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State of the Art Assessment on Process Performance Measures

Patterns & Agility for Capability Engineering Methodology - Requirements Engineering (PACEM-RE)

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Defence R&D Canada – Valcartier
Contract Report
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Abstract

This report provides a state-of-the-art review on the subject of process performance measures and more specifically on how performance measures could be applied to the Capability Engineering Process (CEP) to evaluate the performance of CEP instances. Special emphasis was put on the concept of “agility”.

The review of literature explores the current definitions, concepts and best practices.

The results of this study aim to provide recommendations to establish a performance measures and a performance measuring system appropriate to the Department of National Defence (DND) Capability Engineering Process (CEP) to potentially assess whether or not the use of patterns makes the CEP more “agile”.

Résumé

Ce rapport fournit une revue de l’état actuel des processus de mesures de performance et plus spécifiquement comment un système de mesures de performance peut être appliqué au processus d’ingénierie des capacités (PIC) pour mesurer la performance d’instances de son utilisation. L’accent a été mis sur le concept d’agilité.

La revue de littérature explore les définitions, les concepts et les dernières pratiques.

Les résultats de cette étude visent à fournir des recommandations pour élaborer et implanter un système et des mesures qui puissent être utilisées à l’intérieur du processus d’ingénierie des capacités (PIC) du ministère de la défense nationale (MDN) pour éventuellement évaluer l’agilité du processus lors de l’utilisation de « patterns ».

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1 Introduction

We present this report to DRDC-Valcartier for the Patterns and Agility for Capability Engineering Methodology – Requirements engineering (PACEM-RE) Applied Research Project (ARP).

This report provides a state of the art review for the definition of measurement metrics for the Capability Engineering Process (CEP)[1].

1.1 Understanding of purpose and scope

It is understood that the issue is to investigate whether the use of "patterns" within the CEP process would make it "better" or more "agile" than its current designed version. This understanding is based on the technical bid of the response to the RFP nbr W7701-083296/A.

The **purpose** of this report is to give concepts, indications and recommendations to allow for the evaluation of the performance of instances of the CEP with or without the use of patterns.

It is understood that the **scope** includes the Capability Engineering Process (CEP) from inputs to outputs and goals. The scope is concerned with the quality of the process and not of the results directly.

1.2 Organization of the Report

This report is organized as follows:

1. First, a series of definitions and concepts are explained to ensure consistency of discussion ;
2. Second, performance measures are discussed in general and also as to their applicability to the problem at hand;
3. Third, some methods are proposed to build a performance measurement system; and
4. Finally, recommendations are provided for the next steps.

[1] DRDC Valcartier TM 2004-425, CapDEM TD: The Capability Engineering Process (CEP) Foundations, Nov 2005

2 Concepts

2.1 Definitions

The following definitions are provided to ensure that readers have a common understanding of the terms used herein.

Activities are the main components of a process. Activities are the actions performed on the inputs using the assets available to produce an output.

Assets are a type of resource that is not typically consumed by the process. Humans, tools and infrastructure, like buildings, are examples.

Agility is generally defined in the business domain as the capacity to achieve quick results based on the declaration of a new need or change in a need. Because there is a possibility that "Agility" becomes the central performance measure of the PACEM-RE project, it is further developed in section 2.7 below.

Evidence: is something that tends to prove[2].

Flexibility/adaptability: adjustable to change; capable of modification[3]. Flexibility consists in a design that can adapt when external changes occur[4]. These two terms are not used in the text below. The definition is provided because these two terms often pop up in conversation about agility.

Inputs: are types of resources also described as raw materials. They are transformed by the process into an output, typically a product or service.

Goals are targets defined by an organization for the process.

Key Performance Indicator (KPI): are financial and non-financial metrics used to quantify objectives to reflect strategic performance of an organization[5].

Maturity: is one of several process metrics. In the context of business process maturity it refers to a compendium of the following qualities: predictability, control, and effectiveness. Maturity is concerned with the attributes (i.e. the management activities) of the process that allow it to be controlled predictable and effective[6].

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2 Webster's New World Dictionary
3 Webster's New World Dictionary
4 http://en.wikipedia.org/wiki/Flexibility
5 http://encyclopedia.thefreedictionary.com/ key+performance+indicator
6 See for example http://personal.stevens.edu/~mmuehlen/downloads/slides/bootcamp/Session-3-TYH-BPM_Maturity.pdf. Maturity is a term that has been made popular by the Capability Maturity Model Integrated (CMMi) by the Software Engineering Institute (SEI)

Measurement: A set of observations that reduce uncertainty and where the result is expressed as a quantity[7]. Herein, it is also defined as one instance of a metric.

Measurement of risk: A set of possibilities each with quantified probabilities and quantified losses. For example, "We believe there is a 40% chance the proposed oil well will be dry with a loss of $12 million in exploratory drilling costs"[8].

Measurement of uncertainty: A set of probabilities assigned to a set of possibilities. For example, "There is 60% chance that this market will more than double in five years, a 30% chance it will grow at a slower rate, and 10% chance the market will shrink in the same period"[9].

Need is a call or demand for possession or presence of something[10]. A need may be addressed by the outcome generated by an output.

Outcomes are the effects created by the outputs on the environment or the stakeholders. Outcomes are the results of releasing the products or services to the stakeholders.

Outputs are the products or services produced by the process.

Metrics are a system of parameters or ways of quantitative and periodic assessment of a process that is to be measured, along with the procedures to carry out such measurement and the procedures for the interpretation of the assessment in the light of previous or comparable assessments[11].

Objective (Goal): A desired end point[12].

Performance: The way someone or something functions[13]. See "More on Performance Definition" below for more specific details.

Point Measures: are measures expressed as a single quantity. For instance, the room is 15 feet wide.

Process: from an engineering point of view, is a set of transformations of input elements into products with specific properties, characterized by transformation parameters[14].

Proxy: As in measurement proxy, is the "unit of measure". It is a recognized "standard" against which the "value" is compared. Let's take an example; length can be measured in inches, centimetres, steps, parsecs, light-years, etc. Each of these is a possible measurement proxy.

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7 Hubbard D. W., How to Measure Anything: Finding the value of Intangibles in Business, John Wiley & Sons, 2007, p. 21

8 Hubbard, D. W., How to Measure Anything: Finding the Value of Intangibles in Business, John Wiley and Sons, 2007, p. 47

9 Hubbard, D. W., How to Measure Anything: Finding the Value of Intangibles in Business, John Wiley and Sons, 2007, p. 47

10 Webster New World Dictionary

11 http://encyclopedia.thefreedictionary.com/metrics

12 http://encyclopedia.thefreedictionary.com/objectives

13 Webster`s New World Dictionary

14 http://en.wikipedia.org/wiki/Process

Range Measures: are measures expressed as a probability (i.e. a confidence interval) of the real measure being between an upper and a lower limit. For example, there is 90% chance that the room's width is between 14 and 16 feet. Because absolute certainty does not exist then it is recommended to express measures as ranges. For example, 90% sure that values lie between lower bound and upper bound[15].

Risk: A state of uncertainty where some of the possibilities involve a loss, catastrophe, or other undesirable outcome[16].

System: is a set of interrelated components working together toward some common objective[17]. For the specific purpose of CEP, a system is a global unit organized into relationships between process, people and materiel (including facilities, software, etc.) to satisfy a stated need. In the context of CEP, a system is a mean of contributing to the delivery of a capability through a grouping of PRICIE elements[18].

Uncertainty: The lack of complete certainty, that is, the existence of more than one possibility. The "true" outcome/state/result/value is not known.[19]

2.2 Goal of performance measurement

The intention behind the establishment of performance targets is to focus organizational attention on particular outputs and outcomes, and to align the behaviour of individuals with overall organizational goals and the expectations of stakeholders.

For CEP, the first step is to define what the focus of the performance measurement system (or metrics) should be. A recommendation will be made on this in the last chapter of this report.

The understanding is that the focus would be to evaluate whether "patterns" improve the agility of the CEP or not. We also understand that CEP does not have a performance measurement system. The concepts, notions and ideas developed below should be general enough to contemplate the establishment of a CEP performance measurement system and also specific enough to devise metrics to evaluate the agility of patterns[20].

15 Hubbard, D. W., How to Measure Anything: Finding the Value of Intangibles in Business, John Wiley and Sons, 2007

16 Hubbard, D. W., How to Measure Anything: Finding the Value of Intangibles in Business, John Wiley and Sons, 2007, p. 47

17 Blanchard B.S. and Fabricki W.J., Systems Engineering and Analysis, Prentice-Hall, 1990, p. 2

18 CEP Online

19 Hubbard, D. W., How to Measure Anything: Finding the Value of Intangibles in Business, John Wiley and Sons, 2007, p. 47

20 Rosser, Bill,, *Process Performance Metrics: Guidelines for BPM Success*, Gartner ID G00162308, dated 19 Nov 2008

2.3 Process as a system

Processes are systems that transform inputs through a series of activities performed by assets into outputs that create outcomes that, hopefully, fulfill the needs of stakeholders. Each of these seven elements is discussed below. Their relevance to CEP is also discussed.

A good process should also be easily modeled or described. This is a condition to a good performance measurement system. A good process model almost generates its performance measures automatically[21].

2.3.1 Inputs

Inputs, the raw materials to be transformed by the process, are usually measured in terms of quantity, availability and timing. The goal is usually to reduce their amount to a minimum (notion of efficiency), for a minimum cost (notion of economy) and have them available just-in-time.

For the CEP, inputs would be information about the capability gap (the requirements and goals) and the possible solutions.

2.3.2 Assets

Assets are typically buildings or infrastructure, equipment and people. They are investments not transformed into the product. Rather, the “host” the process

Assets are usually measured in terms of cost, productivity and durability. Their cost is fairly constant. The goal is usually to maximize productivity and durability while minimizing maintenance costs.

For the CEP, the main assets used are people and the knowledge of the CEP itself. The measurements would focus on the quantity of human resources and their costs. This is something that is measurable for instances of the CEP using patterns or not.

2.3.3 Activities

Activities are a more granular level process. Activities have inputs, assets and outputs. Therefore the general metrics applied to a process can also be applied to an activity.

The most common metrics or measures are concerned with throughput, capacity, reject or defect rates (notion of rework).

The set of activities can also be examined as a whole. The number of activities can be counted; flow or throughput (i.e. dead time between activities) can be measured.

For the CEP, at a granular level, the number of activities, duration and effort expended by each could be measured. This would require a time tracking system as most activities are based on human resources creating deliverables (i.e. outputs). Additional criteria could be set around cost and customer satisfaction. This can be done for both patterned and non-patterned instances of the CEP.

[21] Schacter, Mark, Not a “Tool Kit”: Practitioner’s Guide to Measuring Performance of Public Programs”, ©Institute on Governance, 2002, p. 12

2.3.4 Outputs

For them the best metrics are those set by the definition of the goals (see below). Outputs are compared to the goals.

In the case of CEP, outputs consist in recommendations or decisions. They are the deliverables defined in the process. This is where the recommendations/outputs are evaluated against one of the capability gap and the proposed performance criteria set for CEP.

2.3.5 Goals

Processes aim to achieve goals through the outputs produced. This goal is also a prerequisite to strategic performance measurement. Normally, the goals are set first for survival or through the interpretation of a need. The set of outputs is then designed and decided upon to achieve the goals.

The CEP has goals[22]. They would be the start point for the design of a CEP process performance measurement system. On the other hand, if the goal is to measure the variation in agility through the use of patterns, then the goals of the CEP are irrelevant. A decision would have to be made on this issue.

2.3.6 Outcomes

Outcomes are generated by the outputs. They might be direct and indirect; immediate, intermediate (in time), or ultimate; intended, and unintended. For example, a direct outcome of a served meal (output) in a restaurant is the reduction in the hunger of the client.

Mostly outcomes are evaluated in terms of their relationship between outputs and the needs. This is a strategic element whereas “agility” is an operational element. If the goal is to measure the agility of the CEP then outcomes are not relevant measures. On the other hand, if the goal is to measure the performance of the CEP including its strategic elements then outcomes would have to be quantified and evaluated.

2.3.7 Needs

The “needs” are the requirements, expressed or not, of the stakeholders or the market. They are the “given” against which outcomes are measured. They are external to the operational process.

If the goal is to measure the agility of the CEP, then “needs” should be set as fixed or rather, the same “new need” or “need change” should be applied to both CEP processes (with and without patterns) to see which one is more agile (i.e. responds more rapidly to the change).

22 DRDC Valcartier TM 2004-425, CapDEM TD: The Capability Engineering Process (CEP) Foundations, Nov 2005, p. iii

2.4 Strategic, Operational and Compliance Performance

Performance is often qualified in terms of "levels": strategic, and operational. There is also a notion, especially in a public organization of compliance to the rules and regulations under which the organization operates.

Following is a short discussion of terms as they relate to the systemic approach explained above.

2.4.1 Strategic Performance

Strategic performance relates to how the organization relates to its environment, long term goals and its "survival". There are two main strategic criteria:

1. **Relevance** evaluates the relation between outcomes and needs. It is concerned with the survival of the organization in its environment. It compares the outcome created by an output to the needs of the stakeholders. For CEP, this criterion would help evaluate the relevance of the recommendation produced by the instance of the CEP to the needs expressed by the decision maker. We would have to be able to differentiate between the recommendations produced by the "generic" (i.e. without patterns) and "patterned" processes; and

2. **Durability:** relates to the longevity (i.e. the relevance over time) of the outcomes to the needs. For CEP, this criterion would be difficult to measure because the time span is only for the duration of the process. Such a measure would require measures well after the completion of the process.

Note that persistence is also a notion of durability but it is operational. It is concerned with the effectiveness over time of the output in adverse conditions (see below).

2.4.2 Operational Performance

Operational performance relates to how inputs relate to outputs; and how outputs relate to goals. The focus is on the operation, the process. There are three groups of criteria:

1. **Effectiveness**: establishes the relation between outputs and goals. It requires critical goals that can bring visible progress and enhancement. In the case of CEP, it is concerned with whether or not the use of patterns allows better recommendation or not; and

2. **Efficiency**: establishes the relation between resources used and minimum resources possible. In the CEP, did the use of patterns reduce or not the quantity of resources? Agility would be one of the sub-criteria to efficiency: did the use of patterns allow for faster (i.e. less time) reaction to changing requirements or goals?

3. **Economy**: is concerned with the cost of the resources: with the question "Were the resources acquired at the lowest possible cost?" For CEP, the use of "patterns" should not affect the acquisition cost of the resources. This criterion is probably most likely not relevant. However, costing the resources should not be too difficult and could be entertained.

Most often the environmental resources that are not paid for, for example air or waste left in the environment, are not counted in this equation.

2.4.3 Compliance

2.4.3.1 Financial Performance

Financial performance has several meanings:

- It relates to the relationship between the actual spending and the budget. In that case, it is a concept of effectiveness as it compares a result (i.e. the actual spending) with a goal (i.e. the budget);
- Financial performance is also a concept of efficiency and economy that strives towards the minimum use of financial resources.

Generally, cost (i.e. money) is the measure of choice because it is a common denominator to all the types of resources (e.g. human resources, assets, raw materials, time, and products)

For CEP, measuring the cost of a CEP instance and comparing it to its estimate or budget should be part of the basic project management practices. In the measurement of the agility of the process, costs are not necessarily relevant because agility is more a notion of time.

2.4.3.2 Legal Performance

Legal performance is a control measure that ensures that the project or process abides by the applicable rules and regulations. It is more of an audit function than an actual measure of performance.

Note that ensuring that financial reporting is done according to the administrative, accounting and financial rules and regulations, is also a notion of legal performance.

CEP, like any other type of process should incorporate legal controls to ensure not only its legality both its compliance to the applicable DND policies, rules and regulations as well as those from Treasury Board and government legislation. However, this is assumed to be outside of the scope of this project.

2.5 Risk in performance measurement

There are several risks associated with measuring performance, for example:

- The measurement could be wrong, for example, counting 3 hours instead of 2;
- The measure proxy could be wrong, for example, measuring in inches rather than meters when all other proxies are in the metrics system;
- The goal of the performance measurement system could be wrong, for example, performance being defined as fire power in a situation where survival depends on agility;
- The measuring system introduces “perverse incentives”, for example, when rewards are based on production volume rather than profitability and the organization ends up with huge unnecessary stocks;
- The performance measuring system has no credibility.

The best mitigation strategy is to build **governance** around the performance measurement system itself: who will be responsible for what and what will be the controls that will ensure that measurements are planned, made and reported on. This will allow risk mitigation and contingency planning as well as monitoring.

For CEP, governance is already in place. There might be a need to establish a specific governance if the goal is to establish a permanent process measurement system. If the goal is to measure agility only than the project management office should be sufficient to "govern" this experiment.

2.6 Evidence: to back the performance measures

For any measurement system, evidence is the careful collection and documentation of the measures. This is a minimum requirement to avoid the issue of credibility (see risk above). Any performance measure should be traceable back to an actual measure devoid as much as possible of subjectivity.

Designing the measurement system for CEP, whatever the purpose, should include a clear definition of how the measurements will be taken, how they will be collected, stored and used.

2.7 Agility

Agility has several slightly different meanings depending in which context it is used. A survey of these is proposed with recommendations as to their usefulness in evaluating the use of patterns in the CEP.

The dictionary defines agility as "quick and easy of movement"[23]. This is a good general definition but not very useful for the CEP and evaluating the agility of CEP when using patterns.

In the general context of business, agility is defined as the capability of rapidly and cost efficiently adapting to changes[24]. This is a more useful definition in that "rapidly" (a notion of time) can be measured and so can "cost efficiency". There is no notion of effectiveness in this definition.

Agility is also a very popular term in software development: "The rules of the agility game [in software development] are relatively simple:

- Work in short release cycles;
- Do only what is needed without embellishment;
- Don't waste time in analysis and design, just start cutting code;
- Describe the problem simply in terms of small, distinct pieces, and then implement these pieces in successive iterations;
- Develop a reliable system by building and testing increments with immediate feedback;
- Start with something small and simple that works, then elaborate on successive iterations. Maintain tight communication with clients and among programmers.; and
- Test every piece in itself and regression test continuously[25]".

An "Agile software development process" seems to be agile because it is fast (little use of the time resource) simple and focused. It does away with the superfluous, overhead and minimizes

[23] Webster's New World Dictionary
[24] http://en.wikipedia.org/wiki/Agility
[25] Constantine L.L., Process Agility and Software Usability: Toward Lightweight Usage-Centered Design, Constantine & Lockwood Ltd, University of Technology, Sydney, reprinted from Information Age, August/September 2002, p. 3

requirements definition. It is defined as focused in that it is based on a direct interface with the client and small deliverable increments.

In the context of process management, agility may be evaluated by certain capabilities of the process. For example, among others:

- The ability to make in-flight changes to a process or processes without having to re-start the process from the beginning;
- The ability to pause or re-start a process at any point;
- The ability to deploy new versions of a process without affecting existing running instances;
- The ability to specify the date and time a new version of a process should take effect without being dependent on staff to deploy the process[26];

One of the secondary goals of the CEP is to: "Facilitate strategic agility in capability-based planning"[27] Agility principles mentioned[28] refer to "evolutionary acquisition", "deliverable centricity", "information sharing", "enforced roles & responsibilities", "workflow guidance", and "transformation enabler".

The CEP team could start the next phase of the project about selecting and defining the specific measurement process for the "patterns" experiment by identifying the specific agility measures derived from the definitions and CEP agility principles defined above.

2.8 Granularity

A process is composed of activities, which, in turn, could be made of tasks. Tasks will most likely be built from sub-tasks, and sub-sub-tasks Granularity relates to the level of detail at which the measures are taken.

Naturally the lower the level of measure, the more detail available. However, there are additional costs due to the additional number of measures taken.

For CEP, a decision has to be made as to how far down we need measures. The decision has to be based on materiality and costs (see below).

2.9 Materiality

Materiality refers to the importance or significance of an element of information[29]. This importance or significance is always in reference to a decision: could the element of information change the answer to the decision? If it is clear that the element of information will not change the answer to the decision then it is not material.

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26 http://www.bluespringsoftware.com/process_agility

27 DRDC Valcartier TM 2004-425, CapDEM TD: The Capability Engineering Process (CEP) Foundations, Nov 2005, p. iii

28 DRDC Valcartier TM 2004-425, CapDEM TD: The Capability Engineering Process (CEP) Foundations, Nov 2005, table 2 pp. 34-35

29 Translated from the Dictionnaire de la comptabilité et de la gestion financière par Louis Ménard, CA édité par l'ICCA, 1994

Materiality often refers to the level of information details or the granularity required in making a decision: will the additional level of detail change the response to the question? If not, the added details are not material. The goal is to organize the performance measures to be "material" but no more.

For CEP, it would most likely be at the activity level, one level down from the process (Process, activity, task and step).

Materiality also refers to the quantity of information or quantity of measures: will the additional information change the decision? Again, a decision has to be made on this subject as part of the design of the measurement system.

2.10 Cost in measurements

Information and measures incur cost to be acquired, stored and used. Costs increase with the quantity and the complexity of measures. The focus is to acquire the smallest number of the simplest measures that will allow good decision making.

There are only three reasons why information has value to an organization[30]:

- Information reduces uncertainty about decisions. This has economic value;
- Information affects the behavior of others. This has economic value; and
- Sometimes, information has its own intrinsic market value.

For CEP, the cost of the measurement system should be taken into account whether it is to measure the agility of the process or its overall performance.

2.11 Scope, "externalities", and environment

Externalities are effects of a process on its environment that are not paid for. Usually, they consist in some form of waste disposal or use of a common environmental resource like air or water.

These are not usually measured although there is a trend toward more of these types of measures.

Because CEP produces recommendations or decisions and has little use of common environmental resources, it is not recommended to be part of the performance measurement system scope.

2.12 Comparability

Measures of performance are usually compared to some sort of standard. Those "standards" usually come from three sources: the same process historical performance, industry statistics (i.e. comparable processes from competitors), or previously set goals (e.g. budgets or plans).

[30] Hubbard, D. W., How to Measure Anything: Finding the Value of Intangibles in Business, John Wiley and Sons, 2007, p. 86

For CEP, it could be compared as follows:

- CEP's agility with or without "patterns": this would require parallel projects;
- CEP to industry standards: it would require research into statistics for similar decision making processes. This is unlikely. The brief Web search has provided no significant information or industry standards in this field;
- CEP to goals: There are three possibilities:
    - Results to goals of the CEP instance: This involves comparing the recommendation generated by the CEP instance (i.e. the output) to the goals defined at the beginning of the instance. For example, how does the recommendation compare to the goal of detecting and identifying users of the North West Passage. This measurement is imbedded in the CEP process through the "Options Analysis". It is part of the process; and
    - CEP Process to CEP Goals: The CEP itself has goals, for instance, "better decision making"[31]. To achieve this measure, metrics and a measurement plan have to be defined. The process outlined in section 5 could be used; and finally
    - Results of the PACEM-RE project to its goals: This last possibility is about improving the CEP with the use of "patterns". Set goals are required. This is feasible if not already done. This is a minimum whether for the measurement of agility or general performance of CEP. Again section 5 could be used to define a measurement plan for this specific purpose;
- CEP to nothing: this would provide performance results that could be used to compare to future projects but would not provide performance evaluation.

The difficulty is to be clear about which results should be compared to what goals … and not to mix things up.

2.13 Conclusions on concepts

The concepts detailed above are provided to foster a common understanding and to organize the discussion about setting up a measurement system for CEP. The most important notion is to plan the measurement system correctly with the following thoughts in mind:

- The process is a system. It is extremely important to figure out the goal for what we are trying to measure. It is also extremely important to understand/model the process. What is the goal, and what is the process that we are trying to measure?
- Secondly, we have to know what will not be measured and why. "The foundation of a good performance story is a detailed understanding of the [process] whose performance is to be measured"[32].
- Thirdly, is the notion of cost of the measurement system what is the minimum level of granularity and materiality required to achieve the measurement goals?

[31] DRDC Valcartier TM 2004-425, CapDEM TD: The Capability Engineering Process (CEP) Foundations, Nov 2005

[32] Schacter, Mark, *Not a "Tool Kit": Practitioner's Guide to Measuring Performance of Public Programs*, ©Institute on Governance, 2002, p. 1

3 Performance Measures

3.1 Attributes of good performance measures

Good performance measures should show the following attributes. This list could be used to evaluate the metrics generated through such exercises as brainstorming sessions:

- **Effectiveness/Achievement of intended results**: the measures taken are the ones that were planned to be taken. "A well developed performance framework allows you to tell a convincing story, backed by credible evidence, about the value added by the [process][33]".Are we getting measures on what we intended to measure?
- **Forward Looking**: A good measurement system generates actions not blame; as such it is "forward looking". It provides focus on the future effectiveness for the short (i.e. operations) and long term (i.e. strategic) purposes.
- **Relevant**: what the measures taken are directly related to the goals and focus of the organization;
- **Efficiency/cost**: Always cost the measuring process so that the cost is not higher than the benefit. Seek balance between the relevance and difficulty of data collection;
- **Accountability**: A measure for which nobody is accountable is another challenge. Performance will never improve if nobody is accountable for the measured results. In defining measurement, ensure accountability;
- **Control**: A measurement on something that is not controllable is of little value. Define the scope of measurement objects to exclude uncontrollable elements;
- **Compliance**: The measurement process and its results comply with the relevant rules and regulations. This should be self evident but it is recommended to have the process reviewed systematically to achieve this attribute;
- **Simplicity**: To maximize the above attributes, the first step is to have simple, well-understood reports[34]. The trick is to start small and grow over time.

These attributes should be used by the CEP team to evaluate alternative measurement options or system options in the design.

3.2 How to select good performance measures

The following table may serve as a checklist to determine the quality of a set of performance metrics[35].

[33] Schacter, Mark, *Not a "Tool Kit": Practitioner's Guide to Measuring Performance of Public Programs*, ©Institute on Governance, 2002, p. 1

[34] Rosser, Bill,, *Process Performance Metrics: Guidelines for BPM Success*, Gartner ID G00162308, dated 19 Nov 2008

[35] http://www.orau.gov/pbm/documents/overview/uc.html

	Possible Metric, for example		
Test Question	**Process duration to measure agility**	**Number of resubmits to measure quality**	**Etc…**
Is the data available?			
Is the measure quantifiable? • Is the metric objectively measurable?			
Are the measures effective? • Does the metric support customer requirements, including compliance issues where appropriate? • Does the metric include a clear statement of the end results expected? • Are the metrics challenging but at the same time attainable?			
Are the measures relevant? • Does the system measure the intended output or outcome? • Does the metric allow for meaningful trend or statistical analysis?			
Does the measure have materiality? • Will the measure change the decision? • Is it at the right level of granularity? • Are the measures sensitive? Do they vary with changes to the process?			
Are the measures reliable, trustworthy, and credible and provide the same measure over time?			
Are the measures forward looking? • Has the metric been mutually agreed upon? • Have those who are responsible for the performance being measured been fully involved in the development of this metric? • Can remedial actions be taken from the results?			
What is the cost of the measuring system?			
Are the measures understandable? • Are assumptions and definitions specified for what constitutes satisfactory performance? • Are the measures understood by the stakeholders?			

Table 1 - Performance Metrics Test Table

3.3 Possible Performance Measures

The following list consists of a list of possible metrics[36] that could be used to evaluate the performance of the CEP. This is submitted as a starting point to cover all aspects of effectiveness, efficiency and risk control. It is not intended as a complete or definitive list:

- **Process Effectiveness** could include:
  - **Achievement of intended results**: for instance:
    - Deliverables delivered versus deliverables planned;
    - Survey of decision makers to evaluate if problem has been addressed;
    - Number of change requests; etc
  - **Quality**: could include:
    - Number of "resubmits" to client;
    - Productivity leakages: Time spent on rework activities. It could include a root-cause analysis; etc
  - **Acceptance by stakeholders**:
    - Stakeholders satisfaction survey;
- **Process Efficiency**:
  - **Costs and productivity**:
    - Number of people involved;
    - Effort, duration and cost of each activity;
  - **Agility**:
    - Number of activities in process;
    - Duration and effort caused by scope changes;
    - Duration to get back to decision makers when changes are requested;
    - Duration of project (i.e. to get recommendation to decision maker). Project duration would provide an indication that a project that takes longer, everything else being equal, is less agile;
    - Cycle time of each iteration;
- **Risk Control**:
  - **Management Direction**:
    - Time required for managers to make a decision;
    - Number of decisions made by management;
  - **Monitoring and Reporting**:
    - Number of control activities within the process;
    - Ratio of control activities to total number of activities in process.

[36] *Source: Gartner 2008 BPM Adoption Survey*

4 Building a performance measurement system

Below are some potential methods and tips in defining a performance measurement system for CEP[37].

4.1 Comprehensive Audit

Comprehensive Auditing was put forth to evaluate the overall performance of organizations rather than just the financial or compliance audits. Although aimed at organizations, it can be used at process level.

There are twelve criteria (or performance indicators) that allow the measure of the effectiveness, efficiency and risk control:

- Effectiveness
  - Achievement of intended results (after the fact)
  - Relevance (solution still needed, after the fact)
  - Appropriateness (logic and size)
  - Acceptance (by stakeholders)
- Efficiency
  - Costs and Productivity (after the fact)
  - Secondary Impacts (risk related among others)
- Risk Control
  - Management Direction (clear objective and support)
  - Responsiveness (capacity to adapt)
  - Financial results (accounting procedures)
  - Work Environment (risk related among others)
  - Protection of Assets (risk related)
  - Monitoring & Reporting (control)

The advantages are:

- The set exists and is readily available;
- The set is complete; and
- It readily prepares the organization for potential audits.

The disadvantages are:

- They are difficult to set for comparison purposes;
- Some criteria might be immaterial

These performance criteria have been used in section 3.3 above to propose a starting list of performance metrics.

4.2 Performance Dashboard

Developed by Kaplan & Norton, performance dashboards “translate the organization's strategy into objectives, metrics, initiatives and tasks customized to each group and individual in the

[37] Schacter, Mark, *Not a “Tool Kit”: Practitioner’s Guide to Measuring Performance of Public Programs*, ©Institute on Governance, 2002, p. 2

organization"[38]. The starting point is to "focus" on the performance criteria necessary to ensure the strategy (i.e. survival and success).

There is no preset set of performance criteria. They follow from the definition of the strategy and are known as key performance indicators (KPIs).

The advantages are:

- KPIs focus on the strategy of the business or process, in the case of PACEM-RE, on the goals set for the performance of the process;
- They are usually few and simple.
- It is well known and recognized as a methodology to set up a performance measurement process;

The disadvantages are:

- It requires a good strategic planning exercise before the dashboard can be implemented;
- It requires several implicit assumptions about the key performance indicators.

For CEP, the idea would be to start small. To this end, it would be appropriate to build a small performance dashboard (e.g. five to six measures at most) to start with and increase the sophistication of the measuring system as experience is gained.

4.3 Capability Maturity Model

The Capability Maturity Model Integration (CMMI) was developed by the Software Engineering Institute (SEI) to assess the maturity of software development processes. The model is based on attributes that define the five maturity of a specific process:

1. Initial (chaotic, ad hoc) - the starting point for use of a new process.
2. Repeatable - the process is able to be used repeatedly, with roughly repeatable outcomes.
3. Defined - the process is defined/confirmed as a standard business process, and decomposed to levels 0, 1 and 2 (the latter being Work Instructions).
4. Managed - the process is managed according to the metrics described in the Defined stage.
5. Optimized - process management includes deliberate process optimization/improvement.

The advantages are:

- CMMI provides a methodology for the process to self-improve over time;
- CMMI better address the needs of organizations at higher maturity levels. It would thus ensure a more effective CEP.

The disadvantages are:

- It requires certified CMMI evaluators and a long term continuous improvement plan;
- CMMI does not cover some issues like metrics[39];
- An overall rating for a set of processes cannot be established.

[38] http://www.information-management.com/issues/20051101/1040487-1.html
[39] http://users.exa.unicen.edu.ar/~asse2002/cmmi.html

The CMMI is not about performance directly but rather about the activities included or not in the process. It is not recommended for evaluating CEP instances as is required here. It should be part of the process design as a tool or method to improve performance over time.

4.4 Method proposed by the University of California

This is a high level method proposed from academia[40]. The process to develop a performance measuring process is organized around four activities:

1. Identify critical activities and customer requirements: The important term is "critical". The goal as per the performance dashboard is to identify the "key performance factors" the strategic goals;
2. Identify critical results desired and align them with customer requirements. The goal is to relate the outputs or outcomes to the clients needs;
3. Develop measurements that will provide information on the key performance factors, the desired goals and client needs;
4. Establish performance goals, standards and benchmarks. This last step is about "variance analysis". To evaluate success, results have to be compared to something as discussed earlier.

The advantages are:

- The methodology focuses on the "critical" elements of the organization or process;
- It is clearer in terms of standards and benchmarks. It is easier to establish a measurement plan.

The disadvantages are:

- "Critical" almost always refers to strategic elements. This method also requires a good strategic planning exercise before the critical elements can be identified;
- This method also creates implicit assumptions about the critical performance activities.

This method is intrinsically similar to the "dashboard" method discussed above. It confirms the method that CEP should follow to get to a simple understandable set of performance measures.

4.5 INCOSE Method

The "INCOSE" document has two goals: provide basic concepts into performance measurement; and "prepare the reader to set up a measurement program"[41]. It should be noted that this method is aimed at process improvement over time. It is also built around four main steps:

1. Characterization to gain understanding of the products and processes. This step, which is common to many methods, provides information on the process so that technical and process measures can be applied;
2. Improvement: Evaluate the process improvement opportunities. Once those are determined, the measurement can be applied selectively to the activities which represent opportunities;

[40] http://www.orau.gov/pbm/documents/overview/uc.html

[41] INCOSE, Systems Engineering Measurement Primer: A Basic Introduction to Systems Engineering Measurements Concepts and Use, Version 1.0 dated March 1998, page 7

3. Prediction: build the measurement system activities to project and predict. This is the "looking forward" concept discussed earlier. It is the construction of the data bases and repositories necessary for trend analysis;
4. Evaluation: Build the system's reporting activities to provide feedback and status to the decision makers.

The advantages are:

- This methodology provides good insights into the technical specification of measures, data collection method an calculation;
- There is attention into solving process issues and constraints.

The disadvantage is:

- It is light on how to set up the reference goals.

For CEP, These "INCOSE" steps can be amalgamated with the performance dashboard method described above to complete the technical aspects of the measurement plan.

4.6 Conclusions

The above methods have several common traits:

- First, a good performance measurement system requires a clear goal and a clear definition of what needs to be measured;
- Second, the process has to be well understood; and
- Finally, the measurement system itself has to be planned and documented.

5 Recommended Next Steps

This recommended plan of action is the amalgamation by the author of, hopefully, the strengths of the various methods outlined above into a coherent set of steps specific to the PACEM-RE situation.

The focus is on simplicity for a better, faster and cheaper CEP whether the process will use "patterns" or not.

5.1 Step 1 – Define the Performance Measurement Requirements

Purpose: Establish what it is that needs to be measured

Description: Have a work session to define the answers to the following questions[42]

- What is/are the decision(s) that we need answered about process performance? What is the purpose?
- What do you mean by "process performance"? What really is the thing being measured?
- Why does this thing matter to the decision being asked?
- What is the value to measuring it further?

Deliverable: A list of critical/strategic performance measurement requirements

Note: This exercise could start with the CEP goals defined in the CEP Foundation document[43].

5.2 Step 2 – Define the Process profile

Purpose: Define "what we know about the process performance now?"

Description: Assemble and collate the following information:

- List of deliverables with Relative importance (weight) and Dates (due and delivered)
- List of activities with dependencies and link to deliverables

Deliverable: A clear process model that will allow the definition of what performance metrics will be applied to what activities and deliverables

5.3 Step 3 – Brainstorming to Generate Metrics

Purpose: Generate a series of performance metrics

Description: Have a brainstorming session:

[42] Hubbard, D. W., How to Measure Anything: Finding the Value of Intangibles in Business, John Wiley and Sons, 2007, p. 43

[43] DRDC Valcartier TM 2004-425, CapDEM TD: The Capability Engineering Process (CEP) Foundations, Nov 2005, p. iii

- For each performance measurement requirement developed in step 1, generate a list of candidate performance metrics
- Evaluate candidate performance metrics with the use of the table developed in section 3.2 above

Deliverable: A list of undocumented performance metrics

5.4 Step 4 - Define the Metrics Chain aka Measurement Plan

Purpose: Establish how, where and when measurements will be taken, collated and analyzed

Description: As follows:

- Define where the measurements will be collected by identifying where the measures defined in step 3 will be applied in the process profile documented in step 2
- Develop the metrics dictionary (i.e. define the metrics, their measure, the collection method, etc)
- Define the metrics dashboard (i.e. define the reports)
- Define when and who will take measurements
- Define where the performance measures will be stored (i.e. the repository system)
- Collate the above five tasks results into a Measurement Plan
- The Measurement Plan could then be evaluated against the criteria listed in section 3 above.

Deliverable: A Metrics Chain or Measurement Plan

5.5 Conclusion

If these four steps have been completed successfully, then the team should be ready to act and measure the performance of the CEP instances.

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This report provides a state-of-the-art review on the subject of process performance measures and more specifically on how performance measures could be applied to the Capability Engineering Process (CEP) to evaluate the performance of CEP instances. Special emphasis was put on the concept of “agility”.

The review of literature explores the current definitions, concepts and best practices.

The results of this study aim to provide recommendations to establish a performance measures and a performance measuring system appropriate to the Department of National Defence (DND) Capability Engineering Process (CEP) to potentially assess whether or not the use of patterns makes the CEP more “agile”.

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