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# Performance Indicators for Configuration Management

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**Abstract.** Configuration Management (CM) with its aim to ensure functional and physical consistency between the product requirements and the reality during the whole lifecycle is becoming more and more important, since the awareness of the resulting advantages rises in many companies. The Institute for Information Management in Engineering at Karlsruhe Institute of Technology has developed a maturity model to evaluate the CM maturity for different organizations on the basis of different CM dimensions. The following paper enhances the capability of this model by developing performance indicators, which are aimed at measuring the quality of implemented CM activities as a supplement to their extent of application, which was measured before. Such indicators have been developed based on an extensive state-of-the-art analysis and were validated and refurbished through interviews with industrial experts.

**Keywords:** Configuration Management, Product Lifecycle Management, Performance Measurement, Maturity Model

## 1 Introduction

Configuration Management (CM) can be seen as a coordinated framework of activities to manage and control configurations [1, 2]. Due to the primary aim of keeping consistency between what needs to be there, what is actually there and what we say is there [3], CM provides several benefits. Many researchers confirm that CM exerts positive effects on product quality, product lifecycle costs and therefore on the ability to compete in an environment with growing complexity [3, 4, 5]. Niknam & Ovtcharova [6] have developed a CM maturity assessment framework which enables the organizations to investigate their CM maturity with respect to the extent of CM application throughout the organization. However, for a higher framework capability, concrete measurements are needed to assess the CM quality. Many organizations are already measuring their overall performance

by using performance indicators (PIs), which usually control important business units or the organization as a whole [7]. Well known examples are the Return on Investment (ROI) or the amount spent on research and development. In order to ascertain organizations performance and success in high levels, the performance of every discipline shall be investigated by utilization of detailed PIs. Thus, the aim of this paper is to develop and present PIs for Configuration Management based on the critical success factors and dimensions in the CM Maturity Model [6].

The remainder of this paper is structured as follows. In section 2, the CM Maturity Model of [6] is briefly presented. Later, a general introduction to performance indicators is given. The research methodology is described in section 4 and in section 5 the PIs developed by the authors are introduced. Finally, section 6 gives a conclusion and outlook of future work.

## 2 Configuration Management Maturity Model

Since maturity models available do not cover CM in detail, Niknam & Ovtcharova [6] have developed the Configuration Management Maturity Model (CM<sup>3</sup>). They define five primary dimensions of CM, which influence the level of success for an organization's application of CM discipline. These five dimensions are Strategy & Performance, Processes, Information Technology, Organization & Value-stream as well as Knowledge & Support. Furthermore, they have created sub-dimensions or critical success factors, describing particular activities and attributes of the each primary dimension which needs to be considered for implementation and establishment of an effective CM discipline. (Figure 1)

Strategy & Performance	Processes	Information Technology	Organization & Value-Stream	Knowledge & Support
CM Strategic Objective and Policy	Clear processes	High level of visualization and user-friendliness	Suitable CM Organization Structure with Respect to Organization Complexity and CM Needs	Standard CM Terminology and Knowledge Support Accessible by Stakeholders
Deployment of CM Strategy in Different Organization Levels	Standard processes	Integration of CM-Tool with other IT-Systems	Defined Roles and Responsibilities for CM Personnel	Regular CM-Related Training Activities
Communication of the Deployed Strategy to Stakeholders	Process ownership, maintenance and update based on feedbacks	Supporting the CM-Functionalities	Cross-Functional Collaboration among Different Stakeholders for CM Purposes	Accessibility and Promotion of Latest Standards, Lessons Learned, Best Practices and Benchmarks
KPIs for Performance Measurement	Stakeholder access to processes	Solid IT-Tools all over the Organization for all Lifecycle Phases	Consideration of Suppliers and Subcontractors in CM Activities	Support and Empowerment of CM Discipline by Top Management
Regular Measurement and Update of KPIs	Process customizability for different scenarios	Authorization Capabilities for different CM activities	Involvement of Key Stakeholders in Major Configuration Changes	Communication of CM Benefits to Stakeholders by Top Management

**Figure 1.** CM Maturity Model sub-dimensions

For assessing the current CM maturity of various industries and validating the developed critical success factors, Niknam & Ovtcharova [8] have done a cross-industry survey using the CM<sup>3</sup> model. The results illustrate a high potential for improvement in CM with respect to its penetration level in the organization.

### **3 Measurement by Performance Indicators**

In this paper, as outlined in the Introduction, the assessment framework of CM<sup>3</sup> is enhanced by the development of performance indicators. These performance indicators shall measure the application quality of each sub-dimension. Therefore, only the quality of CM-activities concerning the given sub-dimensions is the point of interest, and not "well-known" measures which focus on the overall performance of a company or different organizational units, as for example Return On Investment. Quality in the context of the indicators refers to the question: "How 'good' is activity A performed?".

Performance measurement in general is used for monitoring and improving performance. Klingebiel [7] highlights that no matter how the performance measurement system looks like, three main perceptions are important:

1. You cannot manage what you cannot measure
2. What gets measured gets done
3. Measurement influences behavior

The three perceptions can be transferred to the context of this paper, since the aim is to manage the improvement of CM.

### **4 Research Methodology**

In order to get a first list of possible PIs for the different sub-dimensions, a broad literature analysis was done. Based on this first collection, the authors conducted semi-structured interviews with industry experts to both validate the indicators and adjust them with respect to their feasibility of application, data availability and importance. The interviews have been done with four experts, coming from automotive and aerospace industry, from plant engineering industry as well as engineering consulting. Summarized about 7 hours of interview time have been done. As a result of the interviews some of the indicators have been approved without any further remarks, some have been supplemented for a better understanding, and a few have been excluded because of doubts about the general significance.

## 5 Performance Indicators

The authors propose the following performance indicators. They are presented in the following format in 3 columns.

Performance Indicators: % - percentage # - number/amount of ∅ - average	Initial source: [ ] : Reference A : Authors' proposal I : Interview	Expert Comments: V : validated U : updated E : emerged - : Not sure
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### Strategy & Performance

<b>CM Strategic Objective and Policy:</b> For successful CM, objectives and policy should be available and be adapted to the corporate strategy		
- % to which CM strategic objectives are derived from overall strategy: the CM strategy needs to fit to the company's overall goals to support their achievement	[9] [10]	V
- Actual frequency / target frequency of updating CM objectives: CM objectives need to be rechecked regularly to be adapted to new corporate goals	[9] [11]	U
- % to which CM policy & objectives are covering all main CM activities in the organization: proper policy and objectives should cover all important subjects to avoid confusion and constitute a guideline	[12] [13]	V
<b>Deployment of CM Strategy in Different Organization Levels:</b> CM strategy needs to be deployed to all levels to provide adapted objectives for all teams		
- % of deployed goals, which can be clearly linked to a higher CM objective	[10] [14] [15]	V
- # CM units having a mission statement that clearly defines their objectives and mission: it is important that all organizational units know what they need to do to achieve main CM objectives	[1]	E
<b>Communication of the Deployed Strategy to Stakeholders:</b> To be able to support CM objectives and policy guidelines, the strategy has to be communicated to the stakeholders		
- # of strategic deviations associated to communication: communication quality can be assessed by conducting audits.	[16]	U
- % employees who can explain the CM strategy and what it means in terms of their daily work: if employees know how their work contributes to CM success the communication has worked properly	[16]	V
- Effectiveness of policy implementation: the policy should not only be mentioned on a document but it should be understood and applied in the operative business	[14] [15]	V
<b>KPIs for Performance Measurement:</b> The fulfillment of objectives needs to be measured with Key Performance Indicators		
- Quality of data available for KPI results (sufficient quantity, completeness): if the database for the KPI application is not sufficient,	[17] [18] [19]	V

then the KPI results won't be reliable		
- # of KPIs: an organization should always focus on a limited number of KPIs to keep the focus	[18]	-
- % KPIs linked to strategic objectives and critical success factors:	[20]	V
- % KPIs from which an action plan can directly be started in case out-coming results are bad: KPIs should always point out success and drawbacks	[18]	-
- Frequency of KPI reviewing and improvement: the usefulness of a KPIs should be checked regularly	[18]	U
<b>Regular Measurement of KPIs:</b> KPIs needs to be measured regularly		
- Frequency of measurement and reporting: depending on the focus the measurement needs to take place constantly and results be reported	[18] [17]	V

### Processes

<b>Clear processes for different org. units, projects and lifecycle phases:</b> Processes should be defined, transparent, controllable, effective, efficient, straightforward, robust and at a right level of detail.		
- # questions/requests about processes due to a lack of understanding: clear processes should be defined in a comprehensible way	[21]	U
- % cases where the result of the process is constructive in a way that predefined objectives are achieved	[21, 22]	U
<b>Standard processes:</b> Standard CM processes like configuration identification, baselining, product structure management, change evaluation –control & implementation, status accounting and configuration audits.		
- Ø time to approve Engineering Changes	[17, 23, 24]	V
- Ø costs per change	[17, 23, 24]	V
- # non-confirmative configurations at the final product: all standard processes are trying to prevent these deviations	[I]	E
- Frequency of reports and audits	[23]	V
- # deviations to make a “fast” design change: this kind of deviation should be totally avoided	[17]	-
<b>Process ownership, maintenance and update based on feedbacks:</b> A specific person is responsible for a process - processes are maintained, updated and improved - feedback among the employees is encouraged and maybe rewarded.		
- Ø benefit per feedback: if possible to measure financial	[A]	V
- Frequency of feedbacks: more reasonable if combined with the benefit	[21, 22]	U
- % of processes with a specific and active process owner, who is responsible for process audit and the interfaces with adjacent processes	[21]	U
<b>Stakeholder access to processes:</b> Access of stakeholders to process information must be defined and managed in an efficient way.		
- Ø Time until process information can be found by the stakeholder	[A]	V
- % of satisfied stakeholders regarding accessing process information	[25, 26]	U
<b>Process customizability for various scenarios:</b> Processes should be able to handle different requirements in a continuously changing working environment.		

- Availability of shortcuts: increases the efficiency for less complex scenarios (also called fast tracks)	[21]	V
- # scenarios which cannot be covered by the company's processes: this can be minimized by very robust or flexible processes – some industrial sectors need very flexible processes others very robust ones	[I]	E

### Information Technology

<b>High level of visualization and user-friendliness:</b> IT-tools should be easy to handle and operate as well as being capable of providing all the information needed. The user should like the usage of these tools and recognize the benefits easily.		
- Ø time a user needs to complete a specific task: this standard tasks must be executed with the IT-system	[27]	V
- IT-happiness-score: measuring the satisfaction level of stakeholders with the CM IT system	[27]	V
- Meaningful and intuitive wording is used for the user interface and wrong data typed in by the user is avoided	[28, 29, 30, 26]	-
<b>Integration of CM-Tool with other IT-Systems</b>		
- % time spent on finding CM-information in the IT system out of overall time spent on CM-activities: if many IT-systems must be accessed, systems are not integrated efficiently	[A]	V
<b>Supporting the CM-Functionalities</b>		
- # processes developed based on given IT-systems: should be minimized because the IT-systems must be specified by CM needs and processes and not the other way around	[A]	V
- % CM-activities supported by IT	[23, 24]	V
<b>Solid IT-Tools all over the Organization for all Lifecycle Phases</b>		
- # cases during the product lifecycle where the format of information needs to be changed because of different IT-tools or databases	[23]	V
- Frequency of data backups	[32]	V
<b>Authorization Capabilities for different CM activities</b>		
- # access rights following logical, transparent and comprehensible rules which are defined by the company	[33, 34]	V
- Ø loss due to wrong authorization	[A]	-

### Organization & Value Stream

<b>Suitable CM Organization Structure with Respect to Organization Complexity and CM Needs</b>		
- # of CM employees / product complexity: if there are different product programs with different variants and the amount of products are high, more contributions are necessary	[9] [35]	U
- CM integration / organization complexity: for managing high complexity a high degree of integration, defined as communication, control and coordination, is necessary	[35]	V
<b>Defined Roles and Responsibilities for CM Personnel:</b> all required roles need to be de-		

fined clearly and the responsibility needs to be distributed to individuals		
- # escalations caused by unclear responsibilities (difficult to measure, could be also assess in audits): if responsibilities are unclear misunderstandings will occur which can end in escalations	[9] [5]	V
- % roles which are clearly defined and documented	[A]	E
<b>Cross-Functional Collaboration among Different Stakeholders for CM Purposes:</b> CM is a cross-functional discipline, which is why the collaboration between functions is required by CM's very nature		
- % of process target achievement for each value chain element: an effective cross-functional collaboration between stakeholders along the value chain will enable every chain element to achieve its goals corresponding to CM activities	[A]	E
- Cycle time per changes involving the value-chain: if collaboration works well, such changes should be able to get passed through fast	[A]	E
- # revisions for change changes involving the value-chain: if collaboration works well revisions should not be necessary	[A]	E
<b>Consideration of Suppliers and Subcontractors in CM Activities:</b> suppliers need to be integrated in CM activities to ensure the CM targets for sourced parts		
- # non-conformities resulted from lack of value-chain involvement: if the exchange of information about changed specifications, requirements etc. does not work well, non-conformities can occur	[9] [24]	U
- # of non-conformities (opposite perspective): if the contractor does not deliver what has been specified, non-conformities can occur	[13] [5]	U
<b>Involvement of Key Stakeholders in Major Configuration Changes:</b>		
- # of complains after changes were implemented (internal or external)	[5] [13]	V
- # of review cycles needed for changed implementation: if all stakeholders are involved from the beginning, changes can be defined in detail and implemented without any more changes to the change	[A]	E

## Knowledge and support

<b>Standard CM Terminology and Knowledge Support Accessible by Stakeholders</b>		
- Frequency of updating the provided information: ensuring actuality of information	[19] [36]	V
- Ø time to find the needed information: ensures a convenient access to knowledge	[36] [19]	V
- # of audit findings illustrating insufficient knowledge of the employees in CM	[A]	E
<b>Regular CM-Related Training Activities:</b> Employees need to be prepared for CM tasks by trainings to ensure the quality of the task execution		
- % of CM activities for which training is available	[17] [24]	V
- Ø amount of training taken by each employee associated with CM	[24] [17]	V
- # of obligated trainings for each role: if the training is necessary to fulfill a role/ tasks it is a sign for a high quality of the training	[A]	E
<b>Accessibility and Promotion of Latest Standards, Lessons Learned, Best Practices and</b>		



<b>Benchmarks</b>		
- % of projects for which CM lessons learned is recorded and accessible by future stakeholders	[19]	V
- % coverage of CM activities by standards and benchmark documents accessible to corporate search engines:	[19]	V
- % of lessons learned used in future projects	[9]	U
<b>Support and Empowerment of CM Discipline by Top Management:</b> To ensure the fulfillment and acceptance of CM, management support is necessary		
- % of management attending CM meetings:	[A]	E
- Frequency of management demands for CM reports: indicates that management's attention to CM	[A]	E
<b>Communication of CM Benefits to Stakeholders by Top Management:</b> For motivation and acceptance of CM it is necessary that the benefits are communicated to all stakeholders		
- Frequency of promoting CM as an influential discipline by Top Management	[37]	-

## 6 Outlook

In this paper, performance indicators for the sub-dimensions of the Configuration Management Maturity Model have been introduced. The developed PIs extend the model's functionality and enable the assessment of not only the implementation extent of CM in the target organization, but also the quality of this implementation. The PIs so far are identified on the basis of literature review and expert interviews. A necessary further step is to apply the PIs in a case organization to find out the feasibility measuring them. The trade-off between the importance and measurement feasibility shall be identified and a more applicable list of KPIs shall be developed. Moreover, to enable an assessment and identifying various maturity levels, an extensive cross-industry assessment is required to understand various available ranges for each PI. After defining the levels the next step would be to define activities which support organizations in achieving the next maturity level.

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