The LEGO Strategy: Guidelines for a Profitable Deployment

Luigi Buglione, Christiane Gresse von Wangenheim, Fergal Mc Caffery, Jean Carlo Rossa Hauck

Abstract

When dealing with improvements, organizations seek to find a break-even point for their applications as early as possible in order to maximize the return from their investment. However, in some cases such a strategy can lead to a long term failure by not realizing the full benefits, when focusing only on a short term. The LEGO (**L**iving **E**n**G**ineering pr**O**cess) approach – a method for building your own process meta-model based on multiple inputs – is a way to make an organization more efficient and effective, optimizing resources, as well as time and costs through looking at its entire Business Process Model. This paper introduces the elements for designing a strategy for a more valuable deployment of a process improvement initiative, in order to optimize the choice of the models and elements to be considered as an input to the LEGO approach.

Keywords

Process Improvement, Maturity Models, LEGO, CMMI, ISO/IEC 15504.

1 Introduction

In the IT domain there are some periodical reports that [1] reveal issues regarding organizational and project management styles and the results achieved, such as the Standish Group CHAOS report [2] or the Gartner Magic Quadrants [3]. Consequently, there much literature exists that analyzes the possible 'top 10' or 'top 5' main causes for project failure. However, these reports do not focus on the core problem, concentrating instead on short-term objectives, and not on the wider mid to long-term ones [4][5][6][7][8]. When trying to understand why this happens so frequently and (possibly) to propose ideas for reducing such phenomenon, it is important to analyze an organizations structure. This can be done by starting from the strategic levels an organization typically formalizes: strategic, tactical and operational, respectively looking at long, mid and short term objectives. Following a Balanced Scorecard (BSC) deployment [9], all the organizational levels (not only the processes within each defined perspectives) must be aligned and properly communicate to each other, providing enough information to enable management at each level to make the organization effective and proficient.

Unfortunately, there is often a misunderstanding concerning coordinating the different purposes, goals and time-targets, provoking an improper distribution of resources across the different organizational areas [10] (aka 'organizational conflict'). One of these areas is the monitoring & control of the organization by periodical audits and appraisals. Due to the 'inner quality' costs, many managers feel that minimizing the cost of the 'monitoring & control' process as well as the associated improvement actions could lead to a reduction of profits on the short-term, but do not consider investing this saving in other 'productive' actions. This lack of vision can be easily represented in business terms through the 'cost of non-quality' (CONQ), as in most, well-known Total Quality Management (TQM) studies. Thus, one of the leverages for minimizing the CONQ is to increase the COQ (Cost of Quality), to help prevent post-release defects and problems from occurring. Looking at the list of possible cost attributes that contribute to the COQ, prevention costs are mostly based on appraisals [11] at different levels, with the aim to detect potential problems or inefficiencies before they happen, removing them earlier at a lower cost, than if detected later after the validation and post-production phases. Thus, the main question is: how much should a company invest in performing appraisals in order to optimize the balancing between COQ and CONQ?

The aim of this paper is to provide at least a partial description of the logical boundary for process appraisals in an organization, not necessarily an IT one, when using Maturity & Capability Models (MCMs). The inclusion of certain questions in management and budget discussions may give the quality department an opportunity to obtain real commitment for long-term objectives [12][13]. Such questions could be e.g.: how many processes should be considered to obtain sufficient information for determining an effective process improvement? Which processes should be included in the initial set of processes to be analyzed in order to stimulate an effective and efficient improvement, when investing a certain amount of budget, without having (or willing) to start with a 'big bang' approach?

The paper is organized as follows: Section 2 discusses the main reasons why a process improvement program fails and what should be focused upon to increase the probability of success. Section 3, introduces the LEGO approach and processes and the need for a strategy. Section 4, describes the first LEGO phase, introducing a simple but effective way to derive your own implementation strategy based upon your historical data and objective evidence. Finally, Section 5 provides some conclusions and the next steps for this work.

2 Why Process Improvement Programs Fail?

2.1 The Three Waves and Most recurrent Problems

Traditionally, process improvement has been used to obtain a path towards achieving certification in a certain model/framework, typically to achieve recognition within respective particular market and/or customer base. For instance, in the mid '90s, the *first wave* was to get certified with ISO 9001:1994 (and ISO 9002:1994 for services), the main standard for quality management, allowing for market recognition as being the best in class. The *next wave* in early Y2K was to gain compliance with

CMMI [14], ISO/IEC 15504 [15] (for ICT companies) or other maturity models, with a focus on the *staged* representation more than the *continuous* one, because of the possibility to achieve a benchmark to enable them to compete against direct competitors. The *last wave* was in the mid Y2K, searching for multi-models approaches, but not having a defined way to create a meta-model. SEI's PRIME initiative [16], like other proposals [17][18][19] seek a proficient way to integrate multiple models into a single model for representing the final 'process reference model' (PRM) that may be used to compare with the organizational BPM. Existing literature [20][21][22] highlights the common problems that occur in an improvement project. For example, lack of resources, time pressure, staff turnover, lack of support, lack of sponsorship, etc.

2.2 Further Attention Points

There are some misconceptions and issues that require particular attention:

- An ISO management system standard such as ISO 9001 or ISO 27001 is a list of *requirements*, not a *process* model. Thus, also mappings and comparisons between requirement and process models (e.g. CMMI) need to be carefully considered, but not treated as complete substitutes as it often happens;
- In MCMs, a *staged* representation proposes a predefined list of processes for an evolutionary implementation using blocks of processes. But few people carefully consider, if such predefined progression is valid for them both from a technical and business viewpoint. For instance, even if many studies (and common-sense) propose and demonstrate that an ISO 9001:2000 certified company is approximately equivalent to a company with a maturity level (ML) between CMMI ML2 and ML3 [23][24][25], a basic and core process such as Root-Cause Analysis (RCA), CAR (Causal Analysis & Resolution) is a CMMI ML5 process. This means that using the staged representation, an organization that is ISO 9001:2000+ certified cannot demonstrate directly an equivalent value from this inner capability (RCA is part of the ISO 9001 requirements). Therefore, creating an impression that's less than its real value. On the opposite side, adopting the *continuous* representation would overcome this issue, by instead measuring capability levels (CLs) for the set of processes – whatever the established ML reference – a company intends to evaluate.
- Well-established SPI models such as CMMI or SPICE (ISO/IEC 15504) include a set of processes covering a large part of the project lifecycle in a timely manner and can therefore be defined as 'horizontal' (following a timeline, from the beginning to the end of a project). Even if an organization adopts a multi-model integration approach, there are some questions that should be answered e.g. which risks could arise if the organization didn't perform a preliminary analysis on critical success factors (CFS) for a proper deployment?

Thus, an RCA should be performed at the strategic level to establish which should be the main list of issues whose fixing would represent the starting point for a sustainable, mid-long term improvement program.

3 Looking for a Solution: Back to the Strategy

3.1 Reactive vs Proactive Moods

Instead of many organizations working in a proactive manner to determine the yearly budget for process appraisals and improvement programs (e.g. ISO 9001, ISO/IEC 20000-1, CMMI-DEV, ISO/IEC 15504, etc.), they instead work in a 'reactive' way. Certification and compliance to standards should be achieved through simply following a logical sequence to accomplish business objectives using common-sense rules and principles. Such a common-sense approach should be based on:

- **People**: even if properly designed, processes will only succeed if executed by competent and skilled people. Most of the core processes in any organization (e.g. requirements elicitation, CMMI-DEV RD process area) cannot be automated. Consequently, attention to 'soft skills' is required.

Furthermore, as in many performance management models and frameworks (e.g. BSC [26][27], MBQA [28], EFQM [29], etc.), people are an 'enabler', coming first in terms of timing in the value chain [9].

- **Data-Information-Knowledge-Wisdom (DIKW**) [30]: is an acronym from the ITIL v3 Knowledge Management process, describing what is required for increasing the organizational knowledge, from historical *data* (less data equates to lower quality estimates and higher discrepancies between estimates and final values) to real wisdom, providing guidance as to 'why' specific actions are or are not taken. The business questions to be answered include: are we assessing/appraising the right things? And are we assessing/appraising the things right?

3.2 The LEGO Approach

In an attempt to encourage proactive process improvement, we have proposed a common-sense approach, called **LEGO** (**L**iving **E**n**G**ineering pr**O**cess) [17] for stimulating organizations to improve their own processes, by taking components (such as the real LEGO bricks) from multiple, potential information sources and integrated them to form a unique, reinforced picture for a particular process or set of processes. The starting point – for this paper – is that any model/framework typically represents only a part of the real story. Thus, through handling similar elements from different sources, we can hopefully find more 'fresh blood' for improving the organizational processes. This becomes necessary as a frequent misconception of organizations when dealing with certification programs is to shift the real target (improving the process to better satisfy the business objectives) with the supporting tool (e.g., achieving a certain maturity level). Therefore, in order to achieve the real target, we need to pragmatically improve organizational processes by introducing best practices from a selection of models/frameworks and experiences. Therefore, after establishing the business goals there is a need to search for and identify which 'supporting tools' are most applicable for the current situation. Unfortunately, it is often the case that organizations prioritise what is required in order to compliance against a particular model rather than striving for the best solution in terms of their processes . And in doing it, they risk achieving the opposite effect to what they intended, i.e. to lose and not gain 'value'. Thus, the 'fresh blood' we need are ideas and practices to be tailored, integrated and re-adjusted in the way that they will work in a specific organization, as opposed to a generic one. Thus, the LEGO approach enables little bricks to be used for building a concrete organizational value. LEGO has four main elements:

1. a 'Maturity & Capability Models' (MCM) repository [31] allowing a systematic search for and identification of relevant processes or MMs from existing models;
2. knowledge about the process architecture of each model, as a basis for understanding how to transform desired elements from a certain model into the target format, especially when considering that the source models may have different architectures that may need to be harmonized 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. a process appraisal method (PAM) to be applied on the target BPM (Business Process Model).

LEGO has also a related four-step process for determining which elements to consider when improving your current BPM:

1. **Identify your informative/business goals**: clearly identify your needs, moving from the current BPM version and content.
2. **Query the MCM repository**: browse and/or search the MCM repository, setting up the proper filters in order to obtain the desired elements (processes; practices; etc.) to be inserted into 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, through tailoring such elements as needed.

The LEGO approach and its basic elements have been presented in more detail in [17][31]. The next step is to provide tips and common-sense rules concerning how to proficiently apply it from the

beginning, providing details about the first step from a strategic viewpoint, but not necessarily from a tactical one.

3.3 Looking for a Strategy

The first step of the LEGO process is to clearly identify your needs and being a technique, it assumes you can choose the preferred way for an organization, according to the amount and quality of data and information available. The interesting question is: how can we do it? This is the goal of this paper. We also attempt to provide an answer this question in a common-sense manner using practically applicable solutions. It is important to have a strategy, and for not to have only a tactical or operational short-mid term focus. Looking at the Webster-Merriam dictionary, one of the possible definitions is "*an adaptation or complex of adaptations (as of behavior, metabolism, or structure) that serves or appears to serve an important function in achieving evolutionary success*". Thus, a strategy should consider the long term ('evolutionary success') and shouldn't be confused with the tactical and operational levels. A possible formalization of such common-sense concepts is the STO model [32], associating different actors, time-frame and business questions to each level.

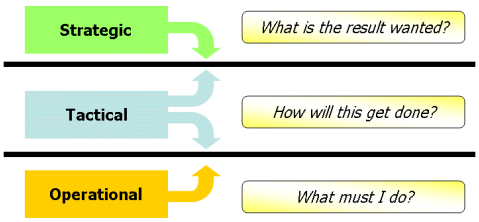


Figure 1: The STO Model [32]

From the viewpoint of appraisers and auditors, they check that the performance of the strategic decisions that were previously established by their management. But is there any consideration as to whether what we are performing is in fact correct or even are we working in the best way possible to achieve our goals? Table 1 below, illustrates a simple example of using STO goals, from the strategic to the operational level:

Table 1. STO Examples

Level	Scenario #1 – Goals	Scenario #2 – Goals
S – Strategic	• Provide quality product/services	• Be the best ICT provider in a certain market
T – Tactical	• Become ISO 9001 certified within 2 years	• Become compliant with main best practice models/frameworks after taking the best of them using the LEGO approach
O – Operational	• Run quarterly audits based on ISO 19011:2011 guidance	• Run periodical appraisals using the resulting (LEGO) meta-model mapped on the organizational Business Process Model (BPM)

The final choice should be made by considering all elements in such a scenario and calculating (even approximately) the ROI looking at different moments in time, not only for determining the BEP (Break-Even Point).

4 Establishing a Strategy from Historical Data

4.1 Positioning the LEGO Approach in the PDCA Cycle

In this section we outline our proposal for the design of a strategy. Using the well-known PDCA (Plan-Do-Check-Act) phases, Figure 2 illustrates the main steps within each of the four phases and the potential added value (also stressed with the '+' or '-' signs) for an organization adopting this approach

to perform process management for the mid-long term. The coloured text shows the additional steps to be run for implementing a strategy against the typical steps for a usual PDCA-based improvement.

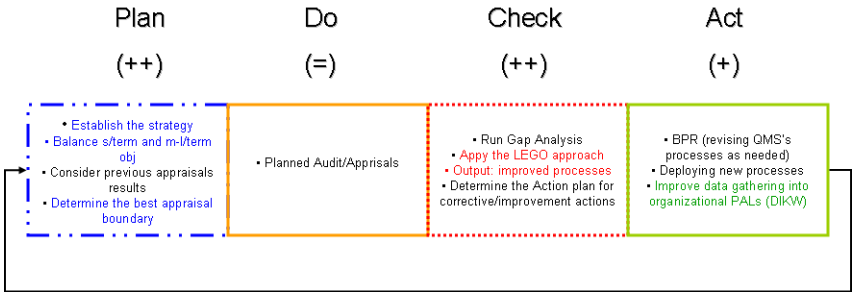
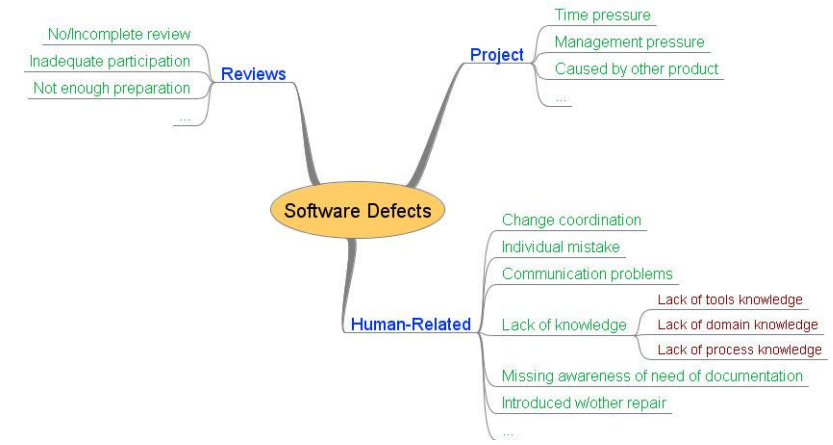


Figure 2: The LEGO Strategy across the PDCA cycle

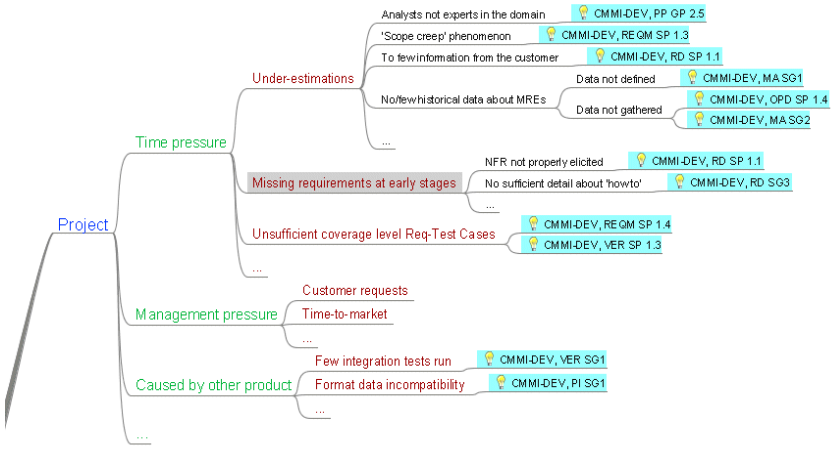
- **Plan**: there are three additional steps: (a) establish the strategy; (b) balance short-term and mid-term objectives; (c) determine the best appraisal boundary. The first two relate to the establishment of strategic and tactical goals. The third one concerns the final decision for determining the technical boundary for performing the audit/appraisal. A recent proposal for this last step is described and augmented in [33].
- **Do**: no additional steps in this phase.
- **Check**: two additional steps: (a) apply the LEGO approach; (b) output: improved processes. These two steps are extensively explained in [1].
- **Act**: just a final, additional step: (a) improve the data gathering into the organizational PALs (Process Asset Libraries), but introducing something more than solely D-I levels (Data-Information) from the DIKW path previously introduced (typical for a PAL, as described in CMMI OPD SP1.5) from the full DIKW (as described in ITIL v3, Service Transition book [30]). Some examples and tips are also proposed in (http://en.wikipedia.org/wiki/DIKW).

4.2 Focusing on Strategy: Making it Work

Focusing our attention on the 'Plan' phase, and on the first step (*Establish the strategy*), we can refer to Total Quality Management (TQM) well-known techniques. TQM tools contain many possible answers whether applying old and new quality tools with a simple common-sense mood: e.g. RCA (Root-Cause Analysis), Affinity diagrams, Pareto diagrams, Control Charts, etc. [34]. Simulations based on historical data could help in designing a program looking at a larger timeframe than is currently used in organizations. Figure 3, presents an example of taking a RCA analysis for determining why a project has many defects more than expected [35], and then redrawing it using mind maps, as suggested in [36]. Figure 3a shows the same elements from the original paper, while Figure 3b proposes a refined analysis using the "5why's game", showing 3-4 levels of depth.
When determining the final leaf for each branch, it is possible to create a match with the process element from the improvement model(s)/framework(s) from which useful support can come for re-designing processes. We now take a deeper look at some leafs, from the top of Figure 3b. Time pressure could be due to underestimations which may have arisen for several reasons such as: little historical data was available to assist the estimating process, or estimates were provided by inexperienced people. In the first case, the root-cause is due to the unavailability of a 'measurement repository' (using CMMI-DEV, would be stated in OPD SP1.4) or to missing definitions for some values in the project data (related in such case to MA SG1). In the second case (low experience), the related CMMI-DEV element would be Project Planning (PP) GP 2.5, this relates to the need for people to be trained. Of course, here a single well-known model has been considered, but suppose we wish to include all the potential elements that could be useful when following the LEGO approach. In other words, the mapping with one/more model elements is a way to name the areas where gaps to be filled need to be reworked.



(a)



(b)

Figure 3: A root-cause analysis (RCA) for the effect '(too many) software defects'

Another fundamental concept in TQM is the classification – based on the frequency a certain fact occurs – or problems with *special causes* (happen with low frequencies and with no seasonality) or *common causes* (happen with seasonality, repeating patterns of activities). A strategic goal should therefore focus upon repeated patterns (in this case with a negative meaning) for determining stable, mid-long term actions reducing (or at least minimizing) potential negative impacts and stressing as much as possible the positive effects for an organization, whatever the perspective. Thus, consider running several RCAs within an organization in a certain timeframe, and think about the frequency of the 'models' elements in order to provide an interesting analysis. We refer to the analysis of the 'Project' main leaf from Figure 3b. Table 2, summarizes how many times that specific element was mentioned and establishing an implementation priority (with 'A' being the highest priority etc.), and based on the causal relationships among processes. Such information is contained into the 'Related Process Areas' section at the beginning of each process area description in the CMMI. Thus, since missing requirements could be the root-cause for having less formalized requirements and therefore fewer test cases than expected (with a higher potential number of final defects at the release phase), working on a better and deeper requirement elicitation (RD – Requirement Development) should be implemented first.

Table 2. Frequency and Implementation priorities from the RCA 'Project' leaf

	Model	Version	Process	Goal	Practice	Frequency	Impl. Priority
			PA	***SG/GG***	***SP/GP***		***Cause-Effect***
1	CMMI-DEV	1.3	**MA**	SG 1		1	**B**
2	CMMI-DEV	1.3	**MA**	SG 2		1	**B**
3	CMMI-DEV	1.3	**OPD**		SP 1.4	1	**B**
4	CMMI-DEV	1.3	**PI**	SG 1		1	**E**
5	CMMI-DEV	1.3	**PP**		GP 2.5	1	**C**

6	CMMI-DEV	1.3	**RD**		SP 1.1	2	**A**
7	CMMI-DEV	1.3	**RD**	SG 3		1	**A**
8	CMMI-DEV	1.3	**REQM**		SP 1.3	1	**D**
9	CMMI-DEV	1.3	**REQM**		SP 1.4	1	**D**
10	CMMI-DEV	1.3	**VER**		SP 1.3	1	**E**
11	CMMI-DEV	1.3	**VER**	SG 1		1	**E**

In order to determine which areas should be given more priority for reinforcing organizational processes, a Pareto analysis can be performed. Such an analysis lists process areas in descending order of the potential gaps from several RCA run across the organization in a certain time frame, see Figure 4.

Process	Frequency	Priority
RD	3	A
MA	2	B
REQM	2	D
VER	2	E
OPD	1	B
PP	1	C
PI	1	E

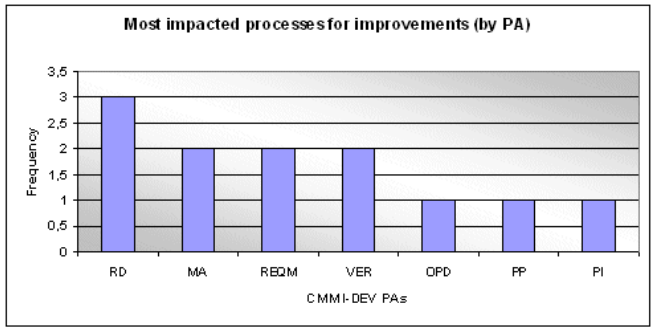


Figure 4: Most impacted processes for improvements (by process area)

Of course, an improvement plan must consider actions grouped by a certain criterion to be run at the same time, because of the causal link between them. In our proposal, this criterion is included in the 'implementation priority' field.

Priority	Process	Frequency
A	RD	3
B	MA, OPD	3
C	PP	1
D	REQM	2
E	VER, PI	3

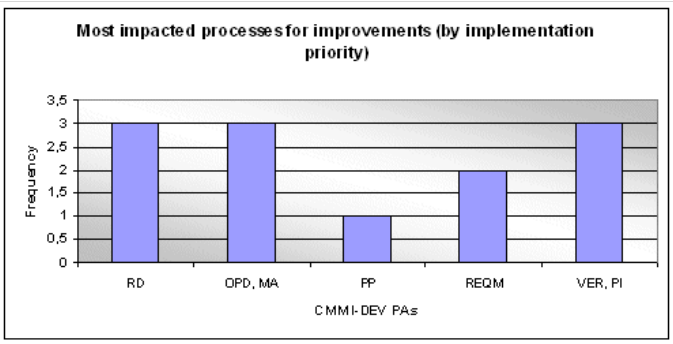


Figure 5: Most impacted processes for improvements (by implementation priority)

Figure 5 groups process areas by implementation priority level (from A to E). Thus, if the main problem for an organization was to have too many defects at the release stage, from such an analysis (assuming it has been validated), the improvement plan should start with refining how requirements are captured, making all requirements visible and no longer implicit (priority A), and then store historical data for improving future estimates (priority B), etc. If work is started on the priority A chunk, LEGO will aim to reinforce the organizational BPM through analyzing all possible maturity models/frameworks in relation e.g. to Requirement Engineering, or Project Management. The substantial difference from this structured analysis as opposed to simply adopting the thoughts from the management of an organization is that such decision will be augmented by the historical data of the organization, therefore adding more strength to such a decision. Finally, Figure 6 summarizes the operational flux for satisfying the 'Establish the strategy' step within the Plan phase.

Thus, the business value from such a preliminary activity would provide a more objective way for deciding which improvement areas should be included when planning an improvement project through using your own historical data as a starting point. Such data can be retrieved from any type of objective evidence (e.g. audits, appraisals) and it is useful as it provides a better understand issues

etc. within previous projects. Therefore, such approach would minimize from the outset the risk of adopting a costly and unfruitful process improvement program.

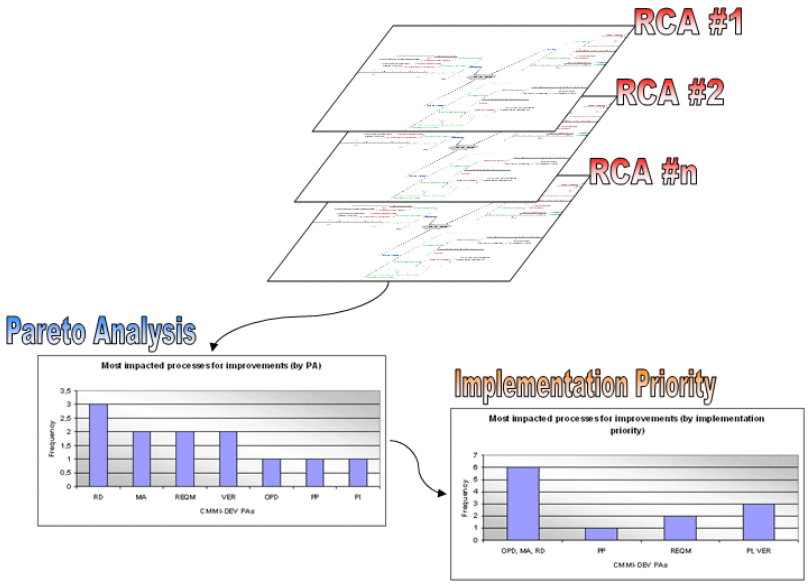


Figure 6: Root-Cause Analysis for determining CSF as pre-filters for adopting LEGO

5 Conclusions & Next Steps

Whatever the organization size, a strategy is always needed: applying a 'flavour of the month' approach cannot allow an organization to achieve mid-long term results, with seeds for a continual improvement over time. Thus, a strategy should be provided that is appropriate to the size and main attributes of an organisation, as also stated both in ISO management system standards (e.g. ISO 9001:2008) and main maturity models (e.g. CMMI-DEV with the quest of introducing a *tailoring* guideline, see OPD SP 1.2). On the contrary, there is a lack of clear organizational strategy that can be easily observed by the absence (or not clear presence) of MVV (Mission-Vision-Values) elements. Such an absence can easily reveal a weak or absent strategy, that would lead an organization to focus mostly on tactical goals, increasing the risk of not achieving its long-term business goals. A BPR (Business Process Re-engineering) initiative applying a multi-model approach such as LEGO should fit with a certain organizational size and characteristics, as often an ideal model is applied without due consideration as to what really happens.

This paper introduced and discussed how a strategy can be established for applying LEGO, through building upon an organization's historical data and objective evidences, using well-known TQM tools. Such a preliminary filter allows an organization to focus resources on its technical priorities but keeps in mind that the reference model is the management system of an organization and that any external model must be a potential input for strengthening it and not the ideal target for modifying the processes. Furthermore, even if many valid models/frameworks could be used for carrying out the LEGO approach, from observing ICT organizations they appear to continue to look for and apply only a few common models, while enlarging the analysis to a wider scope could provide richer sources. E.g. performance management models such as the Malcolm Baldrige Quality Award (MBQA) and the European Foundation for Quality Management (EFQM) could provide greater assistance in relation to Leadership (their first 'enabling' criteria) supporting and sustaining improvement initiatives and programs, as well as when using LEGO, which is not particularly developed in ISO 9001 [37] requirements and in CMMI or ISO/IEC 15504 models. The more the potential sources to be used, the higher the probability to redesign a set of valuable, improved processes for your own organization.
The next steps of this research will be to formally apply the LEGO strategy on real case studies, in order to validate it by quantitative figures comparing the initial different working hypothesis for an improvement program with and without such an approach.

Acknowledgements

This work has been supported by the CNPq (*Conselho Nacional de Desenvolvimento Científico e Tecnológico* – www.cnpq.br), an entity of the Brazilian government focused on scientific and technological development.
This research is also supported in part 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 (the funding of this project was awarded by Science Foundation Ireland under a co-funding initiative by the Irish Government and European Regional Development Fund), and supported in part by Lero (http://www.lero.ie) grant 10/CE/I1855.

References

[1] Eveelens J.L., Verhoef C., The Rise and Fall of the CHAOS Report Figures IEEE Software, Jan/Feb 2010, pp,30-36
[2] Standish Group, CHAOS Summary 2009. The 10 Laws of CHAOS, 2009
[3] Gartner, Magic Quadrants, URL: www.gartner.com/technology/research/methodologies/research_mq.jsp
[4] PM Solutions, Strategies for Project Recovery, Research Report, 2011
[5] Kappelman L.A., McKeenan R., Zhang L., Early Warning Signs of IT Project Failure: The Dominant Dozen, Journal of Information System Management, Fall 2008, pp.31-36
[6] Al-Ahmad W., Al-Fagih K., Khanfar K., Alsamara K., Abuleil S., Abu-Salem H., A Taxonomy of an IT Project Failure: Root Causes, International Management Review, Vol. 5 No. 1 2009, pp. 93-104
[7] Benjamin R., Project Success as a function of Project Management Methodology: an emergent system approach, MBA thesis, University of Hull/UK, April 2006
[8] Whittaker B., What went wrong? Unsuccessful information technology projects, Information Management & Computer Security, 7/, 1999, pp 23-28
[9] Kaplan R., Norton D., The Balanced Scorecard: Translating Strategy into Action, Harvard Business Review Press, 1996, ISBN 9780875846514
[10] Arvid Johnson R., Management, systems, and society: an introduction. Pacific Palisades, Calif.: Goodyear Pub. Co, 1976, pp. 148–142. ISBN 9780876205402
[11] Jagannathan S.R., Bhattacharya S., Matawie K., Value Based Quality Engineering, TickIT International, 1Q05, January 2005, pp. 3-9 C:\AppData\Local\Temp\Temp1_LEGO Strategy.zip\www.tickit.org\TI1Q05.pdf
[12] Abrahamsson P., The role of commitment in software process improvement, Dissertation, University of Oulu/Finland, 2002
[13] Ahmad A., Making Management Commitment Happen in SPI, Master Thesis in Software Engineering and Management, IT University of Goteborg (Sweden), 2007
[14] CMMI Product Team, CMMI-DEV (CMMI for Development) v1.3, Technical Report, CMU/SEI-2010-TR-033, Software Engineering Institute, November 2010
[15] ISO/IEC IS 15504-x, Information technology -- Process assessment, Parts 1-7, International Organization for Standardization, 2001-2007
[16] SEI, Process Improvement in Multimodel Environments (PrIME), webpage, URL: http://goo.gl/p2GX3
[17] Buglione L., Gresse von Wangenheim C., Hauck J.C.R., McCaffery F., The LEGO Maturity & Capability Model Approach, Proceedings of the 5th World Congress on Software Quality (5WCSQ)
[18] Pricope S., Lichter H., A Model Based Integration Approach for Reference Model, Proceedings of PROFES 2011, Torre Canne (Bari, Italy), June 2011
[19] ARMONÍAS: A Process for Driving Multi-models Harmonization, ARMONÍAS Project, University of Castilla-La Mancha (Spain), 2009
[20] Niazi M., Wilson D., Zowghi D., A maturity model for the implementation of software process improvement: an empirical study, Journal of Systems and Software (JSS); Elsevier, 74(2), January 2005, pp. 155 - 172
[21] CSE, Critical Success Factors for Successful Process Improvement, Centre for Software Engineering, URL: http://goo.gl/lgROc
[22] Niessink F., van Vliet H., Measurement Program Success Factors Revisited, Information and Software Technology, Vol 43 no 10 (August 2001), pp 617-628
[23] Paulk M.C., A Comparison of ISO 9001 and the Capability Maturity Model for Software, Technical Report, CMU/SEI-94-TR-012, Software Engineering Institute, July 1994
[24] Mutafelija B., Stromberg H., Process Improvement with CMMI v1.2 and ISO Standards, Auerbach, 2008, ISBN 978-1420052831
[25] Kitson D., Vickroy R., Walz J., Wynn D., An Initial Comparative Analysis of the CMMI Version 1.2 Development Constellation and the ISO 9000 Family, Special Report, CMU/SEI-2009-SR-005, Software

Engineering Institute, March 2009
[26] Kaplan R., Norton D., Strategy Maps: Converting Intangible Assets into Tangible Outcomes, Harvard Business Review Press, 2004, ISBN 9781591391340
[27] Reo D., Quintano N. & Buglione L., ESI Balanced IT Scorecard Infrastructure & Innovation Perspective, ESI-1999-TR-043, December 1999
[28] NIST, Malcolm Baldridge, 2011-12 Criteria for Performance Excellence, URL: www.quality.nist.gov
[29] EFQM, EFQM Excellence Model, 2009, ISBN 9789052365015
[30] Cabinet Office, ITIL v3 Service Transition book – Refresh 2011, ISBN 9780113313068
[31] Gresse von Wangenheim C., Hauck J.C.R., Buglione L., Mc Caffery F., Cardoso Lacerda T., Viera da Cruz R.F., Building a Maturity & Capability Model Repository, Proceedings of PROFES 2011, 12th International Conference Product Focused Software Development and Process Improvement, Torre Canne - Bari (Italy), June 20-22 2011, 2nd Proceedings: Short Papers, Doctoral Symposium and Workshops, ACM, ISBN 978-1-4503-0783-3, pp. 2-5
[32] Callahan K., Brooks L., The Essentials of Strategic Project Management, John Wiley & Sons, 2004, ISBN 9780471649854
[33] Buglione L., Mc Caffery F., Hauck J.C.R, Gresse von Wangenheim C., FIRST: Common-sense Process Scopes for Starting a Process Improvement Program, Proceedings of SPICE 2012, Palma de Mallorca (Spain), May 2012
[34] Ishikawa K., Introduction to Quality Control, Productivity Press, 1990, ISBN 9784906224616
[35] Leszak M., Perry D.E. & Stoll D., A Case Study in Root Cause Defect Analysis, Proceedings of the 22nd International Conference on Software Engineering (ICSE 2000), Limerick (Ireland), June 4-11 2000, ISBN 1581132069, pp.428-437
[36] Buglione L., Strengthening CMMI Maturity Levels with a Quantitative Approach to Root-Cause Analysis, Proceedings of the 5th Software Measurement European Forum (SMEF 2008), Milan (Italy), 28-30 May 2008, ISBN 9-788870-909999, pp. 67-82
[37] ISO IS 9001:2008, Quality management systems -- Requirements, International Organization for Standardization, December 2008

6 Appendix A: List of Acronyms

BEP	Break-Even Point
BPM	Business Process Model
BSC	Balanced Scorecard
CAR	Causal Analysis & Resolution (CMMI ML5 PA)
CFS	Critical Success Factor
CL	Capability Level
CMMI	Capability Maturity Model Integration (www.sei.cmu.edu/cmmi)
CMMI-DEV	CMMI for Development
CNPq	Conselho Nacional de Desenvolvimento Científico e Tecnológico (www.cnpq.br)
CONQ	Cost of Non Quality
COQ	Cost of Quality
DIKW	Data-Information-Knowledge-Wisdom
EFQM	European Foundation for Quality Management (www.efqm.org)
GP	Generic Practice
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission (www.iec.ch)
ISO	International Organization for Standardization (www.iso.org)
IT	Information Technology
ITIL	IT Infrastructure Library
LEGO	(**L**iving **E**n**G**ineering pr**O**cess
LERO	The Irish Software Engineering Research Centre (www.lero.ie)
MA	Measurement & Analysis (CMMI ML2 PA)
MBQA	Malcolm Baldridge Quality Award (www.nist.gov/quality)
MCM	Maturity & Capability Model
ML	Maturity Level
MVV	Mission-Vision-Values
OPD	Organizational Process Deployment (CMMI ML3 PA)
PAM	Process Assessment Model
PDCA	Plan-Do-Check-Act cycle (Deming)
PI	Product Integration (CMMI ML3 PA)
PP	Project Planning (CMMI ML2 PA)
PRIME	Process Improvement in Multimodel Environments (http://goo.gl/p2GX3)
PRM	Process Reference Model
QMS	Quality Management System
RCA	Root-Cause Analysis
RD	Requirement Development (CMMI ML3 PA)
REQM	Requirement Management (CMMI ML2 PA)
SFI	Science Foundation Ireland (www.sfi.ie)
SG	Specific Goal
SP	Specific Practice
SPI	Software Process Improvement
SPICE	Software Process Improvement and Capability dEtermination (ISO/IEC 15504)
STO	Strategic-Tactical-Operational
TQM	Total Quality Management
VER	Verification (CMMI ML3 PA)

7 Author CVs

Luigi Buglione

Dr. **Luigi Buglione** is an Associate Professor at the École de Technologie Supérieure (ETS) – Université du Québec, Canada and is currently working as a Measurement & Process Improvement Specialist at Engineering.IT SpA (formerly Atos Origin Italy and SchlumbergerSema) in Rome, Italy. Previously, he worked as a Software Process Engineer at the European Software Institute (ESI) in Bilbao, Spain. Dr. Buglione is a regular speaker at international Conferences on Software/Service Measurement, Process Improvement and Quality, and is actively part of several International (ISO WG10-25, IFPUG, COSMIC, ISBSG, MAIN) and National (AutomotiveSPIN Italy GUFPI-ISMA, AICQ, itSMF Italy) technical associations on such issues. He received a Ph.D in Management Information Systems from LUISS Guido Carli University (Rome, Italy) and a degree in Economics from the University of Rome "La Sapienza", Italy. Further information @ SEMQ website (www.semq.eu). He can be reached at luigi.buglione@computer.org or luigi.buglione@eng.it.

Christiane Gresse von Wangenheim

Dr. **Christiane Gresse von Wangenheim** is a Professor at the Federal University of Santa Catarina (UFSC) and the coordinator of the Software Quality Group at the Brazilian Institute for Research and Technology on Digital Convergence (INCOD). Her research interests are software process improvement, project management and usability engineering. Previously, she worked at the Fraunhofer Institute for Experimental Software Engineering and the UNIVALI. She received a Ph.D. degree in Production Engineering at the Federal University of Santa Catarina (Brazil) and a Ph.D. degree in Computer Science at the University of Kaiserslautern (Germany). She's also a PMP – Project Management Professional and Assessor of the Brazilian Process Improvement Model MPS.BR. She can be reached at gresse@gmail.com

Fergal McCaffery

Dr **Fergal Mc Caffery** is a Lecturer with Dundalk Institute of Technology. He is the leader of the Regulated Software Research Group in Dundalk Institute of Technology and a member of Lero. He has been awarded Science Foundation Ireland funding through the Stokes Lectureship, Principal Investigator and CSET funding Programmes to research the area of software process improvement for the medical device domain. Additionally, he has received EU FP7 and Enterprise Ireland Commercialisation research funding to improve the effectiveness of embedded software development environments for the medical device industry. He can be reached at fergal.mccaffery@dkit.ie

Jean Carlo Rossa Hauck

Dr. **Jean Carlo Rossa Hauck** is a Lecturer at the Universidade do Sul de Santa Catarina and researcher at the Software Quality Group – Brazilian Institute for Research and Technology on Digital Convergence (INCOD). His research interests are in software process improvement and project management. He received his M.Sc. in Computer Science and his Ph.D in Knowledge Engineering from the Federal University of Santa Catarina. He can be reached at jeanhauck@incod.ufsc.br