Misurare il software

I modelli di misura come prodotti

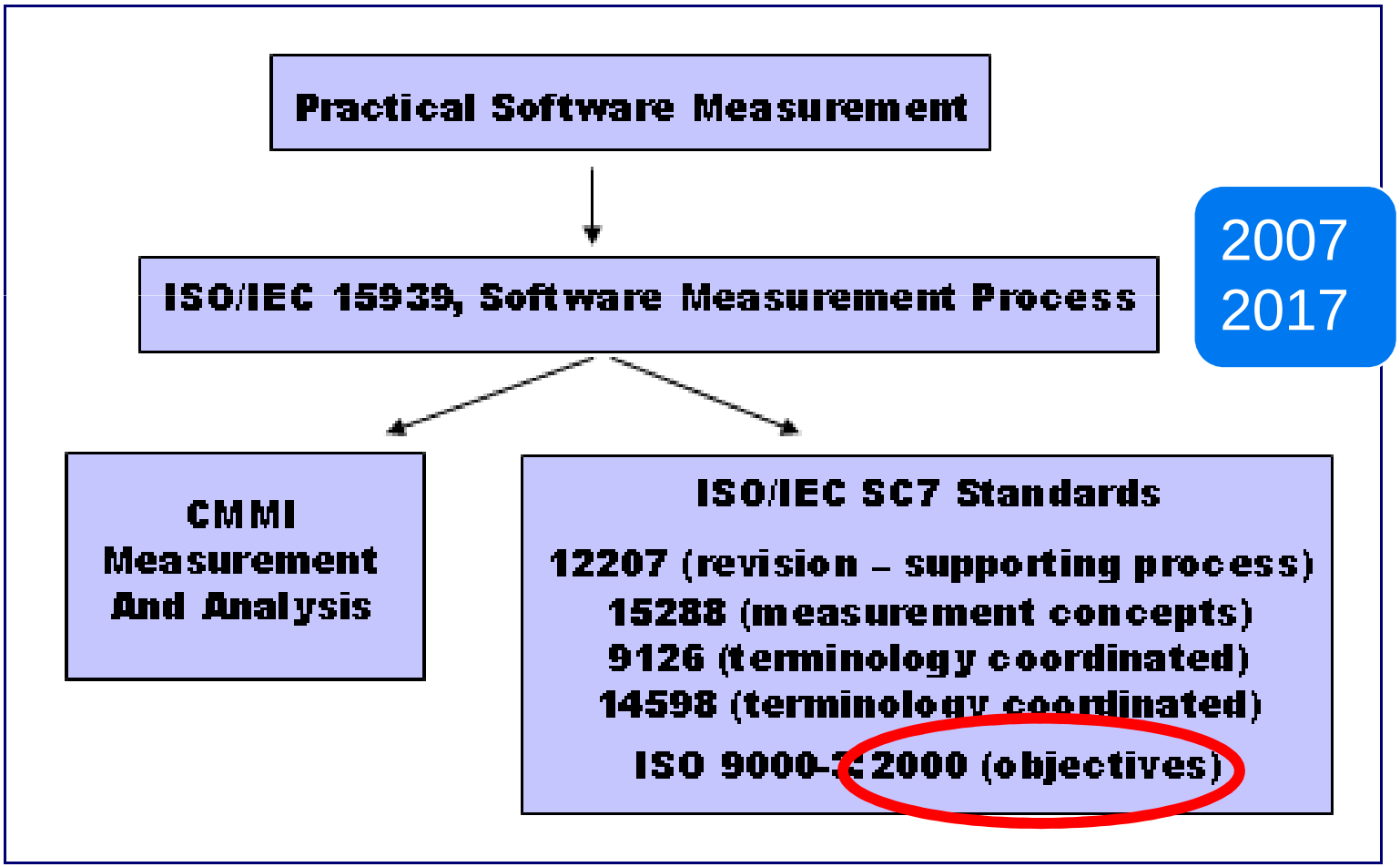
Processi di misura

Vari approcci

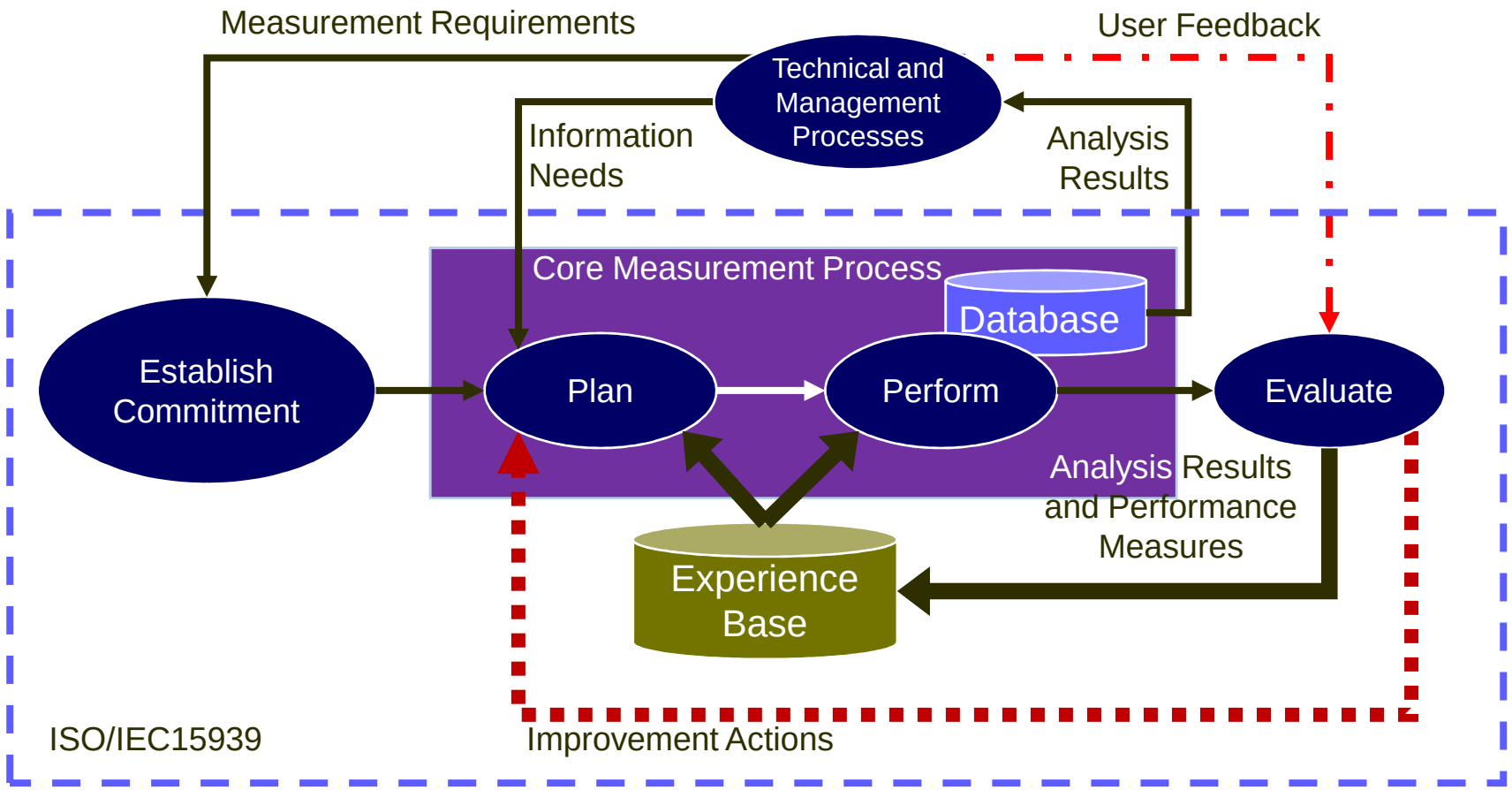
- GQM, QIP, EF: **1988 e succ.**
- CMM **1990 e succ.**
- STANDARD
  - SPICE **1993** **ISO/IEC 15504**
  - Practical Software Measurement (PSM)
    - **ISO/IEC/IEEE 15939: 2007. Systems and software engineering -- Measurement process.** **2007 - 2017**

PSM

Practical Software Measurement (PSM) vs. ISO/IEC 15939



Measurement Process – ISO/IEC 15939



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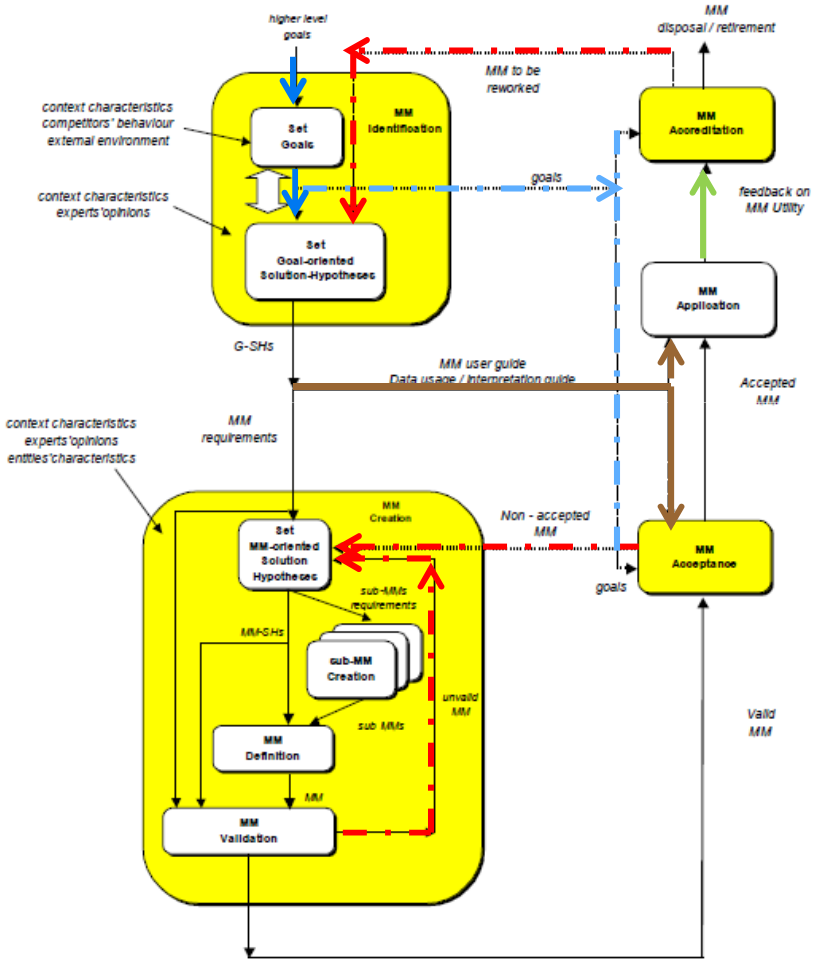

1999-2000

See the next section “Measurement plan” for details

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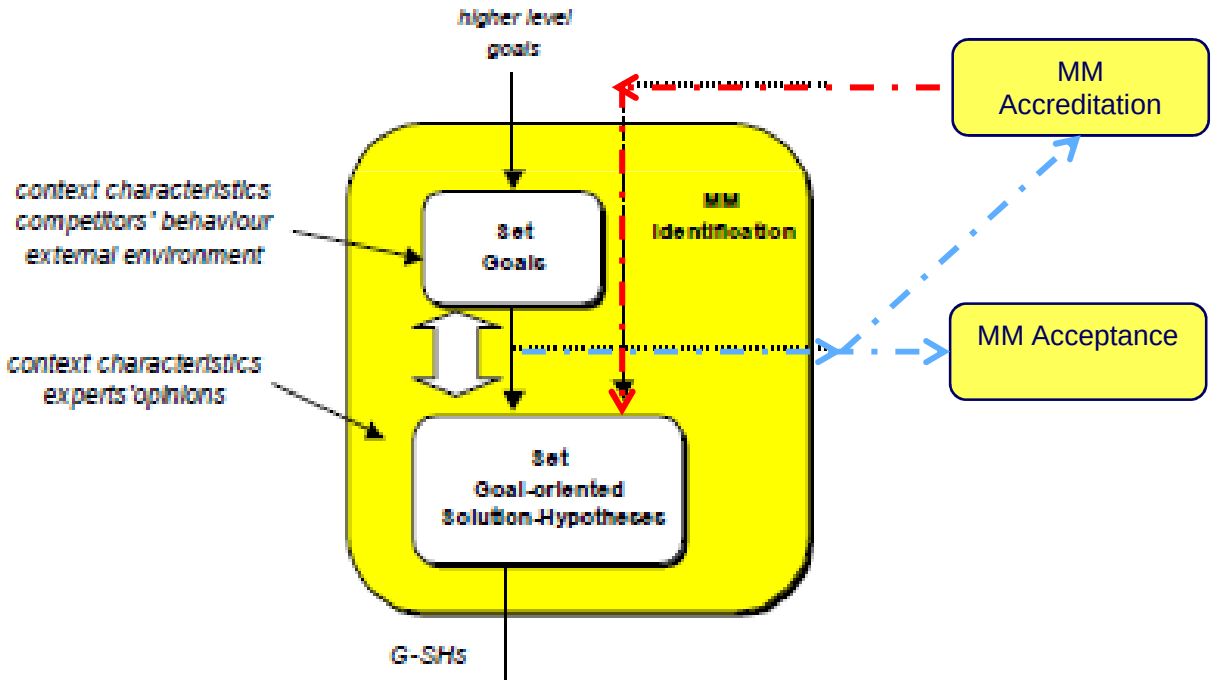
IDENTIFICATION.



See the next section “Measurement plan” for details

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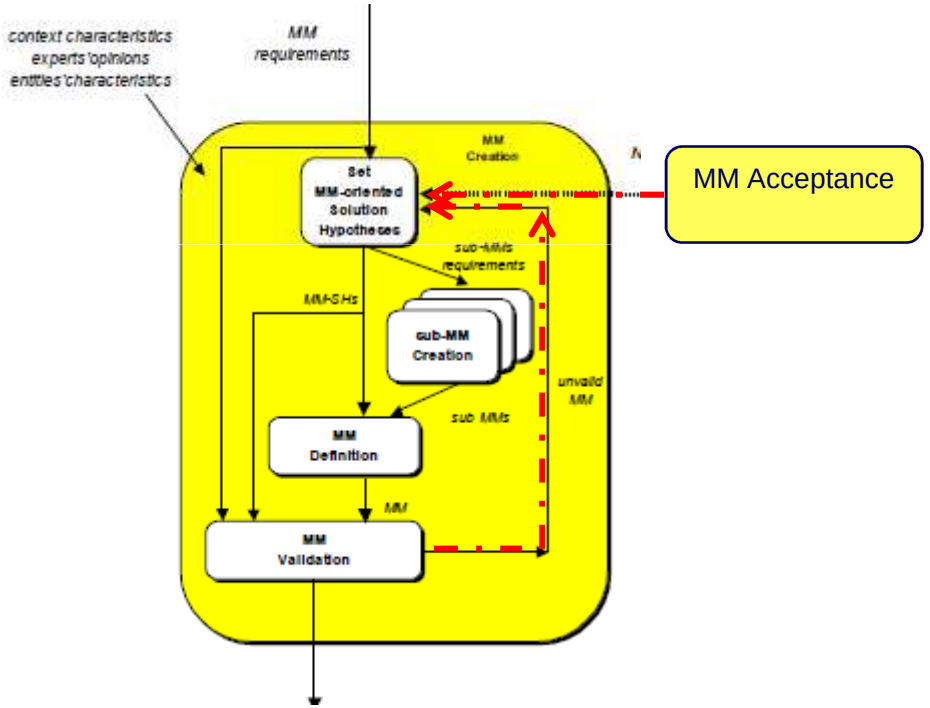
CREATION



See the next section “Measurement plan” for details

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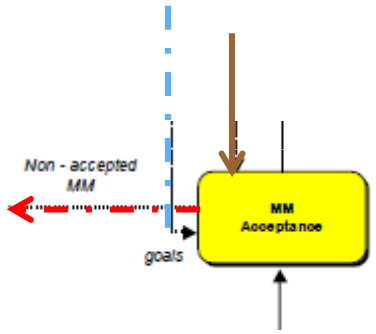
ACCEPTANCE



See the next section “Measurement plan” for details

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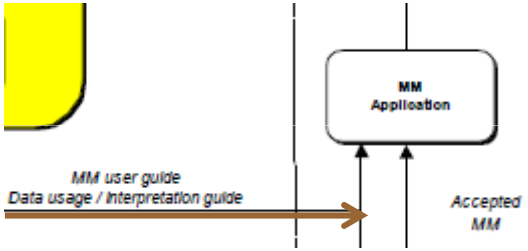
APPLICATION.



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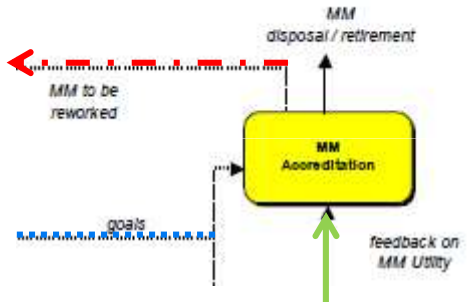

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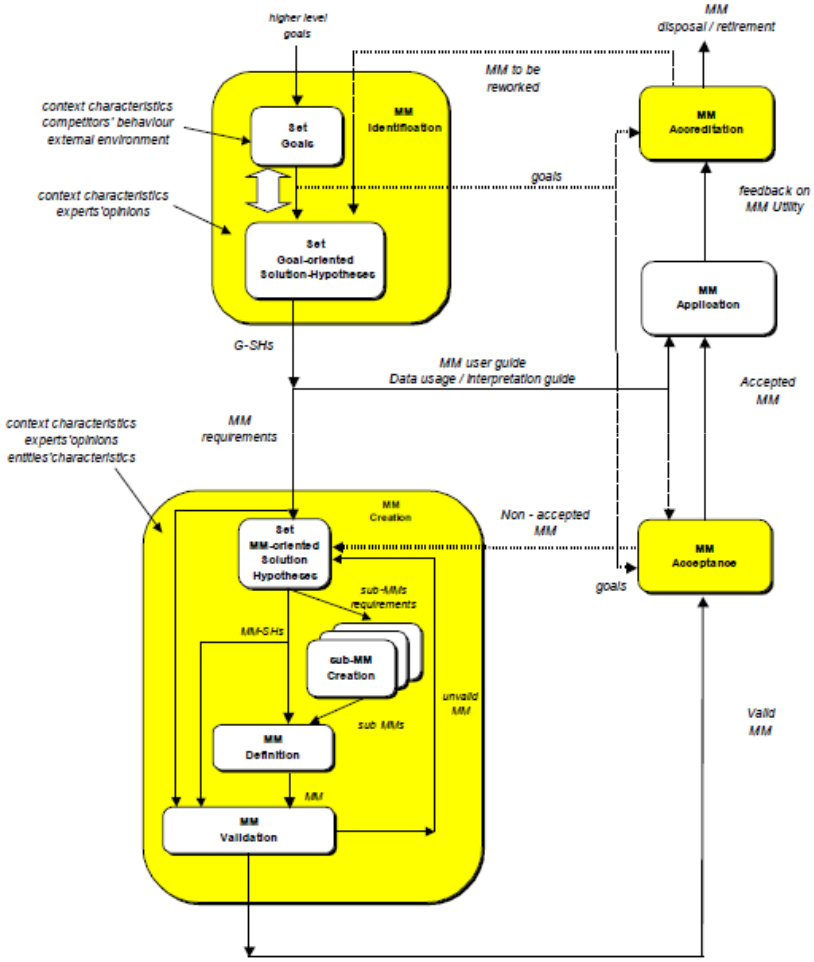


See the next section “Measurement plan” for details

COMPONENTS OF A SMM

A MM package is expected to include (but is not limited to) the *descriptive* | *predictive* | *prescriptive* MM's ***basic components*** (see Part I), which the next tables summarize.

BASIC COMPONENTS OF A DESCRIPTIVE SMM PACKAGE

MM Nature	Components	Description
Descriptive MM	Attribute Properties	Set of the properties of the attribute of the entity that the MM is meant to capture.

BASIC COMPONENTS OF A DESCRIPTIVE SMM PACKAGE

MM Nature	Components	Description
Descriptive MM	Attribute Properties	Set of the properties of the attribute of the entity that the MM is meant to capture.
	Entity Model	A model of the entity showing the characteristics that are relevant for the attribute.
	Mapping Function (Scale and Unit)	The measure function linking the empirical world (empirical relational system) to a formal one (formal relational system).

BASIC COMPONENTS OF A PRESCRIPTIVE SMM PACKAGE

They are similar to components of a descriptive SMM package.

BASIC COMPONENTS OF A PREDICTIVE SMM PACKAGE

MM Nature	Components	Description
Predictive MM	Sub-MMs	Definition of the included sub-MMs.
	Statistical Relational System	The statistical relationship between the measured attributes and the estimated one.

Preliminary examples of Predictive relationships: **Basic CoCoMo**

Effort Applied (E) = $\mathbf{a_b(KLOC)^{b}_{b}}$ [man-months]

Development Time (D) = $\mathbf{c_b(Effort\ Applied)^{d}_{b}}$ [months]

People required (P) = **Effort Applied / Development Time** [count]

Software project	a_b	b_b	c_b	d_b
Organic	2.4	1.05	2.5	0.38
Semi-detached	3.0	1.12	2.5	0.35
Embedded	3.6	1.20	2.5	0.32

Organic projects - "small" teams with "good" experience working with "less than rigid" requirements

Semi-detached projects - "medium" teams with mixed experience working with a mix of rigid and less than rigid requirements

Embedded projects - developed within a set of "tight" constraints. It is also combination of organic and semi-detached projects.(hardware, software, operational, ...)

FURTHER COMPONENTS OF A SMM

A MM package is also expected to include *any kind of information useful for* the MM *assessment*, *reuse*, and refinement.

Preliminary examples of Predictive relationships: **Intermediate** CoCoMo

Effort Applied (E) = $\mathbf{a_b(KLOC)^b{}_b}$ (EAF) [man-months]

Cost Drivers	Ratings					
	Very Low	Low	Nominal	High	Very High	Extra High
Product attributes						
Required software reliability	0.75	0.88	1.00	1.15	1.40	
Size of application database		0.94	1.00	1.08	1.16	
Complexity of the product	0.70	0.85	1.00	1.15	1.30	1.65
Hardware attributes						
Run-time performance constraints			1.00	1.11	1.30	1.66
Memory constraints			1.00	1.06	1.21	1.56
Volatility of the virtual machine environment		0.87	1.00	1.15	1.30	
Required turnabout time		0.87	1.00	1.07	1.15	
Personnel attributes						
Analyst capability	1.46	1.19	1.00	0.86	0.71	
Applications experience	1.29	1.13	1.00	0.91	0.82	
Software engineer capability	1.42	1.17	1.00	0.86	0.70	
Virtual machine experience	1.21	1.10	1.00	0.90		
Programming language experience	1.14	1.07	1.00	0.95		
Project attributes						
Application of software engineering methods	1.24	1.10	1.00	0.91	0.82	
Use of software tools	1.24	1.10	1.00	0.91	0.83	
Required development schedule	1.23	1.08	1.00	1.04	1.10	

Effort Multipliers to obtain the Effort Adjustment Factor

APPLYIG MEASUREMENT MODELS INTO AN ORGANIZATION

MEASUREMENT PLAN

To be successfully applied within a development environment, the development of a measurement plan is expected.

This includes a set of MM Packages, where the MMs are designed to achieve a given goal.

MEASUREMENT PLAN SPECIFICATION

A measurement plan is also expected to specify:

- the "**why**" (the underlying reasons)
- the "**what**" (attributes to measure)
- The means (**by** "**what**" tools and/or automats) and in case the "**who**" (the involved personnel), and the "**how**" (the data collection procedures)
- the "**when**" and "**where**" (in the process),

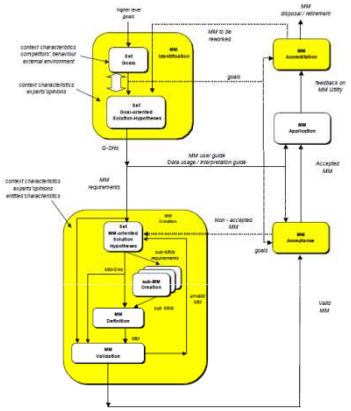
of the corresponding measurement activities.

But, rarely all of these aspects are equally taken into consideration by the adopted approaches.

COMPONENTS OF A MEASUREMENT PLAN

Item	Description
Set of MMs	The measurement models to be used (as ad-hoc tools) for achieving a given goal.
MM characteristics	The MM characteristics include: • The MM nature (descriptive, predictive). • The scale type and unit. • The relevant user oriented MM attributes, such as precision, usability, complexity, robustness, scope, etc.
MM application guide	This guide describes the MM related data collection procedures, that is both how/when to apply the given MM within the operational context and, the involved personnel.
MM data interpretation/usage guide	This guide describes how to employ the data provided by the MM.

SMMLC: CICLO DI VITA DI UN MM



Come già detto, SMMLC è basato su quattro fasi principali, oltre quella di Applicazione:

- Identificazione
- Creazione
- Accettazione
- Accredito.

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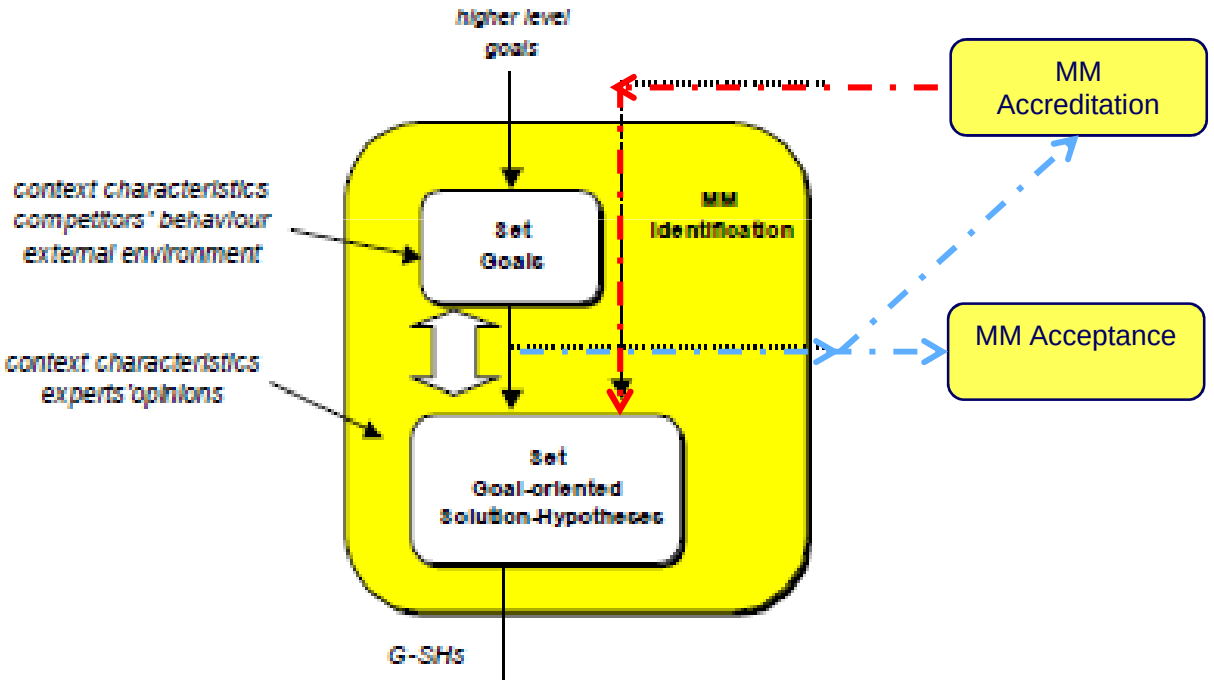
IDENTIFICATION.



SMMLC: IDENTIFICAZIONE

- *Identificazione*: consiste nel derivare un MM soddisfacente, come componente di un piano di misura fondato sugli interessi aziendali.

  Gli elementi chiave di questa fase sono:

  - Scopi (“*goals*”)
  - Ipotesi di soluzione.

SMMLC: IDENTIFICATION. GOALS.

Gli *scopi* possono, peraltro, suddividersi in:

- **funzionali**, i quali esprimono il “che cosa”,

e

- **non funzionali** (e.g., di qualità), i quali esprimono vincoli su come gli scopi funzionali devono realizzarsi.

SMMLC. IDENTIFICATION. GOAL. LEVEL

Gli *scopi* possono altresì organizzarsi gerarchicamente.

Goal Level	Goal Structure	Goal Facet
Strategic Goal	*Object of Study:*	External market
	Purpose:	Increase (i.e. improve)
	Quality Focus:	Share
	Viewpoint:	High level management
	Context:	Organization
Area Goal	*Object of Study:*	Customer care
	Purpose:	Improve
	Quality Focus:	Reliability of contracts estimates in terms of product delivery
	Viewpoint:	Customer
	Context:	Area of bespoke software development
Project Goal	*Object of Study:*	Software development process
	Purpose:	Improve
	Quality Focus:	Predictability of product delivery time
	Viewpoint:	Project manager
	Context:	New projects

SMMLC: IDENTIFICATION. GOAL. SUB-GOALS

A goal may lead to MMs (not necessary software MMs, e.g. a MM for the market share at strategic level), may evolve over time or may be decomposed into sub-goals, more exactly settable and achievable.

For example, the project goal in the previous table could lead to the sub-goals described in the next table.

SMMLC: IDENTIFICAZIONE. GOAL. SUB-GOALS

Goal Level	Goal Structure	Goal Facet
Project Sub Goal 1	*Object of Study:*	Software development process
	Purpose:	Reduce
	Quality Focus:	Risks of time overruns
	Viewpoint:	Project manager
	Context:	New projects
Project Sub-Goal 2	*Object of Study:*	Software development process
	Purpose:	Improve
	Quality Focus:	Estimation capabilities
	Viewpoint:	Project manager
	Context:	New projects

SMMLC: IDENTIFICATION. SOLUTION HYPOTHESES (SHs)

- Le *ipotesi di soluzione* sono orientate a definire il "*come*" delle attività di misura. Esse identificano quali informazioni bisogna fornire alla gestione per abilitarla a:
  - raggiungere gli scopi aziendali,
  - verificare se gli scopi si stanno raggiungendo / sono stati raggiunti oppure no.

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SMMLC: IDENTIFICATION. SOLUTION HYPOTHESES (SHs)

- SHs are based on an intuitive understanding of the goal-achieving problem, and represent the first attempt towards a structured solution. In other terms:
  - SHs summarize information and data coming from different sources (e.g. the descriptive models of processes and products of the target environment, the experts' knowledge about context and measurement, the point of view of the MM potential users).
  - SHs imply possible solution(s) to goal achievement that has not yet proven to be feasible and correct.

SMMLC: THE CONTINUAL TRANSFORMATION OF GOALS IN MMs

Once started, the intellectual process that goes from goals to MMs is a continual process, consisting of a step by step identification, refinement and verification of the problem solution. Each step may include a question-answering mechanism (GQM approach), and provides the rationale behind the choices that lead to the further step. This strategy makes easier the subsequent verification activities and use of the identified/created MMs.

SMMLC: THE CONTINUAL TRANSFORMATION OF GOALS IN SMMs. Goal-based Templates

In order to speed up and simplify the process, and reduce the involved risks, structured process-driving templates should be provided.

In particular, the need of goal-based templates, i.e., templates based on the various goal facets, is advocated.

Types of SHs.

As first step towards the construction of such templates, we divide the hypotheses into two levels, on the basis of their information contents and abstraction: *Goal-oriented SHs (or high-level SHs), and MM-oriented SHs* (or low-level SHs).

The formulation of the Goal-oriented SHs completes the MM Identification phase, whereas the formulation of the MM-oriented SHs constitutes the first step of the next one, i-e., the MM Creation phase.

SMMLC: THE CONTINUAL TRANSFORMATION OF GOALS IN SMMs. Goal-based templates for Goal-oriented Solution Hypotheses

Aspect	Guidelines
Set of MMs	The set of attributes to measure in order to achieve the goal is affected by the context maturity and resources (Goal Facet: Context). For example, besides the main MMs, other MMs to collect extra information for future actions could be necessary.
	The complexity of the measurement plan has to be discussed with the potential MM users (Goal Facet: Point of View), which could, for example, ask to reduce the number of MMs to be employed.
	....
MM requirements	MM nature: it has to be defined and eventually refined on the basis of the specific goal (Goal Facet: Purpose). MMs may in fact slightly differ depending on the particular task they have to perform (e.g. characterization, monitoring or evaluation for descriptive MMs, and prediction, control and change, for predictive MMs).
	Scale type, unit and user oriented aspects: they have to be agreed with the MM users (Goal Facet: Point of View), by taking into consideration the specific goal (Goal Facet: Purpose) and previous experience.
	....
MM Application Guide	How and when of the data collection has to be defined with MM users (Goal Facet: Point of View) and discussed with the process manager (Goal Facet: Context). The resources manager has to be involved in defining the staff (Goal Facet: Context).
MM data interpretation/usage guide	Use to be made of the collected data has to be defined with MM users (Goal Point of view), and coordinated with the project manager (Goal Facet: Context) in terms of interaction with other activities (measurement and not).
	....

SMMLC: THE CONTINUAL TRANSFORMATION OF GOALS IN SMMs. Goal-based templates for Goal-oriented Solution Hypotheses *(Cont'd)*

Aspect	Guidelines
Set of MMs	The set of attributes to measure in order to achieve the goal is affected by the context maturity and resources (Goal Facet: Context). For example, besides the main MMs, other MMs to collect extra information for future actions could be necessary.
	The complexity of the measurement plan has to be discussed with the potential MM users (Goal Facet: Point of View), which could, for example, ask to reduce the number of MMs to be employed.

SMMLC: THE CONTINUAL TRANSFORMATION OF GOALS IN SMMs. Goal-based templates for Goal-oriented Solution Hypotheses *(Cont'd)*

Aspect	Guidelines
MM requirements	MM nature: it has to be defined and eventually refined on the basis of the specific goal (Goal Facet: Purpose). MMs may in fact slightly differ depending on the particular task they have to perform (e.g. characterization, monitoring or evaluation for descriptive MMs, and prediction, control and change, for predictive MMs).
	Scale type, unit and user oriented aspects: they have to be agreed with the MM users (Goal Facet: Point of View), by taking into consideration the specific goal (Goal Facet: Purpose) and previous experience.

SMMLC: THE CONTINUAL TRANSFORMATION OF GOALS IN SMMs. Goal-based templates for Goal-oriented Solution Hypotheses *(Cont'd)*

Aspect	Guidelines
MM Application Guide	How and when of the data collection has to be defined with MM users (Goal Facet: Point of View) and discussed with the process manager (Goal Facet: Context). The resources manager has to be involved in defining the staff (Goal Facet: Context).
	....

SMMLC: THE CONTINUAL TRANSFORMATION OF GOALS IN SMMs. Goal-based templates for Goal-oriented Solution Hypotheses *(Cont'd)*

Aspect	Guidelines
MM data interpretation/usage guide	Use to be made of the collected data has to be defined with MM users (Goal Point of view), and coordinated with the project manager (Goal Facet: Context) in terms of interaction with other activities (measurement and not).
	....

SMMLC: THE CONTINUAL TRANSFORMATION OF GOALS IN SMMs. EXAMPLE: Goal-oriented Solution Hypotheses (Measurement Plan) for Project Sub Goal2

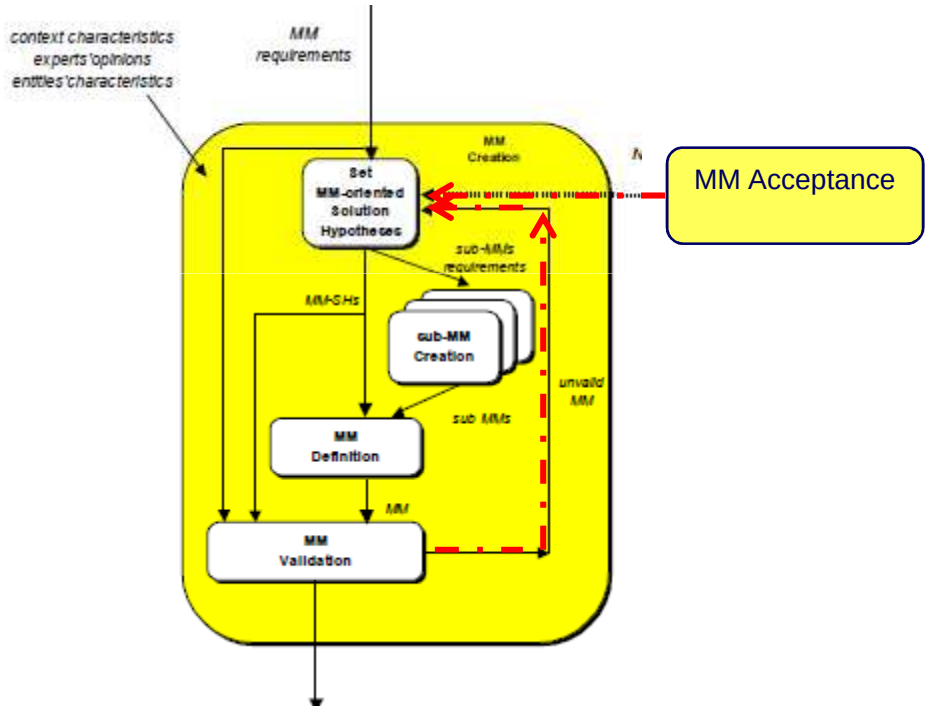
MM	Item	Description
MM1 MM2 MM3	Set of MMs	• MM1 estimates the delivery time since the beginning of the project (management tool) • MM2 characterizes at which extend software reuse is applied (long-term learning tool) • MM3 monitors project delay during development (real-time data-sensing tool)
Details for MM1	MM1 requirements	• Nature: predictive • Scale type and unit: Ratio, month • User oriented MM aspects: MM tolerance +/- 10%; MM input represented by Requirements; MM takes into consideration aspects such as the product type (e.g. real-time, legacy, etc.) and the expected requirements instability; MM has to be computer supported
	MM1 application guide	The Project Manager Assistant applies the MM at the end of the analysis on the Requirements documents (Object Model, Use-case Model, etc.)
	MM1 data interpretation/usage guide	The Project Manager (i) gives information to the high level management and (ii) inputs other MM tools to estimate other attributes, such as staff level over time

SMMLC: IDENTIFICAZIONE

- At the end of the Identification phase, the measurement plan is completely defined and it could be applied were all the identified MMs available.
  - The next step is therefore the creation of the needed MMs on the basis of the corresponding requirements.
  - Alternatively, it might possible to select from a repository the MMs that better match the stated requirements and therefore suitable to be reused or adapted with a minimum of tailoring effort.

SMMLC by G. Cantone, P. Donzelli, IJSEKE 2000.

CREATION



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SMMLC. CREAZIONE

- *Creazione*: consiste nel definire e validare un MM.

  Si articola in tre passi:

  - assunzione ipotesi di soluzione
  - definizione del modello
  - validazione del modello.

  In relazione ai risultati della validazione, MM può essere rilasciato o inviato a un passo precedente.

Template Esempio 

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SMMLC. CREAZIONE

The MM-oriented SHs refine/enrich the MM requirements by including specific MM information that partly depends on the nature (descriptive or predictive) of the MM itself. They focus on the components of a MM as a previous slide showed.

When the model under work is a composite model, i.e. the attribute under study is based on other attributes (indirect measurement model), other MMs are needed. Hence, the MM requirements for such component MMs are formulated and, the corresponding creation phase is performed, as illustrated by the branch in the last figure.

SMMLC. CREAZIONE. Template Example

Table in the next slide shows an example of goal-based templates that should be developed in order to support the formulation of MM-oriented SHs. Also this table is clearly incomplete and has been developed only to exemplify the suggested approach.

SMMLC. CREAZIONE. Example of Goal-based templates for MM-oriented SHs

Aspect	Guidelines
Attribute Properties	Mathematical properties that characterize the attribute. They represent an intuitive understanding of the attribute and are therefore independent from any specific product and goal.
	They should not be contradictory and should hold for the desired measure scale (specified by the MM requirements)
Entity Model	Characters of the entity that are relevant for the attribute and that the model has to capture should be chosen by considering the MM nature (Goal Facet: Purpose), the available knowledge about the entity (Goal Facets: Context and Object), and the MM user-oriented aspects (Goal Facets: Viewpoint).
	…
Mapping Function (Scale and Unit)	The link between the empirical and the formal world has to reflect the MM potential user (Goal Facet: Point of View), previous experience, adopted formalisms for the entity (Goal Facet: Context and Object).
	…
Statistical Relational System	Statistical Relational System has to be built by considering MM potential user (Goal Facet: Point of View), previous experience, and characteristics of the environment (Goal Facet: Context).
	…

Operazione

SMMLC. CREAZIONE. MM Component definition.

The MM Creation phase proceeds with the definition of the components of the MM (as listed in a previous slide). The main steps are:

- For a descriptive MM:
  - *select an entity model suitable to show the relevant entity's characteristics*
  - *define the measure properties, by specializing the attribute properties, on the basis of the chosen entity model, and by completing the empirical relational system; choose a draft mapping function.*

SMMLC. CREAZIONE. MM Component definition.

- For a predictive MM, having completed the previous steps for all the included descriptive sub-MMs:
  - *choose a draft statistical relational system by refining at a rather qualitative level the MM-oriented SHs.*

SMMLC. Creazione. Validazione.

Once defined, the MM has to be validated. This step concludes the creation phase.

A variety of frameworks for formal and statistical validation have been proposed in literature.

Here only the main aspects are taken into account.

SMMLC. Creazione. Validazione. **Validazione di un modello descrittivo.**

La Validazione di un modello descrittivo è di tipo formale.

E’ necessario, infatti:

- assicurarsi che il modello sia coerente con la definizione dell'attributo, soddisfi cioè le proprietà che lo caratterizzano
- individuare l'insieme più ampio delle trasformazioni ammesse dalle scale (cioè il livello di scala minimo) che conservi tali proprietà.

Sono noti due approcci alla validazione dei SMM.

- Un primo, valido per scale Reali, caratterizza la relazione che misurazioni di tal tipo inducono sull'insieme delle entità da misurare, in modo da poterla confrontare con la relazione empirica associata all'attributo d'interesse.

  Esso è stato utilizzato per studiare ampia parte delle misure di complessità basate su grafi; è estendibile a misure di altro tipo; permette di validare misure reali su scala ordinale, sebbene con alcune difficoltà; considera scale Ratio necessariamente di tipo additivo e questo ne costituisce un limite.

- Un secondo utilizza specifiche algebriche per definire in modo rigoroso un MM e per verificarne formalmente le proprietà.

SMMLC. CREAZIONE: VALIDAZIONE. Validazione di un modello predittivo.

La validazione di un modello predittivo è anche di tipo statistico.

Validare un modello predittivo significa, infatti:

- validare preliminarmente i modelli descrittivi che vi compaiono
- verificare l'esistenza dei legami ipotizzati fra gli attributi misurabili (Mi) e l'attributo da prevedere (P).

SMMLC. CREAZIONE: VALIDAZIONE. Validazione di un modello predittivo.

Sono analizzati i vari tipi di legami (criteri di validità) ipotizzabili fra gli attributi.

Per ognuno è indicato il tipo di impiego più idoneo del corrispondente modello predittivo e sono suggeriti i metodi statistici, parametrici e non, adatti alla sua verifica.

SMMLC. Validazione di un modello predittivo.

La validazione di un modello predittivo può avvenire utilizzando i dati raccolti durante un processo campione, impiegando dati reali oppure generati sinteticamente.

Si noti che validare significa anche formalizzare i legami statistici perché, in fase iniziale, si operano normalmente previsioni di tipo prettamente qualitativo.

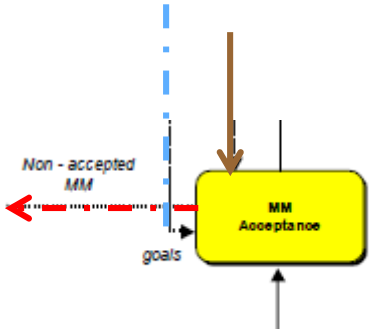
A validazione avvenuta, il MM può impiegarsi operativamente, fermo restando la necessità di riverificare ogni volta, ed eventualmente migliorare, le relazioni stabilite in precedenza.

SMMLC. Accettazione dei modelli di misura.

Questa fase può avere differenti gradi di complessità, in dipendenza della criticità delle informazioni che il MM deve fornire.

Essa è realizzata osservando il comportamento del MM nell'ambiente semplificato di un'applicazione, atta a riprodurre le caratteristiche pregnanti dell'ambiente effettivo.

SMMLC. ACCETTAZIONE



- *Accettazione*: il MM è sistematicamente osservato in laboratorio e/o reparto; ciò allo scopo di verificare le prestazioni del MM in relazione agli obiettivi aziendali.

  Questa fase, infatti, ambisce a sperimentare MM in contesti prima, eventualmente, artificiali (*Esperimenti controllati*), poi mediamente rappresentativi dell'ambiente applicativo e delle applicazioni ivi sviluppate (*Progetti pilota*), poi ancora con applicazioni e utilizzatori reali (*Casi di studio*).

SMMLC. ACCETTAZIONE

A fini di accettazione, le prestazioni del MM vengono valutate rispetto sia agli obiettivi iniziali dell'organizzazione (i.e., il supporto che MM fornisce al loro raggiungimento), sia ai requisiti del MM.

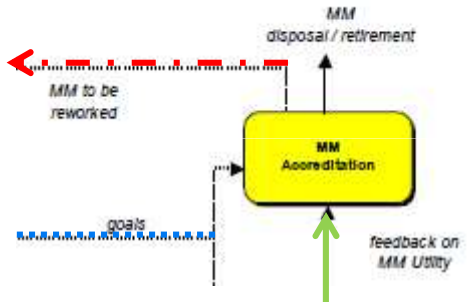
In particolare, se alcuni requisiti possono essere validati in fase di Creazione (correttezza, rappresentatività), l'Accettazione si concentrerà sui *requisiti di qualità e d'uso*, quelli, dunque, caratterizzati da forte soggettività e strettamente relativi al contesto d'impiego (usabilità, adeguatezza, precisione ecc.).

SMMLC. ACCETTAZIONE

In aggiunta alla verifica dei risultati ottenuti in fase di Creazione, l’operazione del MM in un contesto reale o prossimo alla realtà fornirà un mezzo per raffinare, arricchire, formalizzare la conoscenza del SRE che lo stesso MM tenta di catturare.

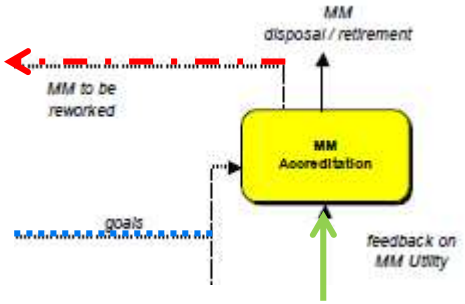
SMMLC by G. Cantone, P. Donzelli, IJSEKE 2000.

Accredito dei modelli di misura.



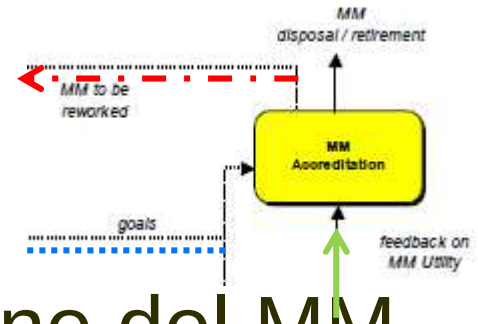
See the next section “Measurement plan” for details

SMMLC. **Accredito dei modelli di misura.**



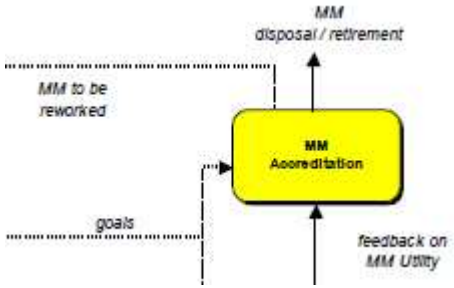
- *Accredito*: Questa fase denota un processo che procede con l'operazione del MM all'interno dell'azienda; concerne l'utilità pratica e la manutenzione del MM. Costituisce un processo dinamico, il quale procede insieme con la vita operazionale del MM all'interno dell'azienda.

  Ambisce all'assestamento del MM, a segnalare azioni correttive, migliorare l'utilità del modello, , i.e., la capacità dell'utente a raggiungere gli obiettivi prefissati.



Da un lato, infatti, l'applicazione del MM potrebbe aiutare nell'approfondire la conoscenza del problema per cui lo stesso MM è stato progettato; dall'altro, il MM potrebbe, prima o poi, manifestare la propria inutilità. Al di là di un tale caso, le conoscenze aggiuntive potrebbero essere utilizzate per riformulare le ipotesi di soluzione e, poi, correggere o migliorare il MM.

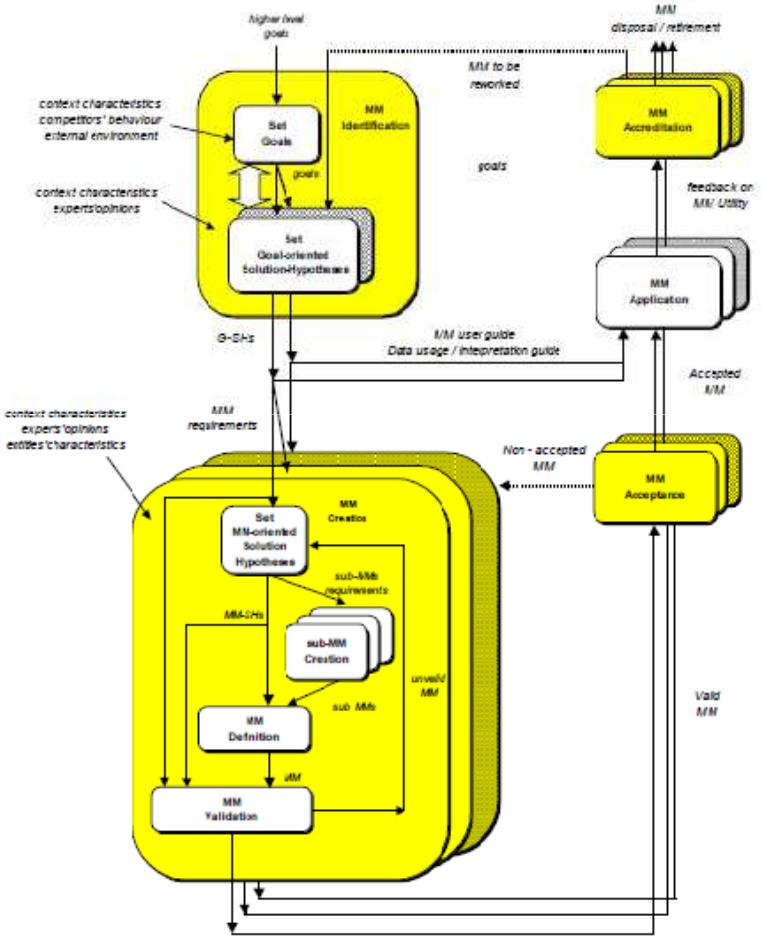
SMMLC. **Accredito dei modelli di misura.**



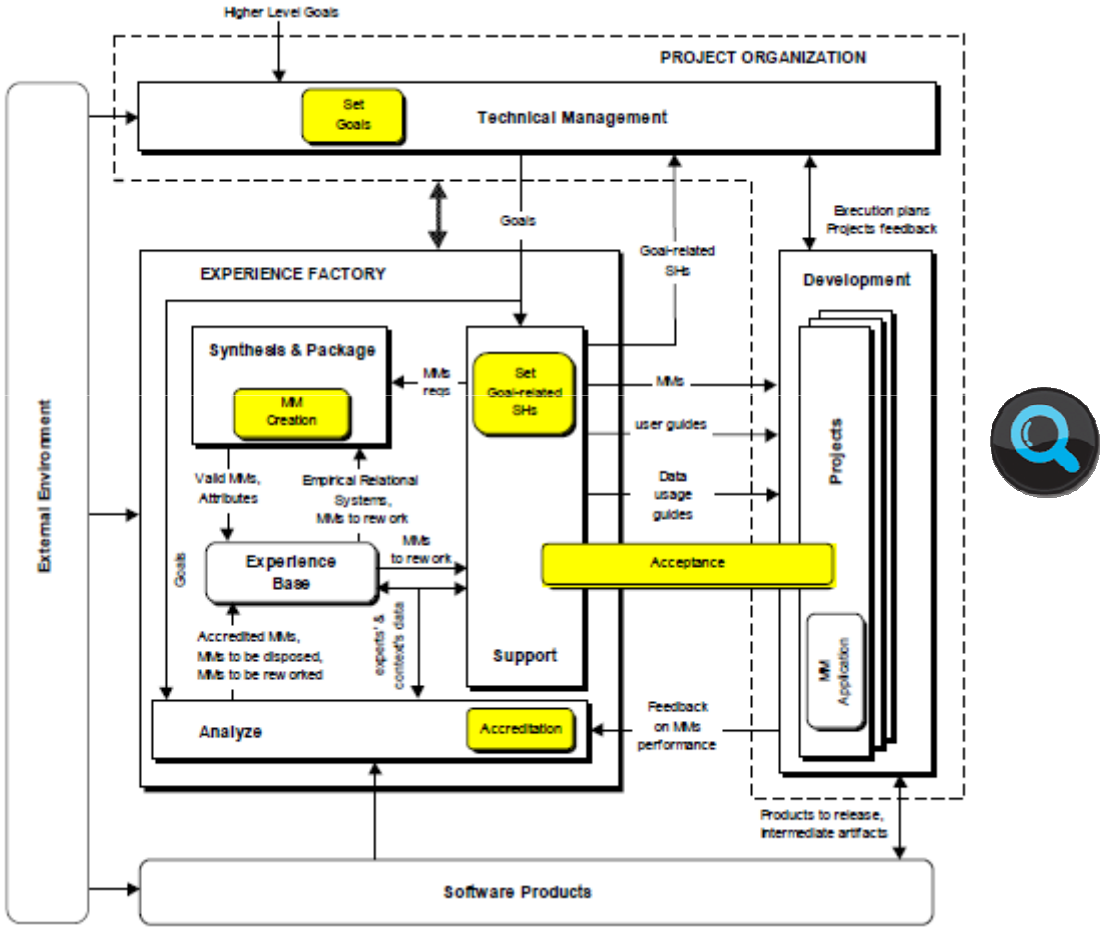
In particolare, per i più complessi MM predittivi, i cambi attesi possono classificarsi in tre livelli:

- Cambi minori, dovuti all'esigenza di meglio calibrare le relazioni statistiche
- Cambi strutturali, richiedenti la riformulazione di relazioni statistiche
- Cambi maggiori, richiedenti di intervenire su alcuni dei MM descrittivi su cui il MM predittivo si basa.

Concurrent development of MMs within a SW organization



MMLC within an Experience Factory-based SW organization.



CONCLUSIONI

Alcune delle parole chiavi usate:

- Processo (target) {di produzione | erogazione | servizio}
- Organizzazione (target)
- Misure (Modello, Processo, Risultato, Piano, Operatione etc.)
  - Misure software

Modelli per la misura del software. Parte 2/3.

Produzione e Manutenzione.

Basato su

Giovanni Cantone, Paolo Donzelli: Production and Maintenance of Goal-oriented Software Measurement. Models. Intl. Journal of Software Engineering and Knowledge Engineering, World Scientific, submitted 1999, published 2000.

http://www.worldscientific.com/doi/abs/10.1142/S0218194000000328

http://www.worldscientific.com/doi/abs/10.1142/S0218194000000328?journalCode=ijseke

Giovanni Cantone, Paolo Donzelli, Gianfranco Pesce; Misure software: teoria, modelli e ciclo di vita. F. Angeli editore, Collana "Informatica & Organizzazioni“ , volume per GUFPI , Cod. 724.36, 512 pp. ISBN 88-464-7139-3, luglio 2008.