ASM.br: A Template for Specifying Indicators

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ABSTRACT

Measurement is a crucial practice for software organizations to monitor projects and improve processes. It defines indicators and provides information to support decision-making. Defining indicators is not a trivial task. Although the literature proposes several indicators, there is not a consensus about how to specify them. This paper presents ASM.br (Assistance for Software Measurement based on relationships), a template for specifying indicators by using a one-page form in which textual and graphical information is recorded and the relationships between indicators and between them and goals are put explicitly. By using ASM.br, indicators are recorded in a standardized way, easing understanding and reuse. ASM.br was applied in a software organization and the results suggests its feasibility and utility.

CCS CONCEPTS

• **Software and its engineering → Software creation and management;** Software Measurement

KEYWORDS

Software Measurement, Indicator, Template

1 Introduction

Software measurement is a process applied by organizations in several contexts. For example, in project management, measurement is used to help develop realistic plans, monitor project progress, identify problems and justify decisions [1]. In process improvement initiatives, measurement supports analyzing process behavior, identifying needs for improvement and predicting if processes will be able to achieve the established goals [2].

For performing measurement, first an organization has to plan it, producing a measurement plan that gathers, among others, the measures to be used and procedures for data collection and analysis [3, 4]. Measurement plans can be defined for organizations or projects. Usually, project measurement plans are defined from organizational measurement plans.

Measurement must be aligned to organizational or project goals. In this sense, measures should be defined aligned to these goals. Besides, measures able to provide information directly used to monitor goals achievement should be used as indicators [3]. Indicator can be defined as a measure, or a combination of measures, usually graphically presented, which provides understanding about software-related entities [1, 5].

In the literature there are many software-related indicators (e.g., [1, 4, 6, 7]). However, the extent and unstandardized list can lead organizations to select indicators without synergy with their goals. Additionally, indicators specifications often do not include enough information to one decide if they are aligned to his/her needs.

An indicator can be analyzed alone or combined with others. Relations between indicators are usually not explicit in indicators available in the literature. Due to the lack of such information, one can select indicators that are not enough to provide necessary information for decision-making. Ideally, when analyzing an indicator, other indicators related to it should also be analyzed, aiming at investigating the influence of some aspects on others.

Considering that elaborating a measurement plan is not an easy task, particularly due to difficulties related to select and specify indicators, as well as make explicit the relationships among them, we developed ASM.br (Assistance for Software Measurement based on relationships), a template for recording indicator specification. AMP.br allows specifying indicators by using a one-page form in which textual and graphical information is recorded, and the relationships between indicators and between them and goals are explicitly presented.

This paper presents AMP.br and is organized as follows. Section 2 presents a brief background about software measurement. Section 3 introduces AMS.br. Section 4 addresses the evaluation of AMS.br in an organization. Section 5 presents our concluding remarks.

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2 Software Measurement

Software measurement is the continuous process of defining, collecting, and analyzing data regarding software processes and products to understand and control them, as well as supply meaningful information to their improvement [8]. It is a primary support process for managing projects, and it is also a key discipline in evaluating the quality of software products and the performance and capability of organizational software processes [5]. It allows organizations to understand their capability to develop reachable plans for delivering products and services, and is important for promoting and providing evidences of organizational evolution and maturity [7].

There are several standards and approaches devoted to assist organizations in defining their software measurement processes, such as ISO/IEC 15939 [5] and PSM (Practical Software Measurement) [1]. Although there are differences between the measurement processes proposed in the several standards and approaches, in general, the software measurement process includes: measurement planning, measurement execution, and measurement evaluation [5].

For performing software measurement, initially, an organization must plan it. Based on its goals, the organization has to define which entities (processes, products and so on) are to be considered for software measurement, and which of their properties (size, cost, time, etc.) are to be measured. The organization has also to define which measures are to be used to quantify those properties and which ones are to be used as indicators. For each measure, an operational definition should be specified, indicating, among others, how the measure must be collected and analyzed. Once planned, measurement can start. Measurement execution involves collecting data for the defined measures, storing and analyzing them. Data analysis provides information to decision making, supporting the identification of appropriate actions. Finally, the measurement process and its products should be evaluated to identify potential improvements [3].

In addition to standards and methodologies that address the software measurement process as a whole, there are some proposals that deal with more specific aspects of the measurement process. Next, we cite some ones related to measurement planning.

GQM (Goal-Question-Metric) [9] is a systematic approach for tailoring and integrating goals to software processes, products and quality perspectives, based on project and organizational needs. For that, questions (information needs) are derived from goals and met by measures. GQ(I)M [10] is a variation of GQM that addresses the definition of measurement goals from organizational goals and indicators to communicate or explain the significance of measurement results against the established measurement goals. PSM (Practical Software Measurement) [1], which is adherent to ISO/IEC 15939 [5], is an approach for measurement guided to organizational information needs. From information needs, measurable concepts are identified and measures are defined.

Although GQM and GQ(I)M help organizations to define their measurement plans, they do not define how indicators should be specified. PSM, in turn, provides in addition to a process to be followed to carry out measurement planning, a set of measures and indicators that can be reused by organizations. However, important pieces of information are not available in the measures and indicators specifications, such as relations between indicators and between them and goals, as well as how relations can be used when analyzing data collected for the measure. Considering the lack of a standardized way of recording indicators specifications and the absence of important pieces of information in indicators recorded in the literature, we developed ASM.br.

3 ASM.br: Assistance for Software Measurement based on relationships

Measurements must be performed according to a measurement plan, which contains the measures and indicators that will provide information to support decision-making. In order to assure measurement consistency and results correctness, indicators must be specified in a clear and unambiguous way. Moreover, the relations between indicators, and between them and goals must be established to obtain alignment between measurement and organizational goals.

ASM.br was created to help organizations record proper indicator specifications in a standardized way. By doing that, all needed information to use indicators can be recorded. Besides, indicators reuse is eased, since information recorded in the indicator specification can be used to help users in indicators selection.

ASM.br proposes the registration of indicators specification in a one-page form, containing textual and graphical information. The use of only one page aims at simplifying the access to information. We expect that the compact layout and the use of visual elements make easier to understand the indicators, contributing to improve the measurement process in the organization.

The use of a common vocabulary to the software measurement domain that represents the relevant knowledge can contribute to share and reuse that knowledge. In this sense, the vocabulary used in ASM.br reuses and extends concepts of the Reference Software Measurement Ontology (RSMO) [3]. RSMO is based on the main measurement-related standards and models and provides a conceptualization to that domain.

Figure 1 shows the ASM.br template. As an example, the template was filled with information regarding the Quality Effort Estimates Accuracy indicator, defined in the case study presented in Section 4. The ASM.br template includes the following information:

- **Indicator:** indicator name, acronym and description. It must be unique in the organization's indicators set.
- **Business Goal**: organizational goal expressing the intention for which strategic actions are planned and performed [3] and to which the indicator is related. The relationship between indicator and business goal aligns measurement to

organizational goals.

- **Measurement Goal**: measurement goal defined based on the indicated business goal and to which the indicator is related. Including a measurement goal in the indicator specification means that the indicator provides useful information to monitor the goal achievement.
- **Information Need:** question identified from the measurement goal and met by the indicator.
- **Category**: logic grouping of indicators considering the main aspect measured by them. Six categories are considered: Productivity, Time, Cost, Scope, Quality and Effort. An indicator can be related to more than one category, and with different degrees. For instance, an indicator that measures effort spent in quality assurance activities is related to Effort and Quality categories. In the template, the degree of the relation between an indicator and a category must be indicated by black circles. More black circles, stronger the relation.
- **CMMI Level and Process Area:** indicates the CMMI process area and the maturity level to which the indicator is related. This information is useful when measurement is performed in the context of software process improvement programs using CMMI [4].
- **Measurement and Analysis Procedures**: presents the flow of activities necessary to data collection and analysis. The notation used to represent the activities flow is based on BMPN [11]. In addition to the activities to be performed, it must be informed: **Base Measures** (measures used to calculate the indicator), **Measurement Periodicity** and **Analysis Periodicity** (temporal frequencies in which data collection and analysis must be done), and **Measurement Responsible** and **Analysis Responsible** (roles responsible for data collection and analysis).
- **Analysis Procedure Based on Criteria**: when analyzing indicators, it is possible to apply criteria that considers a premise and suggests a possible conclusion. For instance, when analyzing data collected to the Schedule Performance Index (SPI) [12], if the collected data are smaller then 1 (premise), it means that the project has spent more time than planned (conclusion). To record an analysis procedure based on criteria it is necessary to identify the premises, conclusions and possible corrective actions, and record them in a table as shown in Figure 1.
- **Analysis Procedure Based on Relationships**: aims to help data analysis by exploring relations between indicators. It is represented by using an adaptation of BPMN [11]. The less (-) and more (+) symbols represent the expected indicators behavior considering the relationships between them. For the example presented in Figure 1, it is expected that in case of reduction in Quality Effort Estimates Accuracy (QEEA), there is an increase on the Risk Index (RI).
- **Indicator Graphical Representation**: indicators are typically represented in graphs, easing data visualization and analysis. Therefore, the template provides an area for including graphs illustrating possible representations of data collected for the indicator, aiming at helping users to understand and interpret data.

Once indicators have been recorded by using the ASM.br template, information can be used to create relationship maps useful for selecting indicators. ASM.br provides relationship maps for selecting indicators considering their relations with goals, CMMI levels and other indicators. As an example, Figure 2 presents a fragment of a goals relationship map. In this map, from business goals it is possible to identify the related measurement goals, information needs and indicators.

4 Evaluating ASM.br in the Industry

Aiming to perform a first evaluation of ASM.br, we carried out a case study in a software development organization. The study followed three main stages: planning, preparation, and execution.

During the **case study planning**, we defined the study goal and procedures to be adopted.

The study *goal* was to evaluate the use of ASM.br in a software organization. By using TAM (Technology Acceptance Model) [13, 14], which intends to determine the perceived usefulness and ease of use aspects of a given technology from the point of view of its users, the goal was decomposed in: (i) evaluate the perception of usefulness, and (ii) evaluate the perceived ease of use. Then, we added (iii) evaluate the feasibility of using ASM.br.

The *procedure* adopted to perform the study involved: presenting ASM.br to the participants, filling in the ASM.br template with indicators specifications, training the participants on ASM.br, selecting among the specified indicators the ones to be included in measurement plans defined for projects, and getting feedback from the participants after ASM.br use.

Interviews were used to get feedback from the participants. To define the information to be gotten and how to analyze it, we used GQM [8] and, from the study goals, we established questions and metrics to be used. As for the questions, we decided to present them as statements, so that the participants could choose one of these answers: totally agree, partially agree, partially disagree, and totally disagree. Concerning the goal (i), the following questions (statements) were defined: (Q1) It was easy to understand how to use ASM.br; (Q2) It was easy to understand the indicators specified by using ASM.br; (Q3) By using ASM.br, it was easy to identify the relations between indicators and organizational goals; (Q4) It was easy to select among the specified indicators the ones suitable for the projects; and (Q5) As a whole, ASM.br was easy to use. For the goal (ii) the following questions were established: (Q6) ASM.br improves your performance when selecting indicators to be included in a measurement plan; (Q7) ASM.br improves your performance when analyzing data collected to indicators; (Q8) ASM.br helps measurement plan elaboration; and (Q9) ASM.br is useful for standardizing indicators specification. Finally, regarding the goal (iii), was defined (Q10) The use of ASM.br in organizations is feasible. For analyzing the answers to the questions, we considered as metrics the number of participants who chose each one of the answers.

ASM [br]
Assistance for Software Measurement based on relationships

Indicator

QEEA - Quality Effort Estimates Accuracy

Quantifies the precision of quality effort estimates, i.e., estimates for the effort to perform quality assurance activities

Information Need

What is the accuracy of the quality effort estimates (i.e., estimates for the effort to perform quality assurance activities)?

Category

Effort ●●● Cost ○○○
Scope ○○○ Quality ●●●
Time ○○○ Productivity ○○○

Goals

Business Goals

- Improve management effectiveness

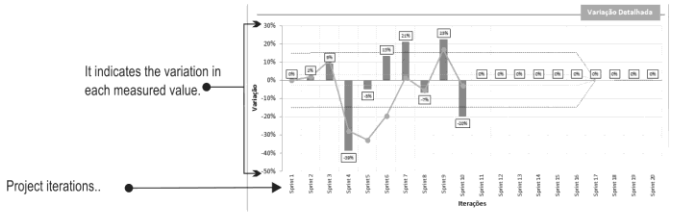
Measurement Goals

Monitor accuracy of effort estimations for quality assurance

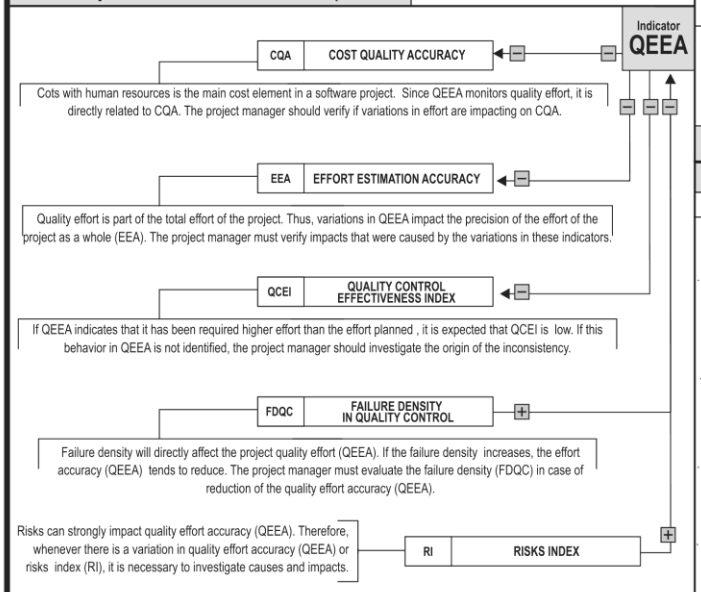
CMMI

LEVEL 3
PA PP

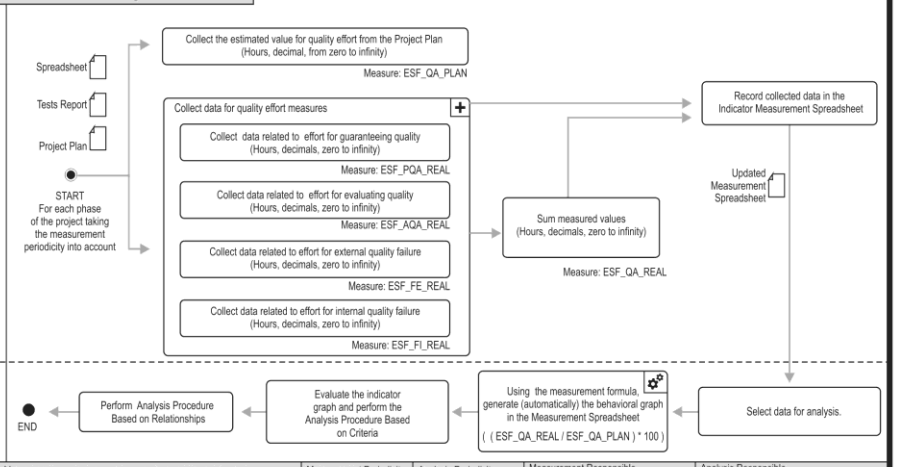
Indicator Graphical Representation



Analysis Procedure based on Relationships



Measurement and Analysis Procedures



Base Measure:	Measurement Periodicity:	Analysis Periodicity:	Measurement Responsible	Analysis Responsible
ESF_QA_REAL – PERFORMED QUALITY EFFORT ESF_QA_PLAN – PLANNED QUALITY EFFORT	MONTHLY	MONTHLY	PROJECT MANAGER, TEST LEADER	PROJECT MANAGER

Analysis Procedure Based on Criteria

ID	Premise	Possible Conclusion	Possible Actions
1	The variation is within the organization's acceptable limits, not achieving alarming or critical limits.	The project quality effort is adherent to the Project Plan.	No action is necessary.
2	The variation achieves the alarming limits (upper or lower).	In one or more project iteration the quality effort was higher than planned.	Identify in the detailed graphic the iterations in which quality effort was higher than planned. - Investigate risks occurrence and identify possible contingency actions. - Investigate the existence of problems in requirements that impacted in quality assurance activities. - Investigate changes in the team productivity.
3	The variation achieves the critical limits (upper or lower).		
4	The variation continuously increases	A tendency is rising. It can be resulting of actions taken by the project manager to align the project to its plan, or an effect caused by a behavior that should be investigated.	If the tendency is an expected result due to project manager's actions, it is only necessary to continue monitoring the indicator. If the variation cause is unknown, investigate the affected iterations aiming to identify possible causes for the variations (e.g., changing in the project team). Treat the variation cause (e.g., make changes in team allocations)
5	The variation continuously decreases		

Figure 1. AMS.br Template

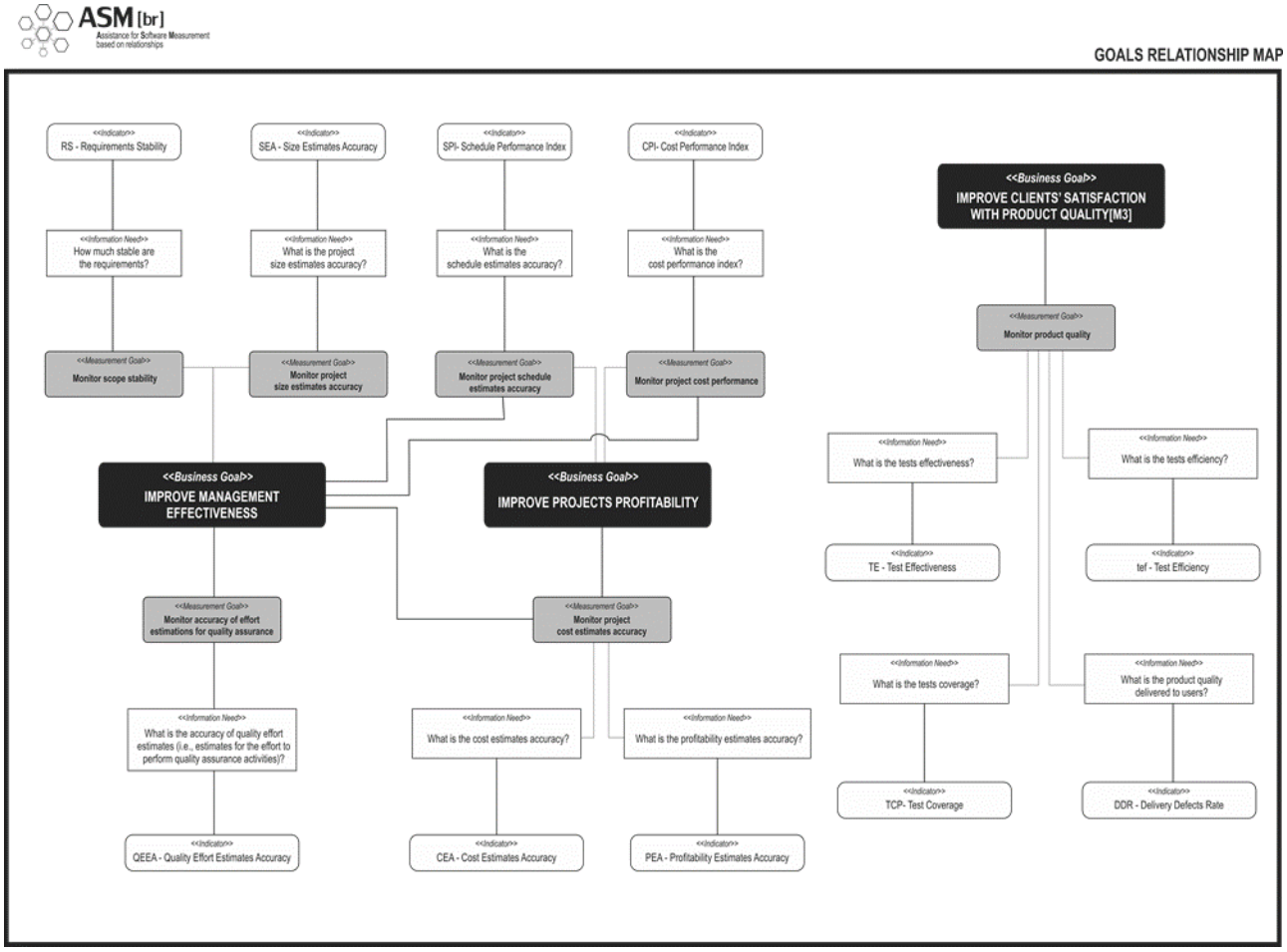


Figure 2 – A goals relationship map

After planning, we did **preparations for the case study**. We started by selecting the organization. It is a software company founded in 2009 with around 70 employees. The study involved 8 employees from the organization management team, being two directors, two senior managers, two medium managers and two technical leaders. Next, we characterized the organizational scenario in which ASM.br would be used. Interviews were carried out aiming to get information regarding goals and indicators used by the organization, as well as new indicators that could be useful. Since the organization had many indicators and goals, we decided to consider only a part of them enough for ASM.br first evaluation. Table 1 presents some of the indicators used in the study.

During the study execution, we performed the procedure established in the study planning. A training was given to the participants, explaining the ASM.br concepts and how to fill in the template, as well how to elaborate and use relationship maps. Thus, interviews and meetings were performed to get information and fill in the template with indicators specifications. Then, the participants used the relationship maps and selected indicators to include in the measurement plans of their projects. After that, they answered the questions Q1 to Q10. Figure 3 summarizes the number of obtained answers for each question. As shown in the figure, the participants answered "totally agree" or "partially agree" for all the questions.

Table 1 – Some indicators used in the study

Business Goal	Measurement Goal	Information Need	Indicator
Improve projects profitability	Monitor project cost performance	What is the cost performance index?	Cost Performance Index (CPI)
	Monitor project cost estimates accuracy	What is the cost estimates accuracy?	Cost Estimates Accuracy (CEA)
		What is the profitability estimates accuracy?	Profitability Estimates Accuracy (PEA)
	Monitor project schedule estimates accuracy	What is the schedule estimates accuracy?	Schedule Performance Index (SPI)

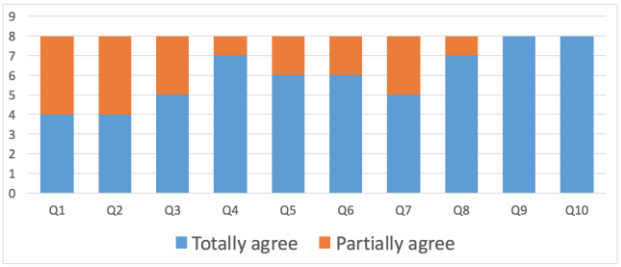


Figure 3 – Participants feedback

Two participants said that they perceived ASM.br as a useful solution, but they did not feel comfortable to totally agree with its usefulness based only on the experienced use, since it was limited. Some participants showed concern with the manual work required to use ASM.br.

The study results show a positive acceptance of the proposal in the organization and can be understood as initial evidences of ASM.br usefulness and feasibility. However, some limitations do not allow generalizing the results, such as: only one organization was considered; the study was performed with intervention of one of the authors; a limited number of indicators was considered; and the study did not address indicators specifications maintenance and evolution. Thus, new studies are necessary to better evaluate and improve ASM.br.

5 Concluding Remarks

This paper introduced ASM.br, a template that helps record indicator specifications in a standardized way, making explicit relationships between indicators and between them and goals. Indicator specifications include textual and graphical information organized in a one-page form. It is important to notice that ASM.br is not a stand alone proposal. It can be used combined with other measurement planning approaches. For example, when using GQ(I)M [10] to plan measurement, ASM.br template can be used to record the specifications of the defined indicators.

We expect that the use of ASM.br contributes to indicators understanding and reuse. Information recorded in the ASM.br template can be used to create relationship maps that support indicators selection considering elements related to them (e.g., goals, information needs, CMMI levels). This can reduce time spent when creating measurement plans. Moreover, knowing the relationships between indicators help data analysis.

We have conducted an initial evaluation of ASM.br. The results, although cannot be generalized, pointed to the proposal usefulness and feasibility. It is still necessary to evaluate the use of ASM.br in more practical contexts, when indicators are used in daily activities. It is also necessary to evaluate the continuous use of ASM.br, which includes the creation, evolution and maintenance of indicators specifications and relationship maps. Furthermore, it is necessary to evaluate the relation between the required effort to fill in the templates and create the maps and the provided benefits from using them.

In addition to perform new studies to evaluate ASM.br, as future work, we intend to develop a tool to support the use of ASM.br. Currently, ASM.br use is supported only by text and graphical editors. We also plan to develop a set of indicators specifications that can be reused by organizations in specific contexts (e.g., indicators related to agile development).

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