphor. In contrast, the thermometer view is the weakest presentation due to the complexity of the metaphor, difficulty of grasping the overview and invisible detailed values.

Whereas, the arc view is the most familiar metaphor surpassing the dashboard overview and current presentation. This could be explained due to the fact that it resembles to the speedometer. Finally, the current presentation fulfills best the stakeholders' needs using simple and tabular visualization. This type of visualization offers the required detailed information to the stakeholders, supporting them to interpret the results.

We should consider, however, the bias that the interviewees might have introduced to the results of this process. A paper-based evaluation was conducted which excluded the possibility to the interviewees to interact and explore the prototypes. Moreover, the interviewees had no previous experience with these three non-standard visualization techniques contrary to the current presentation.

The evaluation's results presented in Table 3 are consistent with the outcome from the open ended questions, summarized in sections 4.5.1 – 4.5.4.

5. VALIDITY

Validity assessment is important to any case study. The validity of the empirical research can be categorized in three groups: internal, external and construct validity [37]. According to Yin [35], internal validity is more encountered and noticeable in

Table 3. Evaluation's results

Question	Current Presentation	Dashboard Overview	Thermometer View	Arc View
In scale of 1–5, how easy is it to overview the indicators?	3.4	4.4	2.4	4
In scale of 1–5, how easy is it to interpret the results?	4.7	4.7	2.7	3.7
In scale of 1–5, how easy is it to find the detailed value of indicators?	5	4	1.4	1.4
In scale of 1–5, how easy is it to understand the metaphors used in this way of presenting the information?	4	4.7	3.7	5
In scale of 1–10, how well does this way of presentation fulfill your information needs?	7.7	6.4	3	5.7

explanatory rather than explorative case studies. The external and construct validity of the empirical research are presented in the following paragraphs.

External Validity: The case study was conducted at a single unit of Ericsson and it is not easy to generalize the results. However, the measurement system is representative because is based on the description of the ISO standard ISO/IEC 15939.

Another important threat in the external validity is the use of only one measurement system as the prototype. As the presentation of information is related to cognitive abilities of the receivers of the information (in our case stakeholders), there is a threat that other sample of subject might have a different opinion about the ease-of-interpretation of the information.

Construct Validity: To minimize the construct validity threat during this explorative case study we used data triangulation [36]. Data triangulation was done by using different data collection methods described in each phase of the case study, presented in section 3.

6. CONCLUSIONS

This paper presented an explorative case study on how we can optimize the presentation of software metrics indicators in industrial measurement systems.

In the course of this case study we identified and evaluated 4 different ways of presenting indicators: dashboards, tables with colors, arcs, and thermometers. The evaluation of the prototypes showed that the dashboard overview presentation is the best solution as it is space-efficient and provides the readers with a possibility to quickly get an overview of all indicators. We have also found that experienced users of measurement systems need a quick access to the details behind the indicators. Therefore having links to detailed information structured around indicators was found to be a very important factor when adopting a particular presentation/visualization technique.

The results showed that the experts acknowledged the effective way of presenting the indicator's boundaries according to the decision criteria model, implying that the visualization technique should present precisely the status of the indicator. As a result, a rapid and graspable overview seems to be the best solution in our evaluation.

Developing visualization techniques based on familiar and intuitive metaphors (i.e. the speedometer) has a direct positive impact on how the user understands the presented information and minimizes the learning curve. This was found to be one of the main factors for the large spread of indicators in the company today.

Our future research is focused on improving the proposed techniques – prototypes – by integrating trend lines and implementing indicator's dependencies in presentation of indicators. Furthermore, we believe it would be interesting to investigate how more advanced visualization techniques could drive a step further the work of quality managers.

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