RSMO: On the Operational Definition of Measure Sub-ontology

An Operational Definition of Measure regards defining in details *how* a measure must be *collected* and *analyzed* according to its intended use.

For instance, measures used at high maturity levels for analyzing process performance must apply statistical process control techniques. Thus, their operational definitions should include such techniques as procedures for analyzing collected data.

This is not the case for measures used at initial maturity levels, where their intended use is to support traditional project monitoring and control.

M. Perini Barcellos *et al.* J Braz Comput Soc (2013) 19:445–473 DOI 10.1007/s13173-013-0106-x
M. Perini Barcellos *et al.*, 2010

RSMO: On the Operational Definition of Measure Sub-ontology

At high maturity levels, measurement data are used for statistical process control, and in this context, the *quality of the operational definitions* is even more important.

In order to analyze the behavior of its processes, an organization has to get a certain *volume* of *data* (greater than the volume required at initial levels). Moreover, it is necessary to form homogeneous *groups* of *data*. This requires data to be collected in a *consistent* way, and *measurement consistency* is directly related to the quality of the operational definitions.

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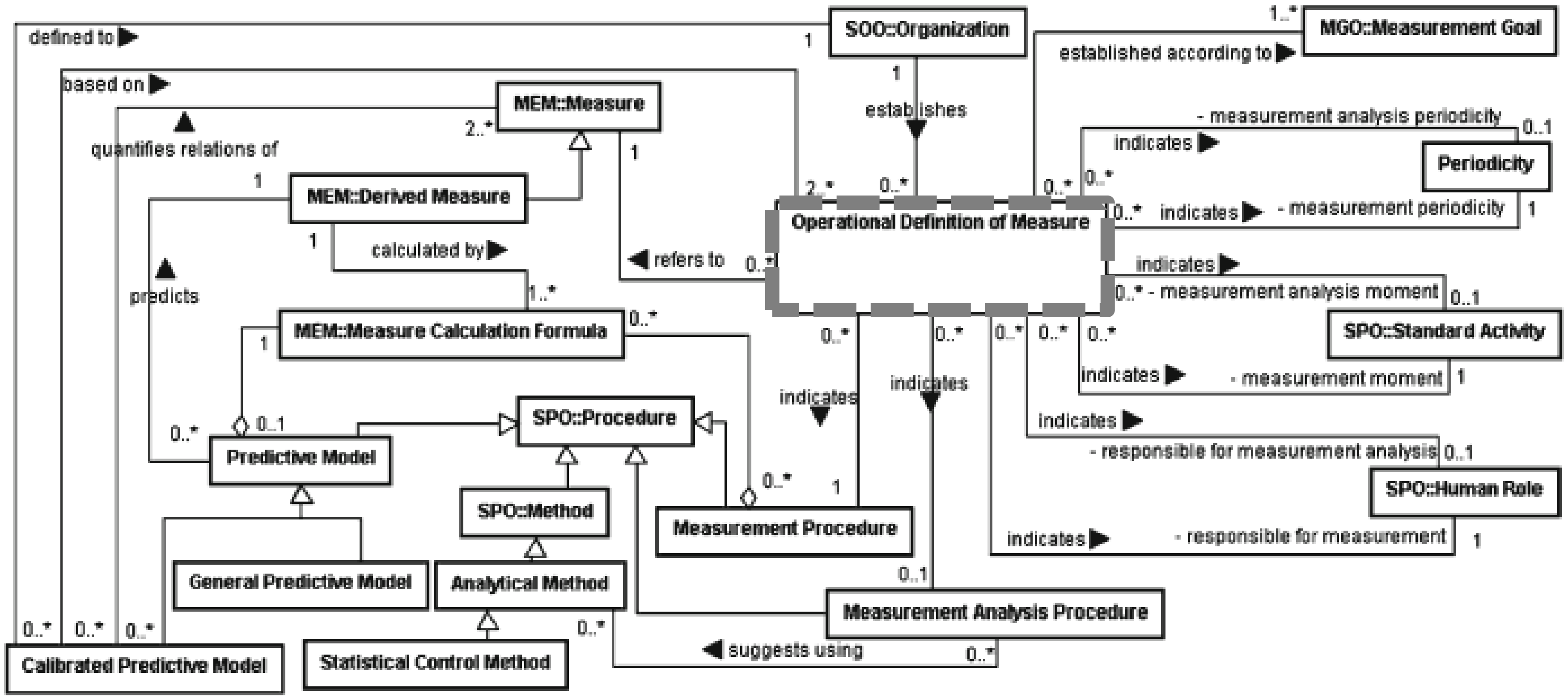
M. Perini Barcellos *et al*., 2010

RSMO: Operational Definition of Measure Sub-ontology (Fragment)



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RSMO: **ODM Sub-ontology's Glossary**

Operational Definition of Measure (ODM): it details aspects related to the data collection and analysis of a Measure in an Organization.

An Organization establishes ODM taking Measurement Goals into account.

For instance, measures related to process performance analysis goals are used to describe the processes behavior and, as such, must have operational definitions suitable for it.

An ODM is expected to indicate the *Moment*, *Periodicity*, *Responsible*, and *Procedure* both for Measurement and possibly for Analysis.

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M. Perini Barcellos *et al*., 2010

RSMO: **ODM Sub-ontology's Glossary**

Measurement Moment: it represents when measurement should occur. In order to integrate the measurement process with the software process, the measurement moment should be established in terms of the activity (Standard Activity) of the standard software process during which measurement should occur (e.g., Requirements Specification Approval);

Measurement Periodicity: it is the frequency with which measurement should be performed (e.g., monthly, weekly, in each occurrence of the activity designated as measurement moment);

Responsible for Measurement: it represents the *Human Role* responsible for performing the measurement (e.g., requirement engineer);

Measurement Procedure: it is the procedure to be followed in order to guide data collection.

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RSMO: **ODM Sub-ontology's Glossary**

An ODM may indicate:

Measurement Analysis Moment, e.g., the activity when the data collected for the measure should be analyzed.

Measurement Analysis Periodicity, i.e., the frequency with which measurement should be performed.

Responsible for Measurement Analysis, i.e., the human role responsible for analyzing the collected data.

Measurement Analysis Procedure , i.e., the procedure to be followed in order to guide data analysis.

Note that information regarding measurement analysis is not defined in every ODM, since there are some measures that are not analyzed separately. For instance, the measure <u>project size</u> could be used just to normalize other measures, not being necessary to analyze its data separately. In this case, the operational definition of the measure <u>project size</u> would not include information about measurement analysis.

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RSMO: **ODM Sub-ontology's Glossary**

Measurement Procedures and Measurement Analysis Procedures are procedures to be followed in order to guide *data collection* and *data analysis*, respectively.

Measure Calculation Formula: a formula that can be included by a Measurement Procedure.

Analytical Methods: in turn, Measurement Analysis Procedures can suggest the use of such kinds of methods for representing and analyzing the measured values. Histograms and bar charts are examples of analytical methods.

Statistical Control Methods: Analytical methods that use principles of statistical control to represent and analyze values. The XmR and mXmR charts are examples of statistical control methods. At high maturity levels, measurement analysis procedures should indicate the use of statistical control methods.

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RSMO: **ODM Sub-ontology’s Glossary**

Predictive Model : it is a procedure used to predict a Derived Measure by quantifying its relations with other measures. A predictive model has a Measure Calculation Formula. A Predictive Model can be a General or a Calibrated Predictive Model.

General Predictive Model: it is a predictive model established considering data collected from projects of several organizations. Typically there are models proposed in the literature, such as the Putnam Model ($E = S^3 / Ck^3T^4$) that predicts the measure development effort from the measures size and time, considering also technologies used in the project.

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RSMO: **ODM Sub-ontology's Glossary**

Calibrated Predictive Model: it is established based on data collected in a particular organization and according to certain operational definitions of measures. For instance, an organization could use data collected through projects for establishing a calibrated predictive model that aim to predict <u>project effort</u> based on their <u>size</u> and <u>complexity</u>.

A calibrated predictive model must quantify the relationship existing between at least **two measures**.

Since calibrated predictive models should be established from a **consistent group of data**, these data should be collected using the **same operational definition of measure**.

Therefore, a calibrated predictive model must be based on one specific operational definition of measure for each measure used to establish the calibrated predictive model.

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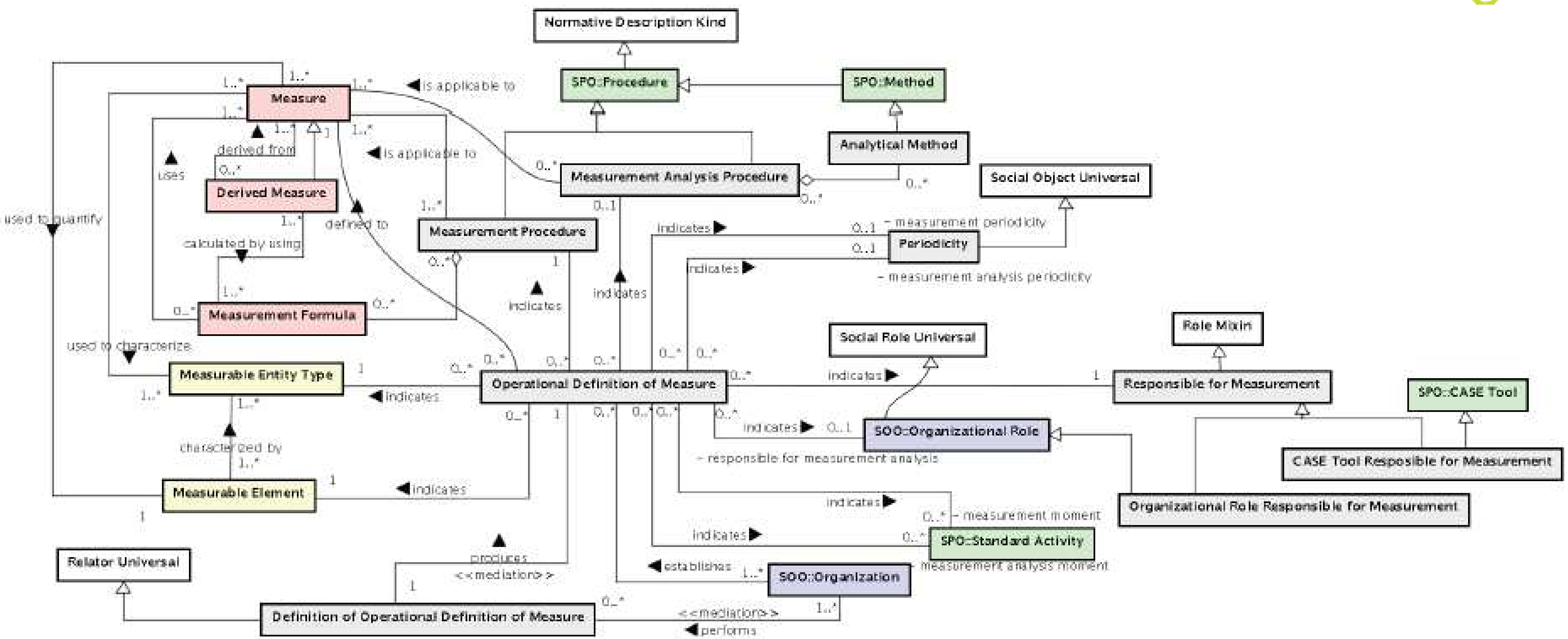
RSMO: Operational Definition of Measure Sub-ontology



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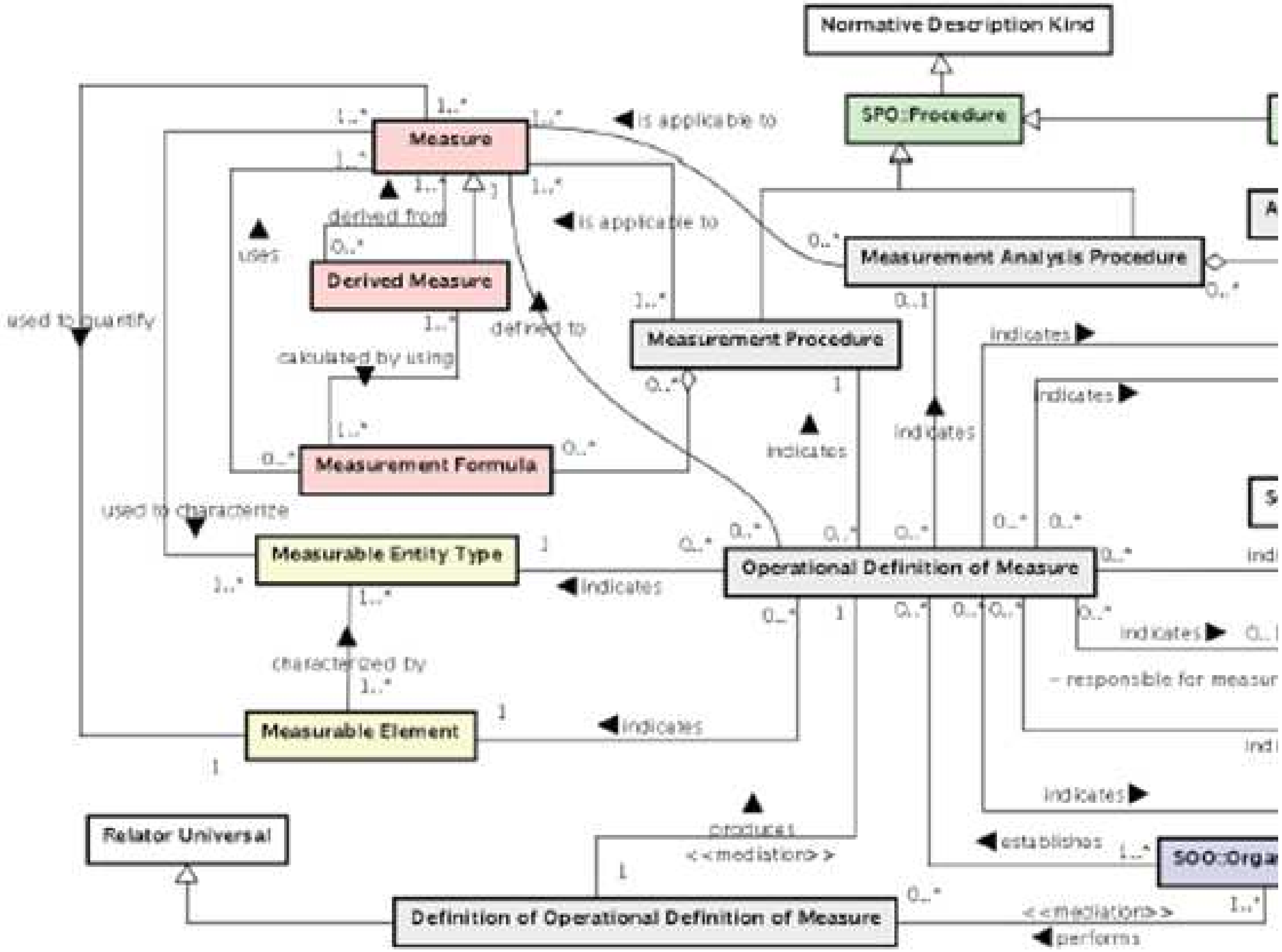
RSMO: Operational Definition of Measure Sub-ontology



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RSMO: Operational Definition of Measure Sub-ontology

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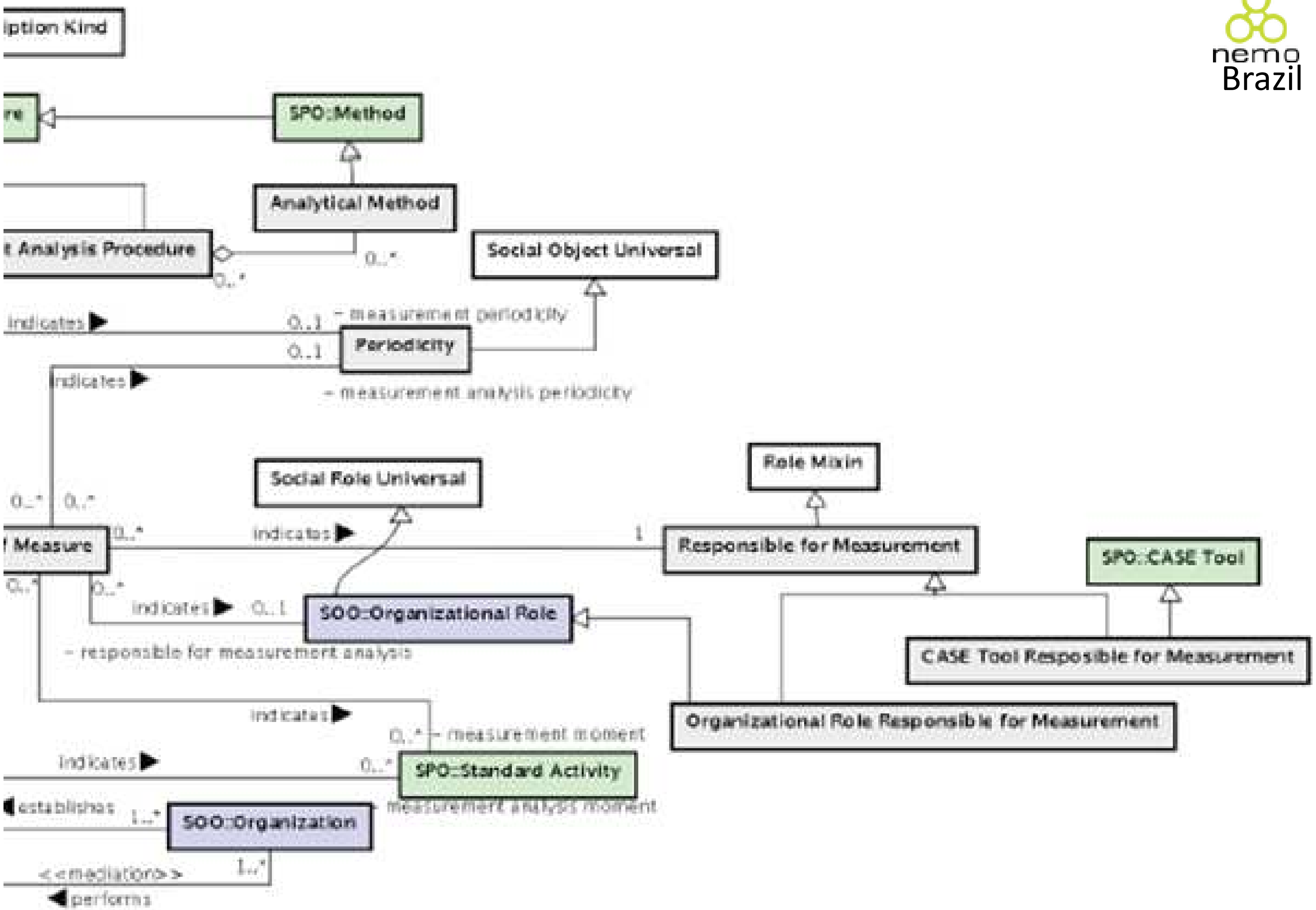

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RSMO: Measurement Sub-ontology (Fragment)

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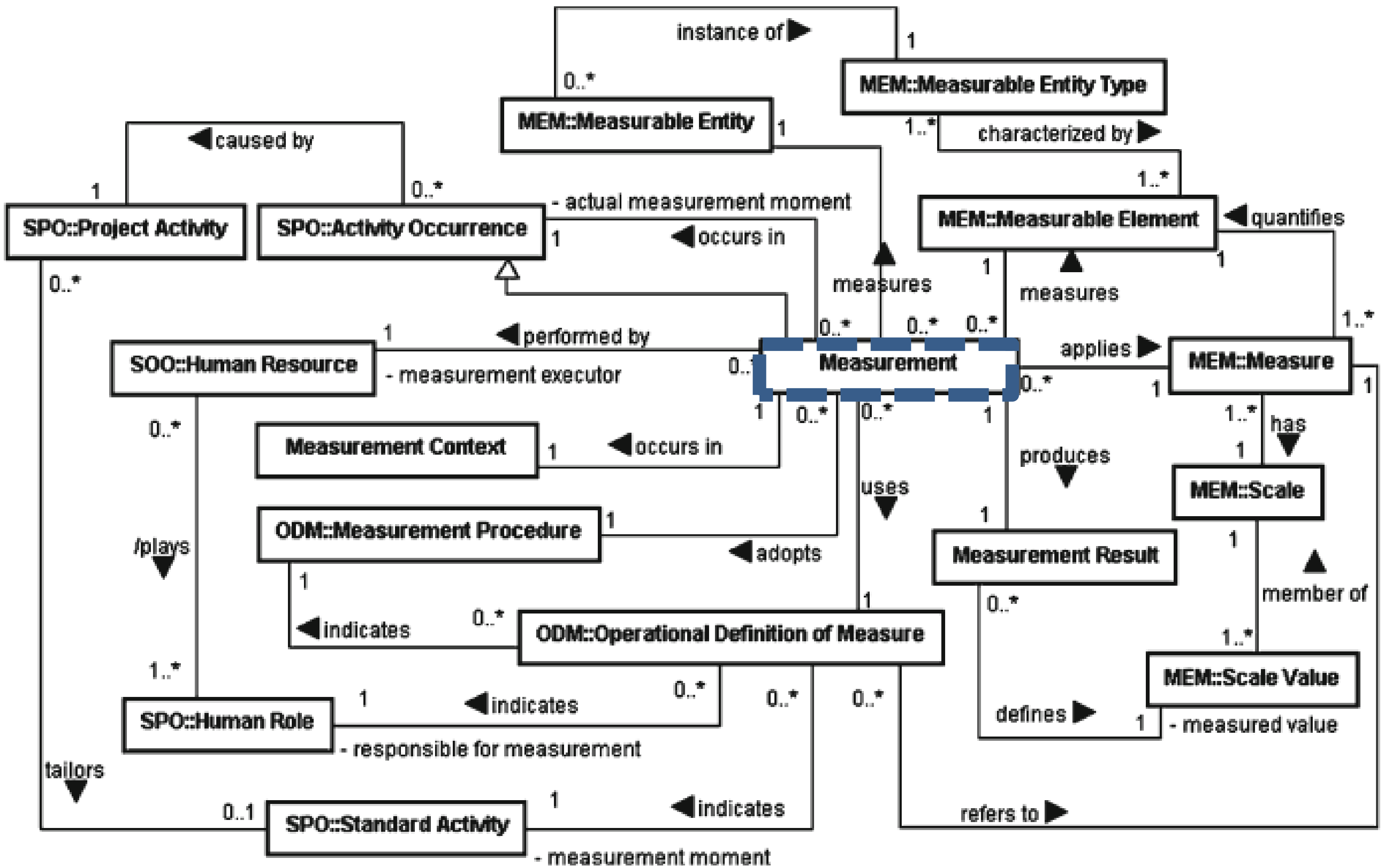

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RSMO: MEA Sub-ontology's Glossary

Measurement: it is an action performed to measure a Measurable Element ["Attribute"] of a Measurable Entity by applying a Measure ["Measurement model"]. As a result, a **Measurement Result** is obtained, which defines a **measured value**. The measured value must be a **Scale Value** of the **Scale** of the applied measure.

For instance, the measurement of the measurable element changed requirements of the measurable entity Requirements Specification Document by applying the measure number of changed requirements could obtain a measurement result, which defines as measured value of the value 12.

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RSMO: MEA Sub-ontology's Glossary

Measurement Context: it is the property of a Measurement that describes the circumstances in which the measurement occurred.

The measurement context is useful to group data or exclude values for measurement analysis, as well as to understand variations among values being analyzed.

Regarding the example cited before, a possible measurement context could be: <u>measurement carried out after changes in the legislation in which the system is based on</u>.

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RSMO: MEA Sub-ontology's Glossary

Measurement Executor: the Human Resource who perform the measurement. S/he adopts a Measurement Procedure.

Responsible for measurement: the Human Role performed by the measurement executor to perform a measurement. The measurement procedure adopted must be the same indicated by the operational definition of measure.

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RSMO: MEA Sub-ontology's Glossary

Actual measurement moment: the activity (Activity Occurrence) of the target process where the measurement activity occurs (e.g., an occurrence of the activity Requirements Specification Approval). This activity occurrence is caused by a Project Activity (e.g., the activity Requirements Specification Approval defined to the project P) that tailors a Standard Activity (e.g., the activity Requirements Specification Approval defined in the Requirements Management standard process). Since an operational definition of measure is used to guide measurement, this Standard Activity has to be the one indicated as the measurement moment by the Operational Definition of Measure.

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RSMO: MEA Sub-ontology

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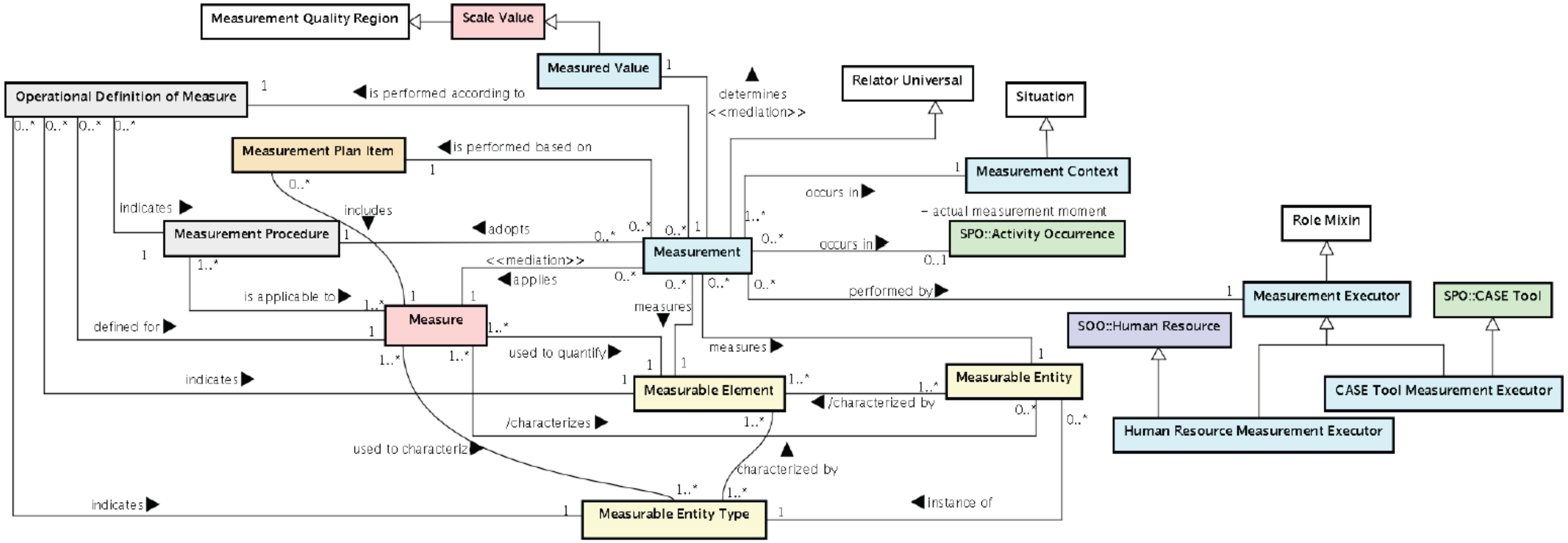

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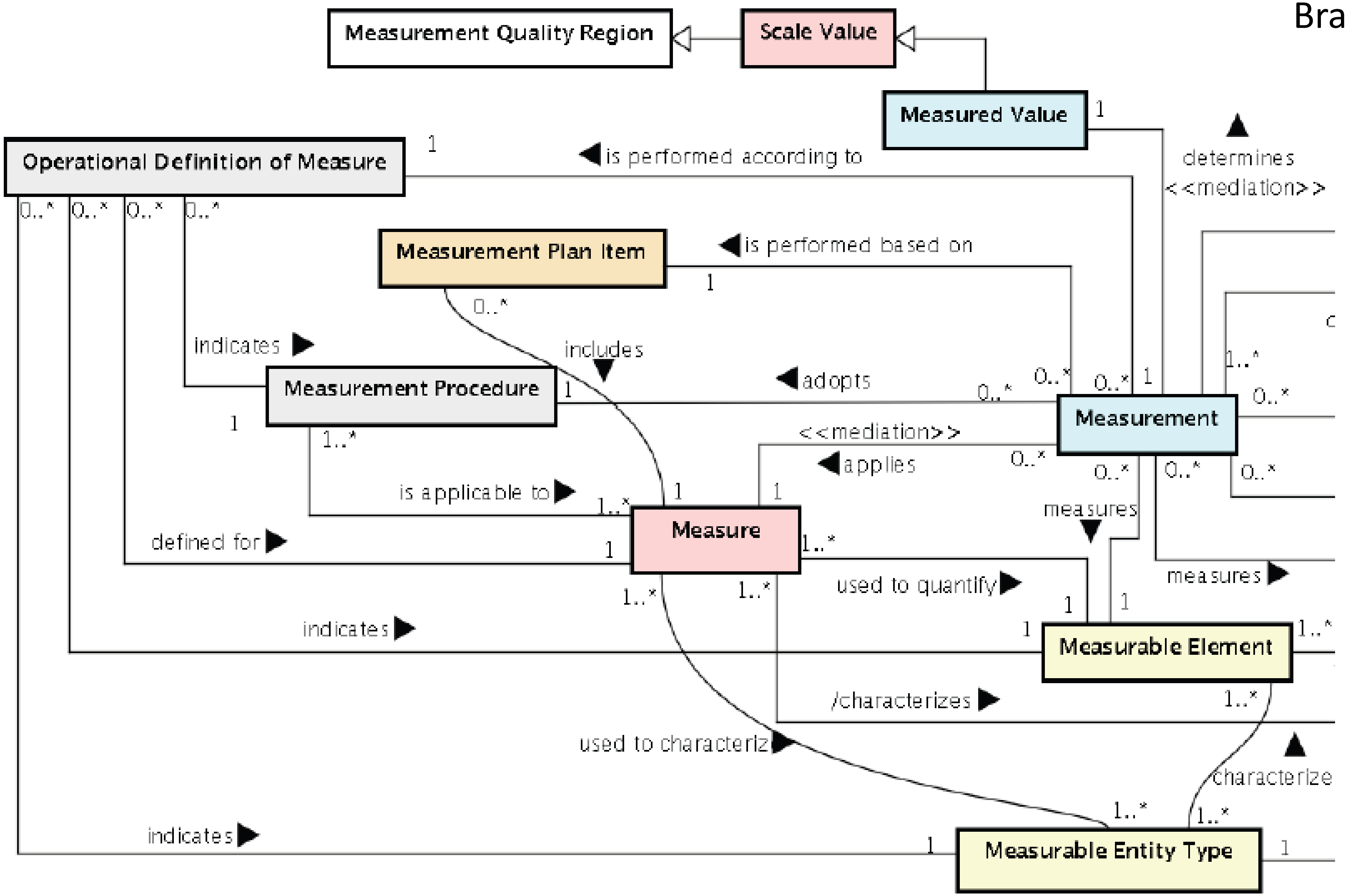
RSMO: MEA Sub-ontology



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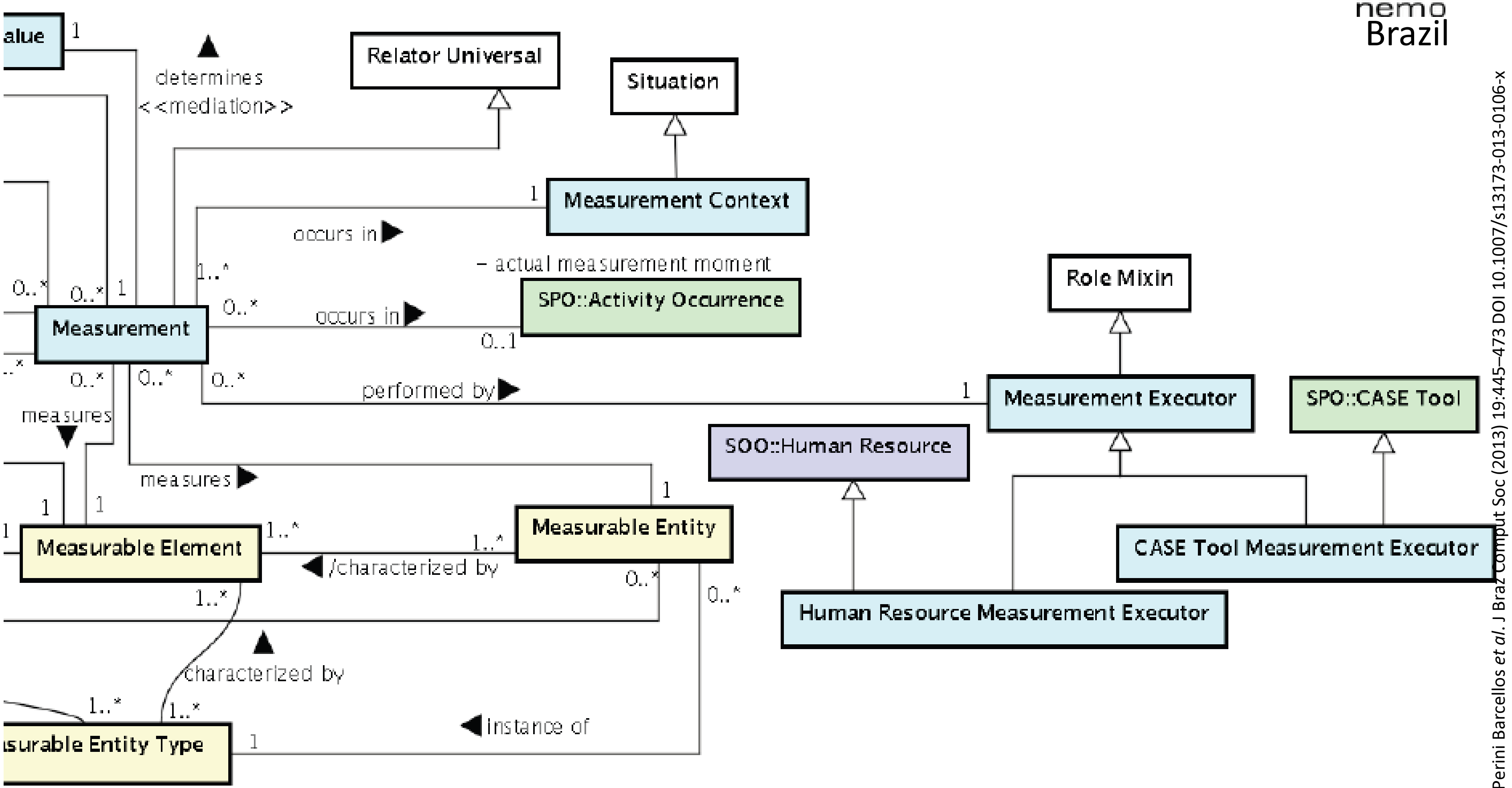
RSMO: MEA Sub-ontology



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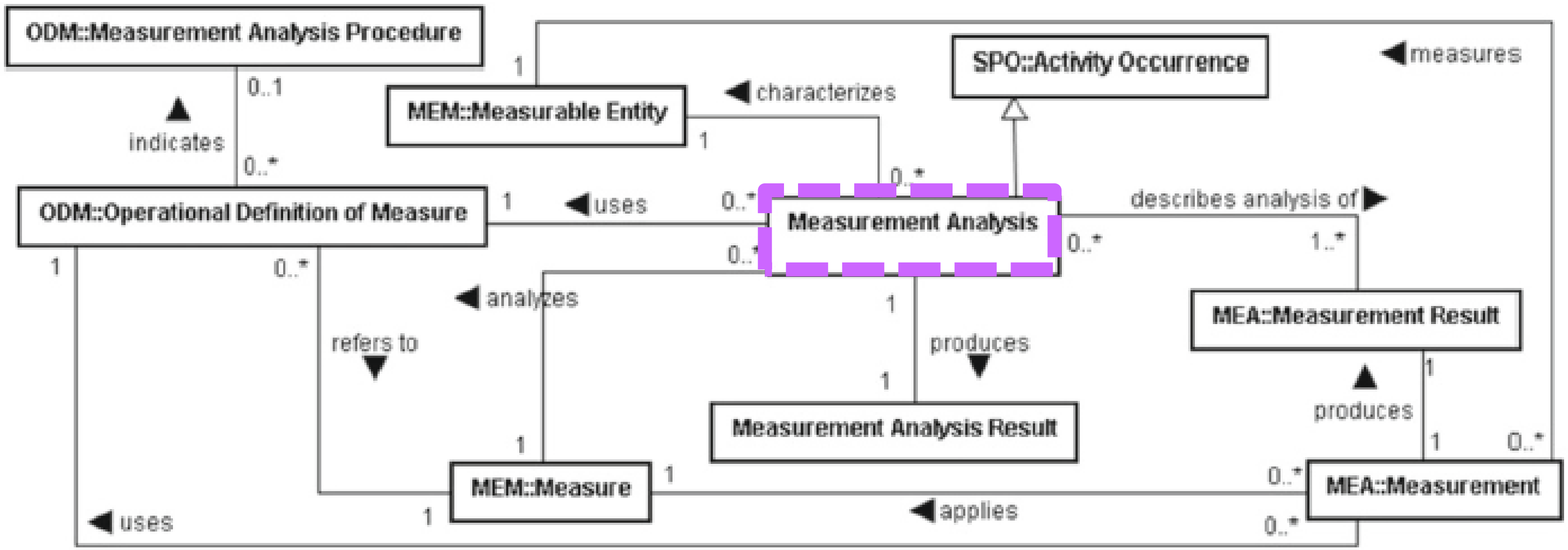
RSMO: Measurement Analysis Sub-ontology (Fragment)



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RSMO: MAN Sub-ontology's Glossary

Measurement Analysis is an action performed to analyze values measured for a Measure [“Measurement Model”] characterizing the Measurable Entity [“Attribute”] measured. The values to be analyzed are described in Measurement Results, produced by Measurements.

An example of Measurement Analysis is the analysis of values measured for the measure requirements changing rate in order to characterize the measurable entity Requirements Management Process in the project P.

Measurement Analysis Result: it is the result produced by the Measurement Analysis.

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RSMO: MAN Sub-ontology's Glossary

Note

The ODM - Operational Definition of Measure used in a Measurement Analysis must be the *same* one used in the Measurements that produced the Measurement Results being analyzed.

Besides, the Measurable Entity characterized by a Measurement Analysis must be the *same* Measurable Entity measured by the Measurements that produced the Measurement Results being analyzed.

A Measurement Analysis adopts an ODM that refers to the Measure being analyzed.

As discussed in the ODM sub-ontology, an ODM indicates the Measurement Analysis Procedure, the Measurement Analysis Moment and the Responsibility for the measurement analysis.

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RSMO: MAN Sub-ontology's Glossary

Measurement analysis executor: in a very similar way than in the case of the Measurement sub-ontology, this is the Human Resource wo carried out the Measurement Analysis.

Actual measurement analysis moment: as argued before with respect to Measurement, ideally, in a Measurement Analysis, the actual measurement analysis moment must be an Activity Occurrence caused by a Project Activity that tailors a Standard Activity indicated as the measurement analysis moment by the ODM. Moreover, the Measurement analysis executor must play the Human Role indicated as responsible for measurement analysis.

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RSMO: Measurement Analysis Sub-ontology

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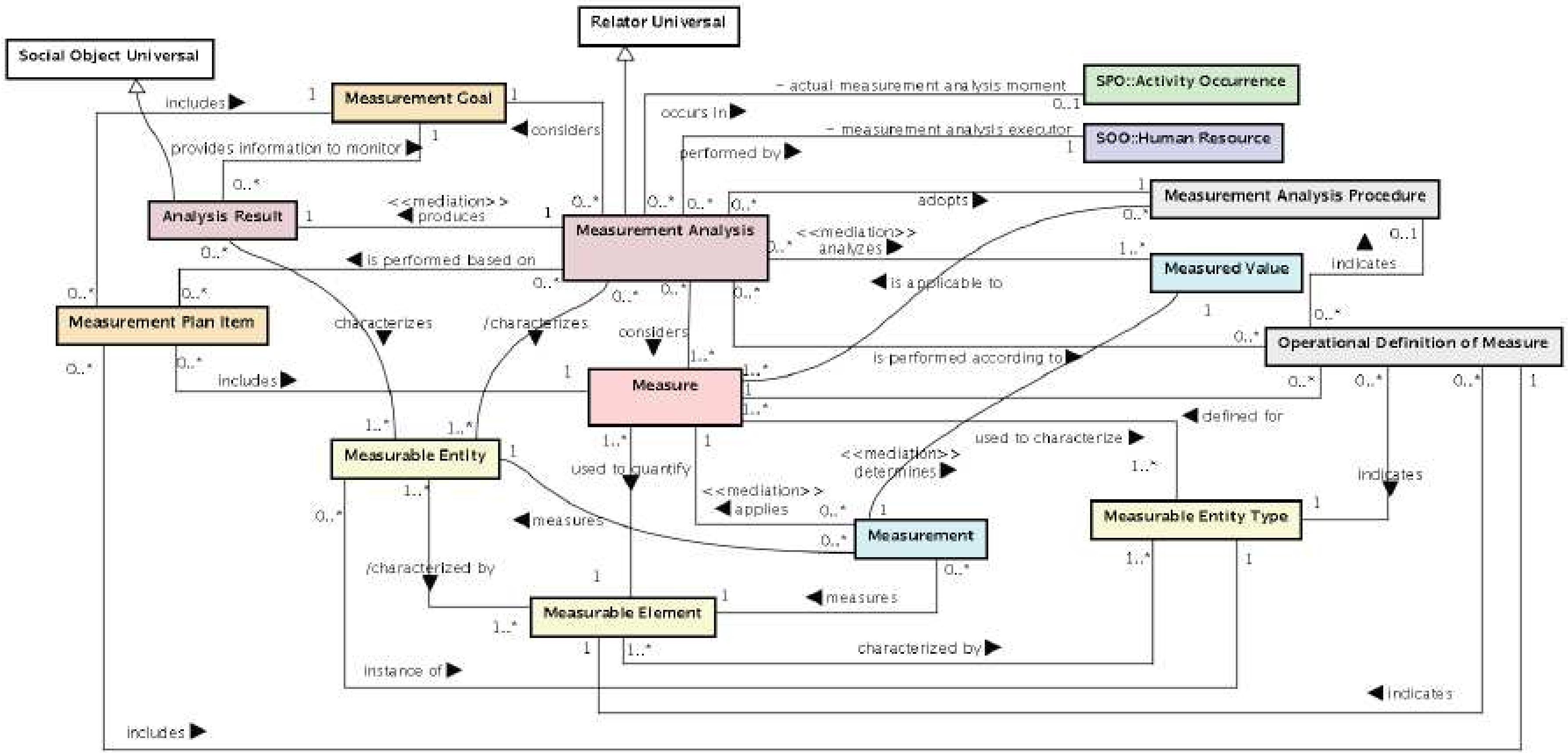

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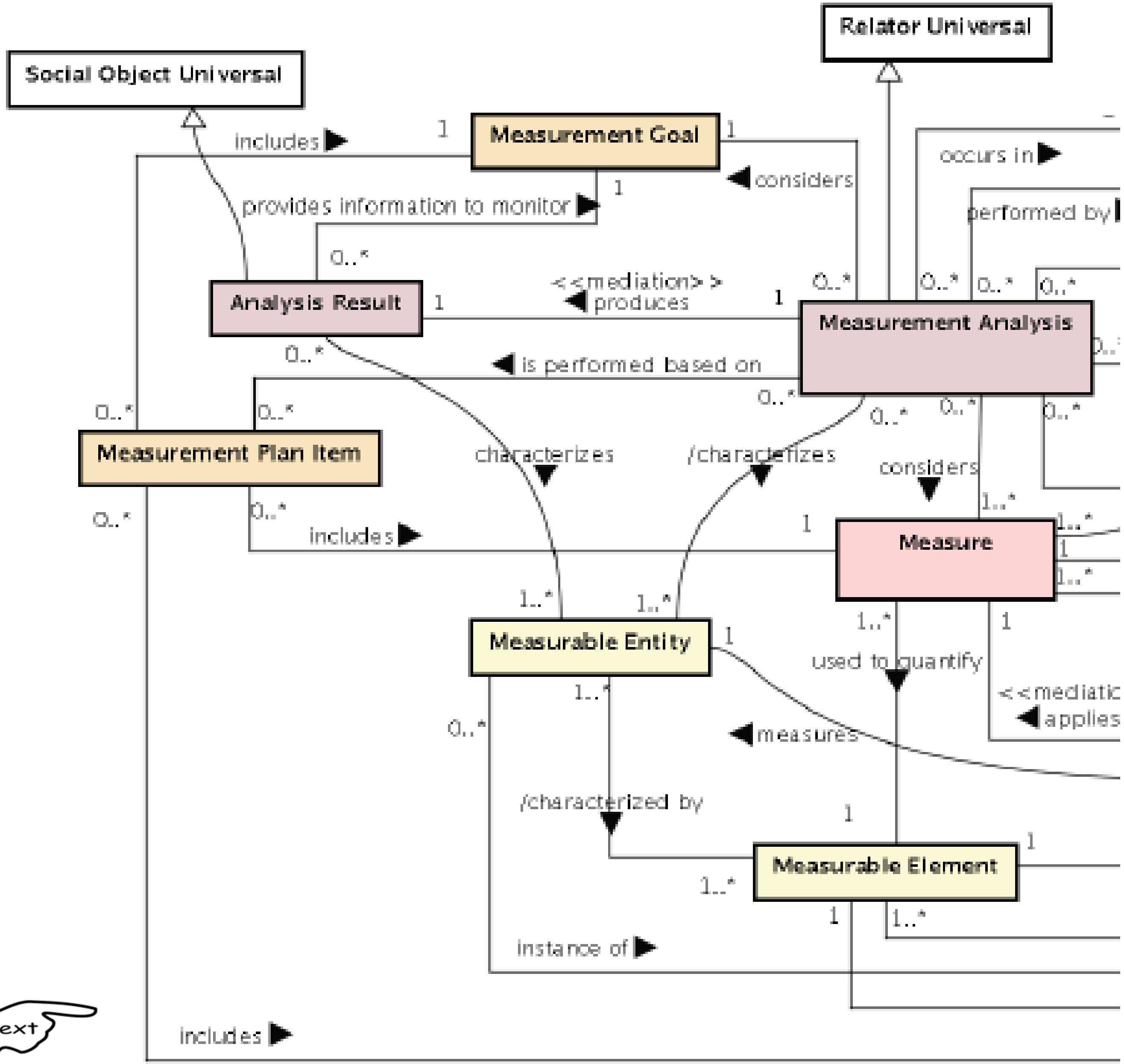
RSMO: Measurement Analysis Sub-ontology



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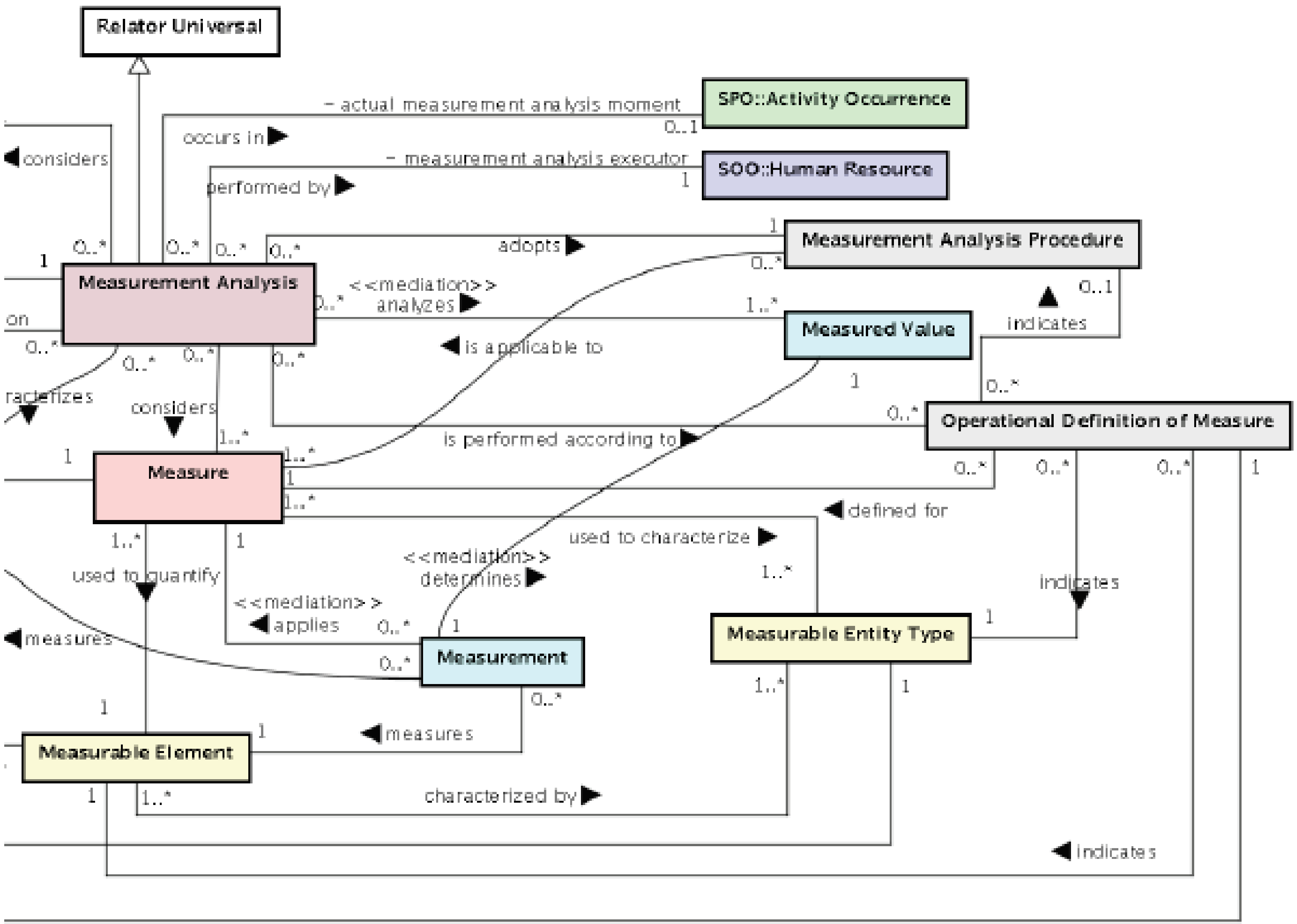
RSMO: Measurement Analysis Sub-ontology



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RSMO: On Sw. Process Behavior Sub-ontology (PBE)

The Software Process Behavior Sub-ontology deals with concepts, relations and constraints involved in software process behavior analysis.

In fact, data are collected from measures, and they are analyzed aiming to provide information that support *decision-making*.

At high maturity levels, information is applied for analyzing the software process behavior.

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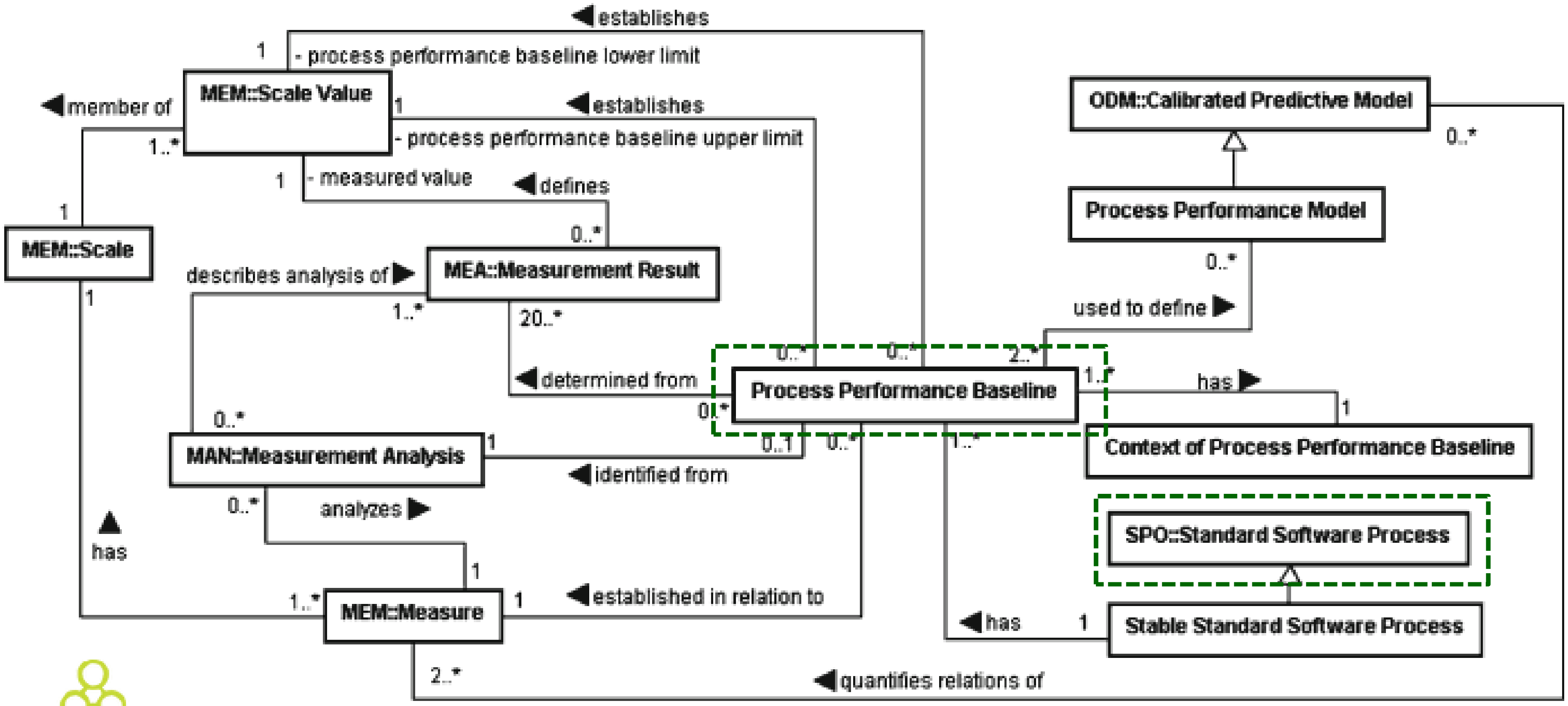
RSMO: Sw. Process Behavior Sub-ontology (Fragment 1/2)



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RSMO: PBE Sub-ontology' Glossary

Process Performance Baseline: in a Measurement Analysis that adopts a Statistical Control Method, it is possible to identify such a baseline, established in relation to a Measure for a *Stable Standard Software Process*.

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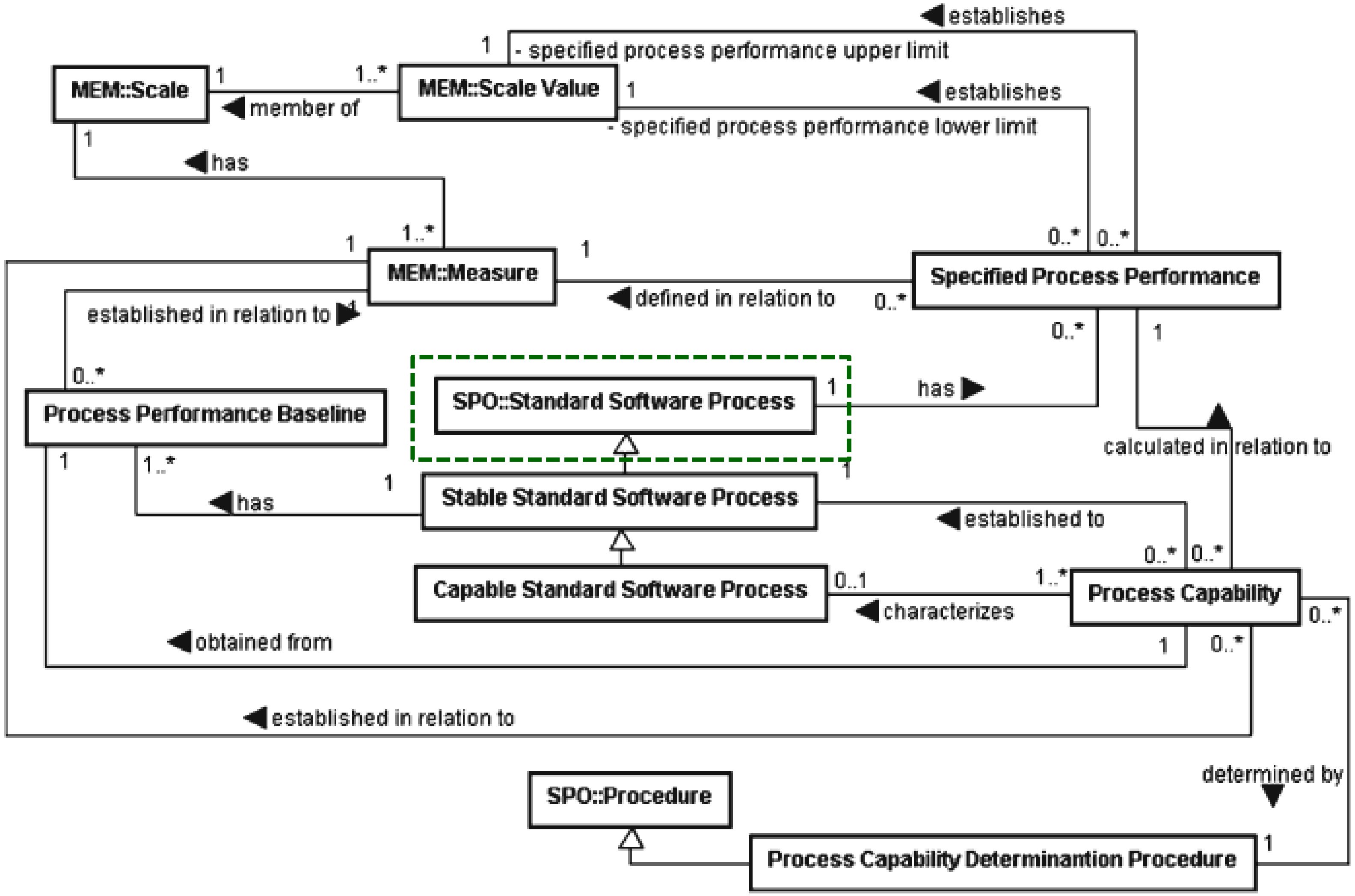
RSMO: Sw. Process Behavior Sub-ontology (Fragment 2/2)



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RSMO: PBE Sub-ontology' Glossary

Stable Standard Software Process: it is a Standard Software Process with stable behavior. In other words, it is a Standard Software Process that has at least one Process Performance Baseline. In fact, according to the *Software Process Ontology*, a Standard Software Process refers to a generic process defined by an organization, establishing basic requirements for processes to be performed in that organization.

It is identified from twenty or more Measurement Results. It is the range of results achieved by a Stable Standard Software Process, obtained from measured values of a particular Measure. This range is used as a reference for process performance analysis and it is defined by two limits: the *upper limit* and *lower limit*.

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RSMO: PBE Sub-ontology' Glossary

Process performance baseline upper limit: it is the upper limit in the Scale Values of the Scale of the Measure considered for establishing the baseline

Process performance baseline lower limit: it is the lower limit in the Scale Values of the Scale of the Measure considered for establishing the baseline.

For computing these and other values involved with a XmR control chart, see for instance: http://openonlinecourses.com/cqi/XmR.asp.

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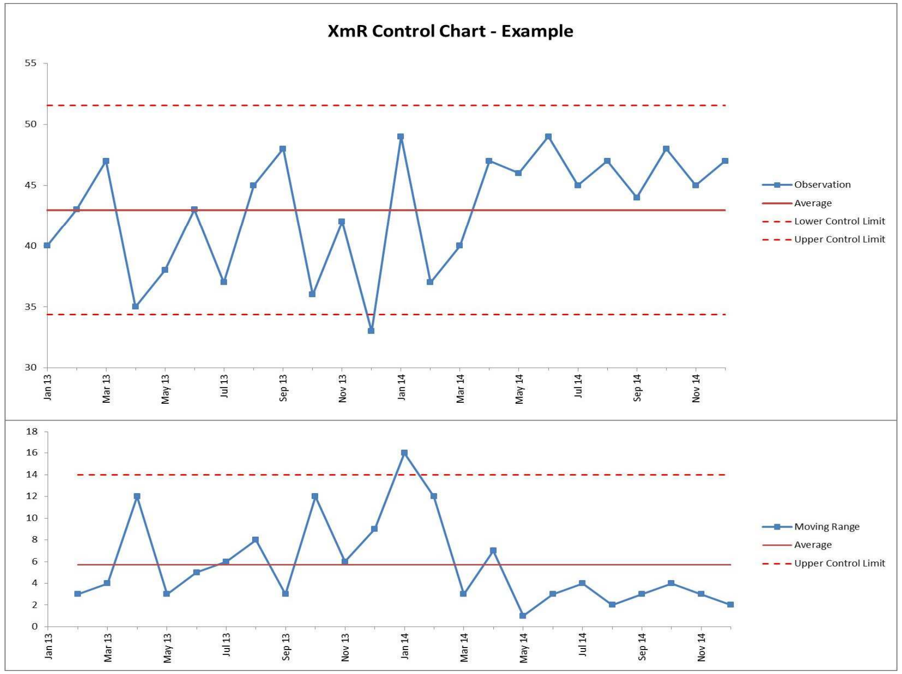
RSMO: PBE Sub-ontology’ Glossary

For instance, let us use the statistical control method XmR control chart: (http://openonlinecourses.com/cqi/XmR.asp). This is actually two charts. The X is the data point being measured and mR the Moving Range which is the difference between consecutive data point measurements. An XmR chart might look something like this:



See https://www.intrafocus.com/2014/07/xmr-chart/ for this picture

The upper chart (X-Chart) displays the data-points over time (Observation) together with a calculated average (Average). The calculated average is then used to calculate the Upper and Lower Control Limits. The lower chart displays the Moving Range (mR-Chart) with its Average and Upper Control Limit. There is no lower control limit as the value of the difference between consecutive observations is recorded as an Absolute Value (positive number).

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RSMO: PBE Sub-ontology' Glossary

The upper chart (X-Chart) displays the data-points over time (Observation) together with a calculated average (Average). The calculated average is then used to calculate the Upper and Lower Control Limits. The lower chart displays the Moving Range (mR-Chart) with its Average and Upper Control Limit. There is no lower control limit as the value of the difference between consecutive observations is recorded as an Absolute Value (positive number).

Let us continue in the example by considering the analysis of values measured for the measure requirements changing rate, related to the Requirements Management standard software process of the organization Org.

Using XmR, this measurement analysis could identify a process performance baseline PPB-01, composed by upper and lower limits 0,1 and 0.25, respectively.

Thus, in this context, the Requirements Management standard software process is considered a stable standard software process.

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RSMO: PBE Sub-ontology’ Glossary

Context of Process Performance Baseline: the context where the Process Performance Baseline is established.

In the previous example, we could have the following situation for the first process performance baseline established to the Requirements Management standard software process: <u>the data used to establish the baseline were collected in six small projects developed by the same team, under usual conditions</u>. <u>In the analysis, two points collected on exceptional situations were excluded</u>.

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RSMO: PBE Sub-ontology' Glossary

Process Performance Model: it is a specific type of Calibrated Predictive Model that uses Process Performance Baselines (at least 2) to establish and quantify the relations between Measures. The Process Performance Baselines used by a Process Performance Model must be defined in relation to the measures whose relations are quantified by that Process Performance Model.

Specified Process Performance: it is the range of values that describes the desired results of a Standard Software Process, considering a particular Measure. A Specified Process Performance is defined by two limits:

Specified Process performance upper limit.

Specified Process performance lower limit.

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RSMO: PBE Sub-ontology' Glossary

As well as baseline limits, the Specified process performance limits are values of the Scale of the Measure used for defining the Specified Process Performance.

Returning to the previous example, consider the Requirements Management standard process of the organization Org. It could have a specified process performance defined in relation to the measure requirements changing rate, given by the upper and lower limits 0 and 0.25, respectively.

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RSMO: PBE Sub-ontology' Glossary

Process Capability characterizes the ability of a Stable Standard Software Process to achieve the process performance specified for it, considering a particular Measure. Process Capability is obtained from a Process Performance Baseline and it is calculated in relation to a Specified Process Performance.

Process Capability Determination Procedure. It is applied to determine Process Capability. This kind of procedure defines a logical sequence of operations used to determine the capacity of a Stable Standard Software Process and to identify if it is a capable process.

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RSMO: PBE Sub-ontology' Glossary

The following is an example of a Process Capability Determination Procedure:

PCDP-01: calculate the **process capability index** using the calculation formula $Cp = (ULb - LLb)/(ULs - LLs)$, where Cp = process capability index, ULb = process performance baseline upper limit, LLb = process performance baseline lower limit, ULs = specified process performance upper limit and LLs = specified process performance lower limit. If Cp is ≤ 1, verify if the process performance baseline limits are within the specified process performance limits.

In the affirmative case, the process is capable. Otherwise, the process is not capable.

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RSMO: PBE Sub-ontology' Glossary

Capable Standard Software Process: the Process Capability reveled that the specific process is capable of achieving the expected performance.

Regarding the examples cited before, consider applying the Process capability determination procedure PCDP-01 to the Requirement Management standard process of the organization Org. As a result, we obtained a Capability index 0.6. Besides, consider that the Process performance baseline limits are within the specified process performance limits. So, this Requirement Management standard process is a Capable Standard Process with respect to the measure requirements changing rate.

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RSMO: PBE Requirements for a Measure to be used in SPC

R1. The measure must be aligned to organizational or project goals

R2. The measure must be able to support decision making

R3. The measure must be able to support software process improvement

R4. The measure must be associated to a critical process

R5. The measure must be able to describe the process performance

R6. The measure must have appropriate granularity level

R7. The operational definition of the measure must be correct and satisfactory

R8. The correlated measures to the measure must be defined

R9. The measure must be correctly normalized (if applicable)

R10. It must be possible to normalize the measure (if applicable)

R11. The criteria for grouping data to the measure analysis must be defined

R12. The measurement data related to the measure must include context information

R13. The measurement data related to the measure must be accessible and retrievable

R14. The measure must be related to the process or activity in which the measurement is carried out

R15. The measure should not consider aggregated data

R16. It must be possible to identify the process definition in which data were collected for the measure

R17. The collected data for the measure must be consistent

R18. The collected data for the measure must be precise

R19. There is no lost data for the measure or the amount of lost data does not compromise the analysis

R20. The amount of collected data is sufficient

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Instrument for Evaluating the Suitability of a Measurement Repository for SPC Ontologies

Monnalessa Perini Barcellos et al.

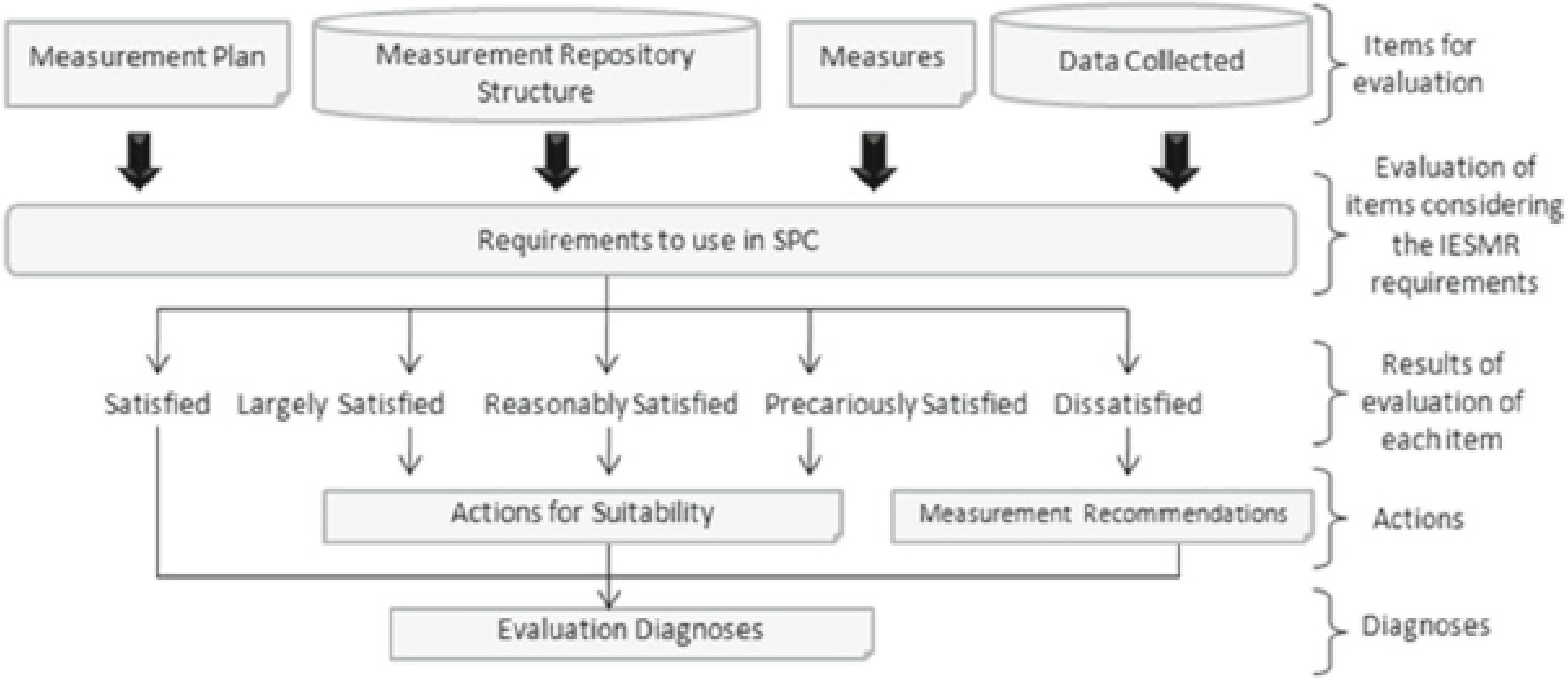
See M. Perini Barcellos · R. de Almeida Falbo · A. Regina Rocha: *A strategy for preparing software organizations for statistical process control*, 2013.

https://link.springer.com/article/10.1007/s13173-013-0106-x

M. Perini Barcellos *et al.* J Braz Comput Soc (2013) 19:445–473 DOI 10.1007/s13173-013-0106-x

IESMR Overview

nemo Brazil



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BRSMS-SPC
The Body of Recommendations for Software Measurement Suitable for SPC

Monnalessa Perini Barcellos et al., 2013

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SEON: A Software Engineering Ontology Network

Fabiano Borges Ruy, Ricardo de Almeida Falbo, Monalessa Perini Barcellos, Simone Dornelas Costa, Giancarlo Guizzardi, 2016

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ORIGINAL PAPER
A strategy for preparing software organizations for statistical process control
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