

### The LEGO Maturity & Capability Model Approach

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#### Abstract

“Maturity model” (MM) (based on Crosby’s original idea) has been one of the main buzzwords over the past 20 years. A variety of MMs have been created in several application domains, from Software Engineering to Contract Management. Despite several models intending to cover the same domain, their PRMs (Process Reference Models) typically have different *scopes*, do not always cover the same set of processes, or have different *levels of depth*, or do not express the same level of granularity when describing concepts. Thus some important questions from the MM users’ viewpoint arise: how to choose the right models for our needs? After selecting those models, how to build a new, tailored MM based on several sources and customized to a specific domain? This paper motivates these important questions and proposes a way to choose, combine and adapt the contents from multiple MMs within a generic-domain approach we call ‘**LEGO**’ (Living **EN**gineering **pr**ocess), based upon the well-known kids’ toy that stimulates creativity through combining different bricks. We present three case studies, one of them based upon the development of the Medi SPICE model, illustrating how the proposed approach may be used to develop MCM (Maturity & Capability Models) in this context.

**Keywords:** LEGO, Maturity Model, Process Improvement, PRM, Process Architecture.

#### 1. Introduction

During the past two decades “maturity model” has become a well-known buzzword in the ICT arena and it has been pervasively diffused among organizations. When a company affirms to have achieved a certain maturity level, this now sounds quite natural to our ears. However, during a recent analysis of the number of ISO 9001 certifications for EA33 (*Information Technology*) vs. those using CMMI-DEV [5], one of the most popular maturity models (MM) for the Software & Systems Engineering domain has shown a ratio of approx. 4.5:1 formal assessments<sup>1</sup>. From analyzing the numbers from the official statistics (the ISO annual survey on one side [16], the SEI data about appraisals published in the PARS website<sup>2</sup> on the other side), one can identify more growth within the EA35 sector (*ICT Services*) as opposed to the EA33 sector. Furthermore, approximately more than 90% of ISO certified companies are Small and Medium Enterprises (SME) as typically CMMI appraisals are achieved by mid-large companies, often for contractual purposes, with investments that can be more consistent than for SME – VSE (Very Small Entities)<sup>3</sup>. IPSS (Improvement Processes for Small Settings) proposed by SEI [9] represents cross evidence for this as well as a series of initiatives for organizations of this size, as reported in [31]. Thus, some of the main drawbacks are easily visible: a single MM cannot cover all our needs irrespective of domain, often leading in practice to the modification of typical practices for a specific domain in order to accomplish the requirements required by such models instead of tailoring the MM to the specific domain by integrating typical best practices into its original Business Process Model (BMP)<sup>4</sup>, strengthening it more and more (e.g. in the System Engineering development). Again, another question arises in relation to how software development is handled in different models. For example: CMMI-DEV does not have a Process Areas (PA) for Reuse, instead it is expressed only in a few practices in the Technical Solution (TS) and Product Integration (PI) PAs, while ISO/IEC 15504 has devoted a process group and processes to the issue of Reuse (REU.x). Some more granular practices and information on Project Management could arise from ‘vertical’ MMs such as OPM3

<sup>1</sup> Obtained crossing the ISO 2009 survey data about ISO 9001 worldwide certifications (982,832, with approx 2,5% for EA33, therefore 25,000)[21] with the SEI data for the same period about CMMI SCAMPI Class A achievement at all maturity levels (4,726)[22].

<sup>2</sup> <http://sas.sei.cmu.edu/pars/>

<sup>3</sup> ISO has created a new working group (JTC1/SC7/WG24) on ‘Very Small Entities’ defined as ‘an entity (enterprise, organization, department or project) having up to 25 people’ [11]. The MM on which WG24 is creating a new standard (29110) is the Mexican one, MoProSoft [15].

<sup>4</sup> A Business Process Model (BMP) is the whole set of processes an organization has and it is a wider concept than the MM one, that’s part of it.

[18] or P3M3 [17] and be added into CMMI-DEV PP (and/or PMC) processes, strengthening their original content [3]. How could both these two situations be handled?

This leads us to a series of common-sense questions: how could we overcome this situation? Is it logical to think that the “one-size-fits-all” approach (in this case to be intended as ‘one-model-fits-all’) could solve all the organizational improvement points instead of looking at other models? And what about the long-term question about staged vs. continuous representation [6]? If MMs also represent SME/VSE (or other specific domains) business opportunities, why is there such a big difference between ISO and CMMI certification data as discussed above? Within the rest of the paper we have developed the following logical path for providing answers to these questions:

- There are plenty of MMs [7][32]<sup>5</sup>, each one focused on a well defined and (obviously) limited *process scope* (see the classification of MM by orthogonality in Horizontal, Vertical, Diagonal) [3][1]<sup>6</sup>. The challenge is to be able to select the best models to better achieve our business goals and then to combine them, since it's very difficult and extremely expensive to apply multiple models in parallel.
- MMs are useful for increasing the maturity/capability of our own BPM and not just for compliance (even if it could be needed for business requirements/constraints). Thus, since MMs should represent a set of ‘best practices’ within a certain application domain, the larger the number of MMs known by an organization, the greater the possibility to choose the real ‘best practices’ to be imported in our BPM. Therefore, two goals can be achieved at the same time: a real process improvement being compliant with the original model, and consequently being ready for official audits<sup>7</sup>.

This paper is structured as follows. Section 2 presents our approach, called LEGO and its main elements. Section 3 introduces the LEGO process and a few application examples, for better clarifying how to play with LEGO. Section 4 presents the conclusions and prospects for future research.

## 2. The LEGO Approach

As briefly introduced, we can add value to our BPM from several sources. But one of the main typical ‘psychological’ problems that appears when dealing with MMs is in relation to the tendency to modify the original processes within the process architecture rather than identifying desired practices and inserting them in our BPM. In order to represent a quick, visual idea about our viewpoint, we propose a component-based approach called **LEGO** (**L**iving **E**ngineering **p**rocess). An organization will choose elements to merge in a new and successful organizational design and fit this into its BPM. Thus, using a visual metaphor, we can compose – as kids do with the traditional LEGO bricks– our own BPM, keeping the best from each different valuable source – and maintaining formal traceability with the source models as well as customizing it to a specific domain which may also mean including something new. A reminder must be given to the organization in relation to what it has to accomplish with its business goals, the model(s) is(are) only one of the tools to be used for achieving those goals, not the goal itself<sup>8</sup>. In order to accomplish

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<sup>5</sup> A further list of MM is also available at [www.semq.eu/leng/proimpsw.htm#quinto](http://www.semq.eu/leng/proimpsw.htm#quinto)

<sup>6</sup> **Horizontal** - some MMs have processes that go through the complete supply chain, from requirements right through to delivery: they could be classified as ‘horizontal’ models. Examples of horizontal models in the ICT world are CMMI, ISO 12207/15504 or the FAA i-CMM [24]. **Vertical** - other MMs focus on a single perspective or process category: they could be classified as ‘vertical’ models, as they provide greater detail on a specific viewpoint. Examples for the second group include TMM [25] or TPI [26] in the Test Management domain, P3M3 [27] and OPM3 [28] in the Project Management domain. **Diagonal** - this third categorization refers to models whose content is mid-way between Organizational and Supporting processes. People CMM (P-CMM) [29] is an example of a diagonal model.

<sup>7</sup> The primary goal is to improve processes and consequently results in the mid-long term. Selecting the best practices and elements, choosing the right and homogeneous *level of granularity* and applying it to the elements of organizational BPM, as explained for the PM domain in [3], where only the PRM issue was discussed (see [4] for PAM). It is irrelevant as to whether this process will be run by a SME or VSE as both will gain benefits from having access to a list of relevant processes from different Capability and Maturity reference models, as this will reduce the time and effort for searching for them on the web or in the technical bibliography.

<sup>8</sup> Just as in the case of the Lego bricks ([www.lego.com](http://www.lego.com)) where bricks come in a variety of shapes and sizes, this is also the case for individual processes and depending upon the particular business goals of a particular organization some organizations may want a large and highly controlled process that will satisfy for example regulatory audits within a safety-critical industry whereas small new start organizations may want a more flexible lightweight process. Similarly, just as in the case of the Lego bricks if we wish to use processes from different reference models then these processes may need to be slightly tailored to fit together – similar to the idea of an interface design pattern in software design terminology if you know what I mean – we are currently doing something like this in the development of Medi SPICE where we have looked at what processes are required to satisfy the Medical device regulations – and really what processes are required by the medical device software process lifecycle model (IEC 62304) – this is derived from ISO 12207. We then look at relevant processes from 15504-5, Automotive Spice, Spice4Space, ISO/IEC15504-10 and SAFE+.

this goal, we identified four main elements that should be taken into account, discussed with more detail in next sub-sections:

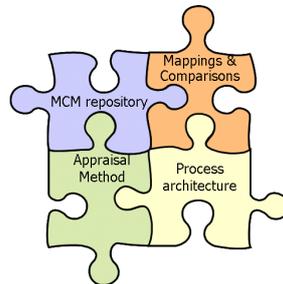


Figure 1 .The four elements of the LEGO approach

1. A 'Maturity & Capability Models' (MCM) repository, from relevant processes or MMs (meaning also the other dimensions – not yet the process dimension) can be identified;
2. Knowledge about the process architecture of each model, for understanding how to transform desired elements kept from a certain model into the target format, especially when considering that the source models may have different architectures to be integrated into a single model;
3. Mapping(s) & Comparisons between relevant models, in order to understand the real differences or the deeper level of detail from model A to import into model B;
4. Process appraisal method (PAM) to be applied on the target BPM.

## 2.1 MCM Repository

The core element in LEGO is the 'Maturity & Capability Models' (**MCM**) repository<sup>9</sup>. Before taking any action, you need to know which existing models contain relevant information – covering (at least partially) the domain of focus, no matter if it's a full process or only a process step or any other process element (normative or informative). For instance, which models in the Software & Systems Engineering domain include a 'Knowledge Management' process? So where do you find the relevant models? Currently process engineers do this mostly based on their individual knowledge of popular models and/or performing literature or internet searches. This often leads to the simple adoption of one reference model, possibly overlooking more adequate models or alternatives, because they are not sufficiently aware of alternative solutions from other models. Copeland started (few years ago) a compilation of 'maturity models', speaking about '*maturity models-mania*' [7] – yet, it is currently quite difficult to obtain information on existing models in a straightforward way - especially in relation to overview information on models that is required to make decisions as to whether to adopt a specific model. What is missing is a uniform classification scheme for such models and an online repository where such information can be browsed or accessed via advanced searches using the classification scheme. Since we need more than the title, we developed a classification scheme of MCMs including - the following technical information derived from our experiences and from the analysis of 52 models found as result of performing a systematic literature review [32]. Using this classification scheme we are currently developing a web-based repository, as shown in Figure 2.

- Domain: classifying a MM according to the domain for which it was developed (e.g. Medical Systems; Software Engineering, etc.);
- Sequential identification: a sequential unique identification (from *m001* to *m052*);
- MM Title and version;
- Short description: a short description on the model;
- Main reference(s): reference(s) for the publication and/or web site where it is described;
- Source Model(s): other models and/or standards on which it is based;
- Capability/Maturity dimension: presenting
  - structure and levels of its associated process assessment model (PAM);
- Process dimension: including

<sup>9</sup> We introduce this new acronym because several models are proposed only with the continuous representation therefore they are not formally 'maturity models' in the strict meaning people think to when dealing with the solely 'staged' representation.

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- process architecture (normative/informative elements);
- complete list of processes by process groups.

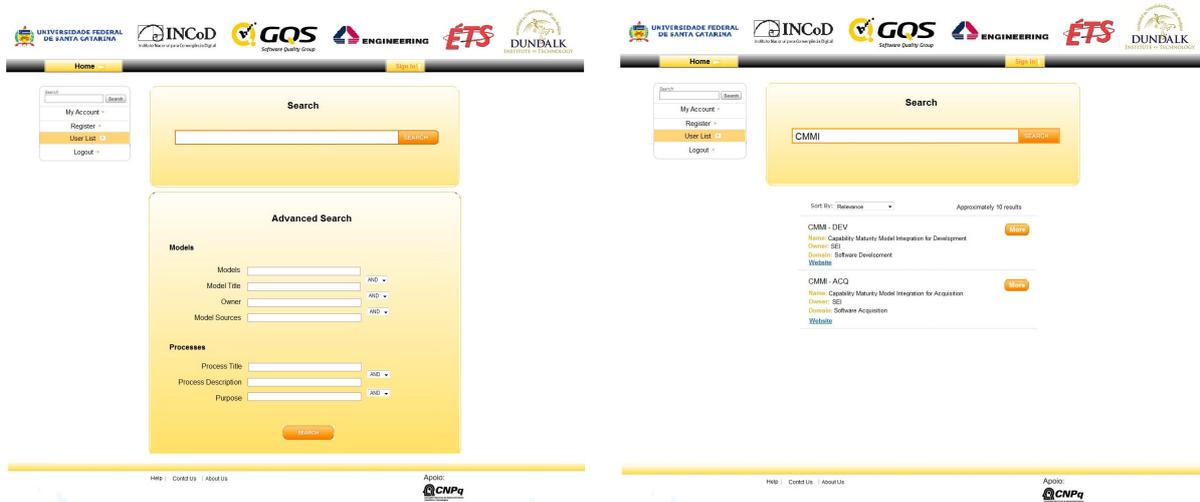


Figure 2. The web-interface for MCM repository [URL: [www.gqs.ufsc.br/mcm](http://www.gqs.ufsc.br/mcm)] <sup>10</sup>

This idea is based on a model of a network of **communities of practice (CoP)** linked loosely by a central body or organization and whose elements are shared through an online space. Here CoP refers to the notion outlined by Wenger [20] as being a joint enterprise that is understood and continually renegotiated by its members with mutual engagement that binds members together into a social entity to share a repertoire of communal resources that members have developed over time with two main goals:

- **Goal 1:** to describe each MCM through its main process attributes/elements (e.g. number and list of its processes, process groups, etc...), with a general schema for addressing the creation/modification of our processes using the core set of elements for incorporating/redesigning or modifying processes coming from other models as well as more awareness in what MCM are and can be used<sup>11</sup>.
- **Goal 2:** to collect and publish systematically the classification scheme to motivate a more consistent description of MCMs as well as to provide a community repository allowing the continuous inclusion of new models by their authors, creating a living repository of such MMs and to enlarge over time this initial set of models, including new valuable MCMs as they appear 'on the scene'. It will support process improvers as the starting point for developing their own tailored models for specific domains.

## 2.2 Process Architecture

The second element to be known for each MCM is the process architecture. From a mechanical perspective, we need to know where to find certain information according to the way each model expresses (or not) it. For instance, looking at a project management example, in [3] on page 4 (Case 3.a.ii) P3M3 has a KPA feature called 'perception' that CMMI hasn't, that's different from GP2.7. So, moving from the MCM database, we could obtain a matrix table with process attributes represented in columns and the MCM analyzed in rows by putting an "x" where the feature is covered (or not) in a certain PRM architecture. The real value of such a matrix would be in having a source for knowing what may be used to improve our own BPM and to estimate the effort for merging with more MCMs.

<sup>10</sup> A note for reviewers: the MCM repository creation is ongoing. In the final version of the paper the public URL for accessing it will be available.

<sup>11</sup> Referring to the ISO 9004:2009 Appendix A, and coming back to the original Crosby's idea with a simple maturity grid [8], yet applied to the ISO 9001:2008 clauses for improving 9001 audits from the standard ISO 19011 rules for assessing an organization. Nowadays this is performed to promote quantitative-based repositories such as the **ISBSG**, one for project data typically based on FSM (Functional Size Measurement) methods counts (<http://www.isbsg.org>) such as IFPUG, COSMIC or NESMA Function Points or the **PROMISE** project (<http://promisedata.org>), a research project gathering datasets to be used for prediction purposes on several areas (at the time of writing: Defect prediction; Effort prediction; General; Model-based SE; Text mining), but nothing about processes and process models.

### 2.3 Mappings & Comparisons

The third element is obtained through mappings between the models being analyzed. Despite numerous published mappings and comparisons<sup>12</sup>, most of them did not follow any scientific procedure (very few studies available, e.g. [33]) during their development or the procedures adopted have not been formally reported. A further element added here in LEGO is the availability of such existing mappings to assist with the search of common elements that may be elaborated and introduced in new or extended BPMs.

### 2.4 Appraisal Method

The fourth element is the appraisal method. In our view, we could use any Process Assessment Method (PAM), e.g. SCAMPI, irrespective of the PRM used. For instance, we can assess the new upcoming ISO/IEC 15504-8 PRM for ITSM processes both using SCAMPI and ISO/IEC 15504-2 PAM. Of course, using different assessment schema and representations, the way results arise will be (slightly) different. However, choosing and applying a single PAM in a consistent manner, will benefit organizations as common language and evaluation rules will be applied across the organization.

## 3. LEGO: the process and some case studies

### 3.1 The process

After describing the elements composing the LEGO approach, we now present the related process:

1. **Identify your informative/business goals:** clearly identify your needs, moving from the current BPM version and content.
2. **Query the MCM repository:** browse the MCM repository, setting up the proper filters in order to obtain the desired elements (processes; practices; etc.) to be inserted in the target BPM.
3. **Include the selected element(s) into the target BPM:** include the new element(s) in the proper position in the target BPM (e.g. process group, maturity level, etc.).
4. **Adapt & Adopt the selected element(s):** according to the process architecture of both process models (the target and the source one), the selected elements may need to be adapted, tailoring such elements as needed.

### 3.2 Some case studies

Now it's time to show a few practical examples about how LEGO could be applied. Due to the limited space for this paper, a qualitative summary of main actions is provided, but full details are contained and/or evincible from the cited references.

#### 3.2.1 Project Management

The first example is about a PM case presented [3] for horizontal vs. vertical models.

**Table 1. LEGO process (Project Management example)**

Id.	LEGO step	Process	Actions	Comment/Note
1	Identify needs	business	<ul style="list-style-type: none"> <li>• Increase the <i>scope</i> of the current BPM about Project Management processes, including the <i>Business Case Development</i> one.</li> </ul>	Hp: current BPM is CMMI-DEV based (horizontal model)
2	Query repository	MCM	<ul style="list-style-type: none"> <li>• Browse MCM repository, filtering by:                             <ul style="list-style-type: none"> <li>○ Domain: project management (→ P3M3)</li> <li>○ Process: Business Case Development (ML2 KPA)</li> </ul> </li> </ul>	Hp: selected the P3M3 OGC's model (vertical model)
3	Include elements into BPM	elements	<ul style="list-style-type: none"> <li>• 'Mapping &amp; Comparison' analysis: Business Case Development is a missing process in the target BPM</li> <li>• Position the new process in an existing CMMI process category (→ Project Management)</li> <li>• Position the new process in one of the defined CMMI ML (→ ML2)</li> </ul>	
4	Adapt & Adopt		<ul style="list-style-type: none"> <li>• Re-write and adjust the content of the original P3M3 KPA in the</li> </ul>	Hp: maintained the current

<sup>12</sup> See e.g. <http://www.sei.cmu.edu/cmmi> for CMMI constellations

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	<b>elements</b>	CMMI-style, both on SPs and GPs parts, filling the 'Elaboration' sections for each GP of the new 'Business Case Development' process and modify GPs in the existing processes where suitable	BPM process architecture
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### 3.2.2 People Management

The second example is a case about horizontal vs. diagonal model (P-CMM) [1].

**Table 2. LEGO process (People Management example)**

Id.	LEGO step	Process	Actions	Comment/Note
1	<b>Identify needs</b>	<b>business</b>	<ul style="list-style-type: none"> <li>Increase the <i>scope &amp; deepness</i> of the current BPM about HRM processes, including the 'Training &amp; Development' one.</li> </ul>	Hp: current BPM is CMMI-DEV based (horizontal model)
2	<b>Query repository</b>	<b>MCM</b>	<ul style="list-style-type: none"> <li>Browse MCM repository, filtering by:                             <ul style="list-style-type: none"> <li>Domain: HR management (→ People CMM)</li> <li>Process: 'Training &amp; Development' (ML2 KPA)</li> </ul> </li> </ul>	Hp: selected the People CMM model (diagonal model)
3	<b>Include into BPM</b>	<b>elements</b>	<ul style="list-style-type: none"> <li>'Mapping &amp; Comparison' analysis: similarities with CMMI's Organizational Training (OT) ML3 process.</li> <li>Valuable element(s) to be extracted: some more 'Typical work products' in P-CMM than currently present in OT</li> <li>Position the new elements in an existing CMMI process category (→ Process Management)</li> <li>Position the new elements in one of the defined CMMI ML (→ ML3)</li> </ul>	
4	<b>Adapt elements</b>	<b>Adopt</b>	<ul style="list-style-type: none"> <li>Re-write and adjust the content of the original OT process area including more WPs in SG1</li> <li>All the 'development' part of P-CMM 'Training &amp; Development' process is out of scope in CMMI → create a new SG3 using the CMMI process architecture style.</li> </ul>	Hp: maintained the current BPM process architecture

### 3.2.3 A different case: Medi SPICE

A further example not formally using all MMs as inputs comes from the new Medi SPICE development [23]. Medi SPICE is a new model based on the ISO/IEC 15504 family of standards for medical device software<sup>13</sup>. In such an application domain additional elements come from the regulatory standards and guidelines within the medical device domain e.g. FDA (US Food & Drugs Administration) guidelines and the IEC 62304:2006 standard for Medical device software lifecycle processes for medical device software development [30]. Let's run the LEGO process looking at the similarities followed in applying the same logical rules.

**Table 3. LEGO Process (MediSPICE example)**

Id.	LEGO step	Process	Action	Comment/Note
1	<b>Identify needs</b>	<b>business</b>	<ul style="list-style-type: none"> <li>Increase the <i>scope</i> of the ISO/IEC 15504-5 PRM and develop a PAM for the Medical Device industry</li> </ul>	---
2	<b>Query repository</b>	<b>MCM</b>	<ul style="list-style-type: none"> <li>At the time of the analysis, there was no MM for 'Medical Devices', therefore we analysed other safety-critical PRM/PAMs that had been developed based upon 15504-5 – For example, Automotive Spice for the Automotive Industry. Browsing ISO/IEC/IEEE standards list, the filters used were:                             <ul style="list-style-type: none"> <li><u>Domain</u>: medical device software</li> <li><u>Process</u>: all relevant processes</li> </ul> </li> </ul>	Hp: <i>selected</i> relevant processes from a series of models: 15504-5 (horizontal model), Automotive SPICE (horizontal model) Hp: selected a series of standards from regulatory bodies: IEC 62304:2006 process model (horizontal model)
3	<b>Include into BPM</b>	<b>elements</b>	<ul style="list-style-type: none"> <li>'Mapping &amp; Comparison' analysis: stressed all the missing processes in the initial PRM (ISO/IEC 15504-5) (e.g. Safety Management and Safety Engineering)</li> <li>Position the new process(es) in an existing ISO 15504</li> </ul>	

<sup>13</sup> <http://medispice.ning.com/>

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		<p>process group (→ e.g. Risk &amp; Safety Management Group – continuous view)</p> <ul style="list-style-type: none"> <li>Position the new processes in one of the defined ISO/IEC 15504-7 ML (→ ML2)</li> </ul>	
4	<b>Adapt &amp; Adopt elements</b>	<ul style="list-style-type: none"> <li>Re-write and adjust the content of the original IEC 62304 processes in the ISO 15504-style, both on BPs and PAs parts. Additionally, we have added a number of new processes - taken from ISO/IEC 15504-5 with additional relevant practices incorporated the medical device regulatory standards or guidelines</li> </ul>	<p><u>Hp</u>: maintained the current ISO/IEC 15504-5 process architecture</p>

There is no real state of the art approach for doing such unifications but LEGO represents a simple, logical approach to stimulate the inner knowledge on what we need for achieving better business results by improving the set of processes an organization is using.

### 4. Conclusions & Next Steps

One of the main problems of these last 15 years is the information overload, with too many possible sources of information paradoxically reducing *de facto* the direct access to information from many people. In relation to maturity models such as CMMI, people often didn't think they are just models but the reality to be directly compliant with for certification purposes, model by model. This risks people losing their final goal which should be to improve their processes and business. At present many organizations work in parallel on different models and such work typically involves a wastage of organizational resources as a duplication of tasks and therefore effort occurs within each of these models. Our idea is that, coming back to roots, there are single logical units (processes) that can be used as LEGO bricks for composing – in a sort of OO logic – our ideal and unique maturity & capability model (MCM), moving from the existence of numerous 'single' models and diffusing them in the ICT arena. Some lessons learned from this experience are:

- Improved knowledge management – you need to know which are the 'ingredients' you need for creating your own solution, this is valuable for improving results. Everything starts with people: they really are the 'wheel' in organizations. Creativity, intuitions and common-sense should be more emphasized than actual.
- Improved skill and awareness of employees in knowing where to search, stimulating how to find solutions for improving processes, implicitly using RCA (Root-Cause Analysis), is the key for saving money and putting in action a continuous BPR (Business Process Re-engineering) of your Business Process Models.

Speaking about process improvement, Humphrey said that "*if you don't know where you are, a map won't help*": this is the core problem we are trying to solve with our LEGO proposal.

### 5. Acknowledgements

This work was supported by the CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico – [www.cnpq.br](http://www.cnpq.br)), an entity of the Brazilian government focused on scientific and technological development. The Medi SPICE part of this research is supported by the Science Foundation Ireland (SFI) Stokes Lectureship Programme, grant number 07/SK/I1299, the SFI Principal Investigator Programme, grant number 08/IN.1/I2030 and supported in part by Lero - the Irish Software Engineering Research Centre (<http://www.lero.ie>)

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