UPGRADE is the European Journal for the Informatics Professional, published bimonthly at <http://www.upgrade-cepis.org/>

Publisher
UPGRADE is published on behalf of CEPIS (Council of European Professional Informatics Societies, <http://www.cepis.org/>) by Novática <http://www.ati.es/novatica/>, journal of the Spanish CEPIS society ATI (*Asociación de Técnicos de Informática*, <http://www.ati.es/>)

UPGRADE monographs are also published in Spanish (full version printed; summary, abstracts and some articles online) by Novática

UPGRADE was created in October 2000 by CEPIS and was first published by Novática and INFORMATIK/INFORMATIQUE, bimonthly journal of SVI/FSI (Swiss Federation of Professional Informatics Societies, <http://www.svifsi.ch/>)

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Cover page designed by Concha Arias-Pérez
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Layout Design: François Louis Nicolet
Composition: Jorge Llácer-Gil de Ramales

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UPGRADE Newslist available at
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ISSN 1684-5285

Monograph of next issue (December 2009)

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CEPIS UPGRADE
The European Journal for the Informatics Professional
http://www.upgrade-cepis.org

Vol. X, issue No. 5, October 2009

Monograph: Experiences and Advances in Software Quality
(published jointly with Novática*)
Guest Editors: *Darren Dalcher and Luis Fernández-Sanz*

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Can Teamwork Management Help in Software Quality and Process Improvement?

Esperança Amengual-Alcover and Antònia Mas-Picacho

In modern organizations teamwork is considered a key factor for success in business. A growing interest on team culture has led to a great number of contributions where different teamwork aspects are analyzed as drivers for teamwork practices improvement. Software development process is a team activity. Consequently, success in software organizations depends largely on the performance of software teams. In this article, firstly we study the teamwork key factors for success and quality in software development projects. Secondly, we present a teamwork assessment model for software teams.

Keywords: Software Process Improvement, Software Quality, Teamwork.

1 The Importance of Teamwork in Software Development Projects

Software engineering has long been recognized as a human activity which is managed through a system of processes and tools. The interaction and dependencies between the processes, the technology used to support them and the people implementing these processes represents the socio-technical environment of a software development project. The integration of the three elements of the "people, process and technology triangle" is usually considered by managers the basis for successful IT projects (see Figure 1).

In software companies technology is usually considered crucial to the effectiveness of their processes and, consequently, technology is normally used to support software development processes (e.g., CASE tools). However, the use of tools can only produce significant gains in software development projects if they are used in an appropriate manner which usually means the implementation of a strategy, a procedure or a well-defined process. Therefore, it seems that we give more importance to the second critical element, the process. In fact, process orientation is the current tendency in Software Engineering literature. Different process improvement models have emerged in recent years and they are becoming, step by step, a reference framework for software development organizations.

In this article we will focus our attention on the third critical element of the triangle: the people. Only people are able to make good use of the other two elements in a balanced way. In our particular triangle, the people dimension is the basis, the most important element (see Figure 2).

Multi-disciplinary research explores how cooperative and human aspects affect software development. A reasonable number of works consider human aspects a key factor in software engineering projects. In [1], its authors highlight that "*it appears the human aspects of software development are more important that the technological aspects for better performance*". According to [2] the majority of problems in software projects "*are due to people problems, not technical ones*". Consequently, bearing in mind that IT projects are usually a team activity, the good performance of teams should be considered essential for the success in these kind of projects.

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2 Teamwork Key Factors

A large number of research projects address fundamental issues about software teamwork. Different authors expose in their studies the elements that should be taken into consideration to efficiently work in a team.

Larson and Lafasto's research on high-performance teams [3] determines the eight dimensions of an effectively

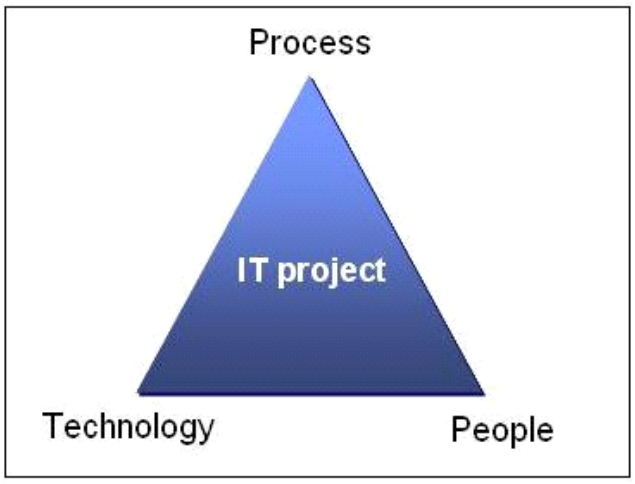

Figure 1: The "People, Process and Technology Triangle"

functioning team. Those eight dimensions include:

1. A clear and elevating goal.
2. Results-driven structure.
3. Competent team members.
4. Collaborative climate.
5. Unified commitment.
6. Standards of excellence.
7. External support and recognition.
8. Principled leadership.

Other relevant contributions to the analysis of team performance in organizations have been Belbin's and Constantine's role theories identifying the different roles in a team [4][5].

Steve McConnell, in his book *Rapid Development* [6], specifies the characteristics of a hyperproductive team:

- Shared, elevating vision or goal.
- Sense of team identity.
- Results-driven structure.
- Competent team members.
- Commitment to the team.
- Mutual trust.
- Interdependence among team members.
- Effective communication, a sense of autonomy.
- Sense of empowerment.
- Small team size.
- High level of enjoyment.

Lakhanpal has proved that team cohesiveness contributes more to productivity than the capabilities or the experience of the project members [7].

According to Barry Boehm, motivation has a larger impact on productivity and quality than any other factor [8]. Despite the number of studies emphasizing the importance of teamwork in software projects, it appears that there is not a consensus among authors to identify the characteristics that define teamwork.

With the goal of assessing teamwork, it has been necessary to precisely define the set of teamwork factors to be considered in order to measure and improve teamwork. As a result of the revision of the existent literature we have identified the following four factors as the "teamwork key factors" (see Figure 3):

- *Management.*
- *Composition.*
- *Communication.*
- *Motivation.*

3 Teamwork in Process Maturity Models

Software process improvement initiatives based on international standards for process assessment and improvement, such us CMM (Capability Maturity Model) [9] or SPICE (Software Process Improvement Capability dEtermination) [10][11][12][13][14], are focused on the assessment and improvement of the software lifecycle processes and do not explicitly consider essential aspects of teamwork.

After developing the Capability Maturity Model as a descriptive model of the characteristics of an organization at a particular level of software process maturity [15], the Software Engineering Institute (SEI[SM]) has developed the Team Software Process[SM] (TSP[SM]), a prescriptive model for software development teams. As it is defined in the SEI technical report which relates the TSP to the CMM [16], "*TSP is a high-maturity process for project teams. It contains an adaptable set of processes, procedures, guidelines, and tools for project teams to use in the production of high-quality software on time and on budget*". In [17] some results from projects that have adopted the TSP are provided. The results show that TSP teams are delivering essentially defect-free software on schedule, while improving productivity.

Regarding applying the other standard, SPICE [18][19], our particular experience in leading software process improvement initiatives has brought us to consider teamwork an important aspect in any process improvement initiative.

4. Teamwork Assessment in Software Projects

With the interest of focusing on teamwork aspects in

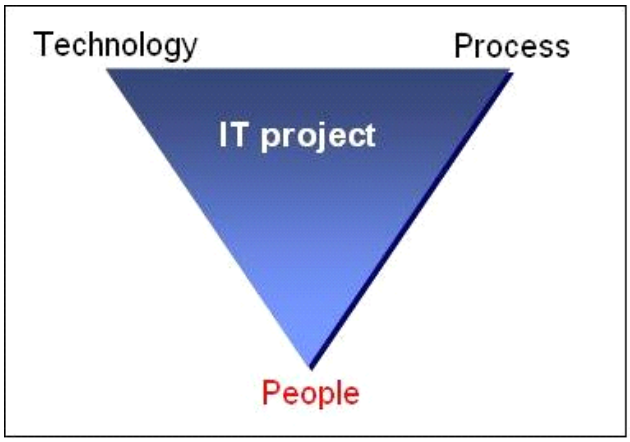

Figure 2: The People Dimension as the Basis of Successful IT Projects.

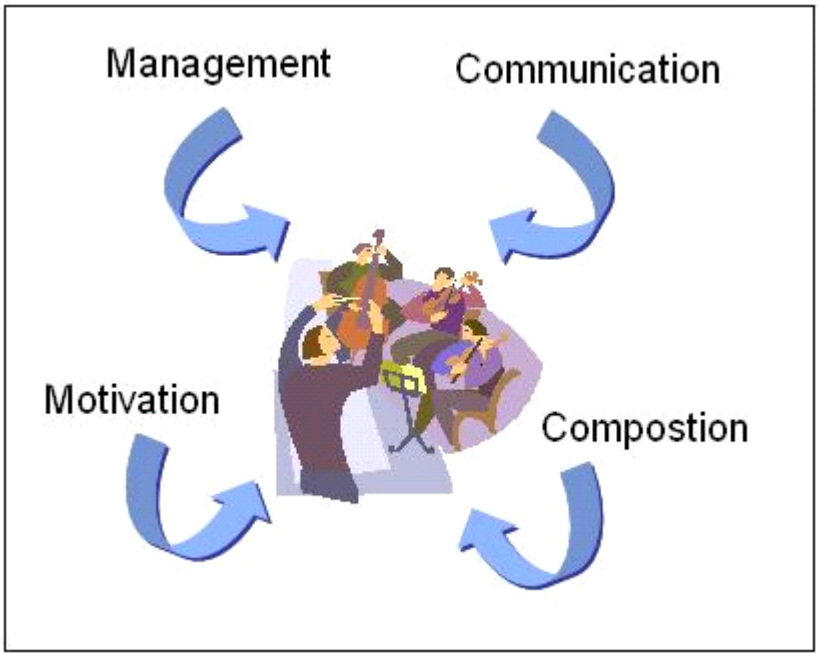

Figure 3: The Four Teamwork Key Factors.

our future software process improvement initiatives, we have developed a teamwork assessment model for software projects. This model comprises a reference model, a questionnaire and a measurement scale.

4.1 A Teamwork Reference Model

The teamwork reference model presented in this article details the factors which should be considered in order to assess teamwork. Each factor of this reference model provides information in the form of:

a) a factor identification;
b) a factor name;
c) a description which details the different aspects for the factor; and
d) a set of teamwork best practices which identify the tasks needed to accomplish the purpose of the factor.

The following four tables show the detail for each one of the four teamwork key factors (see Table 1 to 4).

4.2 A Teamwork Assessment Questionnaire

At a conceptual level, our intention is to measure teamwork in software projects from two different perspectives: the project manager and the team members. This measurement goal has been refined, moving from a conceptual level to an operational level, by posing questions which compose a teamwork assessment questionnaire. Each question addresses a particular aspect of a teamwork factor.

The questionnaire comprises 55 questions distributed in two groups:

- A group of questions for the manager of the team. The main goal of this set of questions is to collect the manager's view about the composition, management and performance of the team.
- A group of questions for all the members of the team. The purpose of this second group of questions is to collect the different responses from all the members of the team. These responses address the four "teamwork key factors".

At a quantitative level, we have defined a measurement framework for the assessment of the teamwork aspects. Within this framework we have established four possible responses to each question: *never*, *sometimes*, *often* and *very often*.

Finally, the performance of each teamwork factor is measured using the rating scale proposed by SPICE where four ordinal points are understood in terms of a percentage (see Table 5).

5. Conclusions and further Work

It is essential that Software Engineering considers the importance of the people dimension in software projects. The best technological solution together with a good process definition does not guarantee the success of a project if this project is not implemented by a team which performs the process in an efficient manner. Therefore, teamwork measurement should be additionally considered in any software process improvement initiative.

After analyzing the state of the art in teamwork in software projects, in this paper we have identified the four "teamwork key factors". These factors compose a teamwork reference model that can be used as a framework for teamwork assessment and improvement.

Our future work is to analyze the usefulness and applicability of this teamwork assessment model. We are currently working in a new SPICE-based software process improvement programme in small and medium companies of the Balearic Islands. The teamwork assessment model is expected to be applied in parallel with process assessment

Factor ID	MAN
Factor Name	MANAGEMENT
Factor Description	• Definition of a common vision that provides the team an identity as a team. • Actions whose goal is to identify the activities and tasks of the project, as well as to define dependencies among them. **Note 1:** Each member of the team needs to know the objectives that the other members expect of him. **Note 2:** All the members must understand their roles and responsibilities and have to agree on how to perform their activities. • Actions for planning the resources to be used during the project development. • Establishment of a monitoring system to control the progress of the project and to assess the performance of the team so that all the members are conscious of their results and see the progress to their objectives in accordance with the plan.
Best Practices	**MAN.BP1:** Evaluate feasibility of the project. **MAN.BP2:** Define the scope of work. **MAN.BP3:** Define the project schedule. **MAN.BP4:** Establish the project plan. **MAN.BP5:** Implement the project plan. **MAN.BP6:** Establish organizational commitment for measurement. **MAN.BP7:** Determine and maintain estimates for project attributes. **MAN.BP8:** Identify and monitor project interfaces. **MAN.BP9:** Monitor project attributes. **MAN.BP10:** Review the progress of the project. **MAN.BP11:** Act to correct deviations. **MAN.BP12:** Perform project close-out review. **MAN.BP13:** Evaluate and communicate information products and measurement activities to process owners. **MAN.BP14:** Evaluate staff performance. **MAN.BP15:** Conduct joint reviews.

Table 1: The Management Factor.

Factor ID	CMP
Factor Name	COMPOSTITION
Factor Description	• Identification and definition of the different roles that can be assigned to the different members of the team. **Note 1**: Define the technical, management and collaboration skills necessary to perform each role. • Selection of the most suitable and competent person for each team role. • Assignation of responsibilities and authorities to the different members defining the team hierarchy. **Note 2:** Each member needs to understand the tasks and responsibilities of his/her role as a team member. • Training aspects to assure that the members of the team have the knowledge and the necessary skills to perform their tasks in the team.
Best Practices	**CMP.BP1:** Define needs for experience, knowledge and skills. **CMP.BP2:** Allocate responsibilities. **CMP.BP3:** Identify needed skills and competencies. **CMP.BP4:** Define evaluation criteria. **CMP.BP5:** Develop staff skills and competencies. **CMP.BP6:** Define team organization for projects and tasks. **CMP.BP7:** Maintain staff records. **CMP.BP8:** Develop a strategy for training. **CMP.BP9:** Identify needs for training. **CMP.BP10:** Develop or acquire training. **CMP.BP11:** Prepare for training execution**.** **CMP.BP12:** Train personnel. **CMP.BP13:** Maintain staff training records.

Table 2: The Composition Factor.

to analyse if teamwork improvement can help in process improvement.

Acknowledgements

This work was supported by TSI-030200-2008-4 "P*lan para la evaluación, mejora de procesos y certificación según la norma ISO/IEC 15504*", FIT-340502-2007-10 "*acción asociativa estratégica de orientación a la excelencia tecnológica en el desarrollo software mediante la implantación de modelos de certificación de calidad (CMMI, SPICE)*", and CICYT TIN2007-67843- TIN2007-67843-C06-04 "*Modelos de simulación basados en ontologías y mejora de procesos para arquitecturas orientadas a servicios*".

Factor ID	COM
Factor Name	COMMUNICATION
Factor Description	• Identification of suitable communication mechanisms (interfaces, tools, software to transfer information, progress reports, joint reviews, etc.). **Note 1:** The members of the team need to be continually well informed about the activities of their colleagues in the team. They also have to have the opportunity of express their interests, worries and suggestions. • Reporting decisions. • Communicating changes to all affected parties.
Best Practices	**COM.BP1:** Communicate software requirements. **COM.BP2:** Communicate system requirements. **COM.BP3:** Communicate system architecture design. **COM. BP4:** Confirm system readiness. **COM.BP5:** Communicate modifications. **COM.BP6:** Collect feedback. **COM.BP7:** Establish organizational commitment for measurement. **COM.BP8:** Communicate measurement results. **COM.BP9:** Evaluate and communicate information products and measurement activities to process owners. **COM.BP10:** Provide feedback on performance. **COM.BP11:** Disseminate knowledge assets. **COM.BP12:** Establish the asset storage and retrieval mechanisms. **COM.BP13:** Notify re-users of asset status. **COM.BP14:** Distribute the results. **COM.BP15:** Track actions for review results. **COM.BP16:** Distribute documents.

Table 3: The Communication Factor.

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Factor ID	MOT
Factor Name	**MOTIVATION**
Factor Description	• Actions addressed to excite the members of the team with the objective of getting their commitment to the project. • Opportunities for the development of the skills and competencies of the members of the team. • Empower all the members of the team to perform their job and develop their creativity. Promote participation. • Public recognition of the team's efforts.
Best Practices	**MOT.BP1:** Ensure sharing of common vision. **MOT.BP2:** Enable active participation. **MOT.BP3:** Develop staff skills and competencies. **MOT.BP4:** Empower project teams.

Table 4: The Motivation Factor.

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Value		% achievement
N	*Not achieved*	0 to 15
P	*Partially achieved*	16 to 50
L	*Largely achieved*	51 to 85
F	*Fully achieved*	86 to 100

Table 5: Teamwork Factors Measurement Scale.

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