

A Model for Measuring Agility in Small and Medium Software Development Enterprises

Victor Escobar-Sarmiento

Systems and Industrial Engineering Department
Universidad Nacional de Colombia
Bogotá, Colombia
vescobars@unal.edu.co

Mario Linares-Vásquez

Systems and Industrial Engineering Department
Universidad Nacional de Colombia
Bogotá, Colombia
mlinaresv@unal.edu.co

Abstract—The worldwide acceptance of software as an important aspect in daily life, and the continued growth of the software development industry, have influenced the creation of new companies (small and medium size) during the last decade. The rapid pace with which the companies are founded makes them to experiment some drawbacks such as informality in the software development process, and technological deficiencies. Software development companies have found in agile methodologies a possible solution for improving their practices and processes. However, transition to agile methods is not a simple task, and the transition process should be assessed in order to know whether it is helping the company to become agile. Thus, in this paper we propose a model which could be used for measuring companies agility in four different levels: project, project management, workteam, and agile workspace coverage. Future work is related to using this model in small and medium development companies.

Index Terms—Agility, SMEs, Assessment, Software development, methodologies

I. INTRODUCTION

In the last decades, the frantic evolution of technology has been a crucial factor in the birth and growth of new companies, providing different types of services worldwide. Nowadays, software development companies fulfill the market, offering new products or solutions. Acs et al.[1] argued that small firms are indeed the engines of global economic growth, technology advancement and employment opportunities. In most countries, Small and Medium Enterprises (SMEs) dominate the industrial and commercial infrastructure. Many economists believe that wealth of the nations and the growth of their economies depends on SMEs performance [2].

SMEs are the most important companies in terms of software production; for example, Ireland is recognized as one of the most important countries in this field, with the software industry being the top driver in their economy; growing 25% faster than international markets in the nineties [3]. In Ireland, almost 99% of companies are SMEs that employ less than 50 people, with this businesses accounting for over 68% of private sector employment [4]. Another remarkable country in the genesis of software development is India; its history in software development began in the 1970s with an unexpected growth, through employing about 345.000 persons in 2004 and generating earnings of approximately 12 billion dollars. These

earnings are equivalent to 3.3% of global services expenses worldwide.

In Colombia, the growth of software development during the last years has been significant, with revenues around \$465 million in 2009, and SMEs provide the market with the 98% of those revenues [5]. Reports from Proexport¹ show that the Colombian market duplicated its earnings from 2006 to 2009 [5]. However, Colombian software products do not have the recognition outside of the local boundaries, because market is not sophisticated and it is oriented just for customers in Latin America [6]. According to Rodriguez [7] and Sanchez et al.[8] a primary set of obstacles for SMEs development in Colombia includes:

- Difficulties in identification and access to appropriate technology.
- Formalization and adoption of new technologies.
- Technical and competitive limitations.
- Poor physical infrastructure.
- Lack of managers with management skills and strategic thinking.
- Lack of qualified human resources.
- Limited access to external markets; among others.

Small and medium software development enterprises are transitioning² to agile methodologies because their promise of improving low rate of successful projects achieved with plan-driven methods, and because this methodologies were conceived for small teams without complicated organizational structures. According to a Forrester report [9], plan-driven processes such as waterfall and RUP cause waste, add risk, and have become obstacles to speed quality and predictability. The agile software development methodologies (ASDMs) have been thought of as a high quality new model for software development, with small workgroups without hierarchy or bureaucracy [10] [11] [12] [13]. These methodologies are characterized by constant planning, continuous feedback and permanent interaction with the customer.

Although transition to agile methods has increased in the

¹Proexport is the entity who promotes the tourism, foreign investment and exportations in Colombia - <http://www.proexport.com.co/> (verified on May 15th, 2012)

²The term transition is used to refer adoption and transformation to agile; the former is related to adopting agile practices; the latter is related to changing the culture to include agile principles and values

last decade [14], the process is done, in some cases ad-hoc, without a right understanding of the agile principles and is limited to the usage of a reduced set of agile practices [12], it means it is reduced to adoption without transformation. Moreover, several transition failure modes are typical in companies while trying to adopt agile methodologies without involving agile philosophy, using retrospectives, or providing the agile team with adequate workspaces [15].

Therefore, it is important that companies use assessment methods to validate if the transition process is providing the company with agility. Some models have been proposed previously to assess agility in software development companies [16], [17], [18], [12], however, agility is usually assessed from different perspectives (company, project, workteam) independently and none of the models provide an aggregated and unique model of agility. Moreover, none of the models [16], [17], [18], [12] includes the retrospective practice [19] not assess whether the workspace (environment) follows the agile guidelines. Thus, it is necessary to create a new assessment model based on different perspectives of agility, aimed to cover adoption and transformation (practices and culture), and that includes aspects not included by the agility assessment models.

The purpose of this paper is to present an agility diagnosis model, able to deal with different agility perspectives in an aggregated way that could provide the companies with a single measure of agility and individual measures for each perspective. The model covers the company position towards agility or discipline, agility in the project management practices, agility in the work team practices and the environment where the projects are carried out. We divided our model in 4 different stages which are: Project Agility Assessment, Project Management Agility assessment, Workteam Agility Assessment and agile workspace coverage. Thus, software development companies will be able to make a deep assessment in each stage and at the end, get an unique view of their agility. The model is oriented to SMEs because transition to agile in this kind of firms is more natural, and it is oriented to assess individual agile teams and not hub-structures as the ones used for scaling agile to large firms[20], [21], [22]. Future work will be devoted to use the model to make a diagnosis on agility in software development SMEs.

II. SMALL AND MEDIUM ENTERPRISES

One of the more important parameters for distinguish the small, medium and big companies is the employees number; this criteria varies according to the country. Nowadays, it is internationally accepted the main definition for small company as the company composed for less than 50 employees. Also, some countries added new parameters in the definition such as sales volume, turnover or balance sheet total.

FUNDES³ gives the following description of how the different latin-american countries classifies their companies range:

- 1) Argentina uses the employees number (< 40 for small companies) and the annual sales as classification parameters.

- 2) Bolivia handles three different parameters: sales, assets and employees number (5-15 for small companies and 16-49 for medium size companies).
- 3) Chile have two parameters, manufacturing and employees number (10-49 for small companies and 50-199 for medium size companies).
- 4) Mexico uses only one parameter; the employees number (16-100 for small companies and 101-250 for medium size companies). However, the definition varies if it is a services company, a manufacturing company or a commercial company.

The SME definition for Colombia is founded on the law number 590 (created in the year 2000). It defines SMEs as every unit of economic exploitation, made by natural or legal persons, in business, agricultural, industrial, commercial or services activities, that must respond to the following parameters:

- Medium Enterprises: from 51 up to 200 employees, and total assets between 5001 and 15000 SMLV*⁴
- Small Enterprises: from 11 up to 50 employees, and total assets between 501 and 5000 SMLV
- Micro Enterprises: less than 10 employees, and total assets lower than 500 SMLV

The most important characteristics of SMEs are [23]:

- 1) SMEs are strongly owner-manager driven. Most of the decision makers time is spent on doing routine tasks. In many cases, they are family run.
- 2) SMEs are driven by the demand for improving productivity, cutting costs and ever decreasing life-cycle phases.
- 3) SMEs do not have extensive processes or structures. They are run by one individual or a small team, who takes decisions on a short-term time horizon.
- 4) SMEs are generally more flexible, and can quickly adapt the way they do their work around a better solution.
- 5) SMEs entrepreneurs are generally "all-rounders" with basic knowledge in many areas. They are good at multi-tasking.
- 6) SMEs are more people than process dependent. There are specific individuals who do certain tasks; their experience and knowledge enable them to do so.
- 7) SMEs are often less sophisticated, since it is hard for them to recruit and retain technology professionals.
- 8) SMEs are more focused on medium-term survival than long-term profits.
- 9) SMEs do not focus on efficiencies. They end up wasting a lot of time and money on general and administrative expenses.
- 10) SMEs are time-pressured.
- 11) SMEs want a solution, not a particular machine or service.
- 12) SMEs focus on gaining instant gratification with technology solutions. These solutions must be simple to use and easy to deploy, and must provide clear tangible benefits.

³FUNDES is an international organization promoting the competitive development of MSMEs in Latin America since 1984 (<http://www.fundes.org>)

⁴legal minimum wage (for its initials in spanish - SMLV: Salario Mínimo Legal Vigente);

- 13) SMEs do not necessarily need to have the “latest and greatest” technology. The solution can use “lag technology”, then it becomes cheaper to obtain and use.

III. AGILE METHODOLOGIES TRANSITION

Agile methodologies are easier to misunderstand and wrong transition could lead to code-and-fix processes. One possible reason is applying some practices or principles provided by the agile methodologies in an ad-hoc way without including the values system provided by the agile manifesto. According to [24], there is a big difference between adopting agile and transforming to agile; adoption means doing agile, and it is related with using agile practices during the software development process; transition to agile, means being agile, and it is related with a culture shift to an agile mindset. Therefore, models for measuring agility in an organization should analyze the agile practices that are used in the software development process and the agile values/principles that are followed by the organization.

A recent study of VersionOne⁵[25] reported that typical leading causes of failed agile projects are related to lack of experience with agile methods or lack of understanding the broader organizational change required. Transition to agile methodologies requires to implement a process that includes all company levels (person, team, company, environment, culture, projects). It is not only related to using agile practices; the most important success factor in transition to agile is to embrace and practice the principles and values provided by the agile manifesto.

Transition to Agile methodologies in a company stems from different kind of reasons like, increase the customer satisfaction, improve the team's performance or a faster software production, anyway, there are many challenges trying to adopt a new methodology in any company. These challenges are: serial thinking, closed mindedness, office politics, black and white mind-set, fear of change, specialized skills, outdated skills, documentation-heavy mind-set, and do-it-all-at-once attitude [26].

- Serial thinking: Many IT professionals have become accustomed to serial approaches and are unreceptive to new and evolutionary approaches.
- Closed mindedness: There are many software professionals who have not invested time and energy to learn about upcoming and promising methodologies.
- Office politics: Office Some people will prevent the use of agile practices to save their power base and their position inside the company.
- Black and white mind-set: People consider that they have to choose from a limited set of options and that there is no scope of selecting a middle path.
- Fear of change: Doubts in people's minds that they would not be able to acquire the required agile skills and/or cope with the new agile environment may instill fear in their minds
- Specialized skills: The people have been being trained in specialized areas of software engineering. This causes

professionals to have highly specialized skills in a particular area while having minimal or no knowledge in other aspects of development

- Outdated skills: Many people face a steep learning curve because they have not brushed up on their skills for several years.
- Documentation-heavy mind-set: Many professionals think about developing effective software as being based on producing comprehensive and detailed requirement and design documents.
- Do-it-all-at-once attitude: Many adoptions of agile methodologies have been made in just one attempt, having unsuccessful results. This adoption should be slow and be made step by step, implementing each agile practice one at a time.

IV. AGILITY ASSESSMENT

Some studies have been aimed to provide methods to assess agility in companies [16], [18], [27], [28]. These studies include agility assessment models and some case studies on assessing agility in different software development companies.

A. Assessment models

1) *Boehm and Turner's Agility and Discipline Assessment*: The Boehm and Turner's model [16] propose a framework to find a balance between agility and discipline. According to [17], [16], discipline creates well-organized memories, history and experience in an organization. Agility uses the memory and the history to adjust to new environments, react and adapt to the changes, and take advantage of unexpected opportunities. Thus, every successful process requires agility and discipline. Boehm et al. [16] exposed that in a world with strong discipline, the result is bureaucracy and stagnation, and in a world with agility the result is “the unencumbered enthusiasm of a startup company before it has to turn a profit”.

Agile software development methodologies (ASDMs) encourage developers to embrace the change and get into the agility, with practices such as closer customer involvement, shorter iterations, and reduced documentation. However, being agile is not the answer for all the software development problems, since some concerns are not tackled easily such as documentation in big projects or coordination of large teams in agile methods. Boehm et al. [16] concluded that there are five critical factors involved in determining the relative suitability of agile or plan-driven methods in a particular project situation (Table II). These factors are represented by a five-axes plane (Figure 1) where:

- The size axis represents the number of persons working in the project.
- The culture axis represents the balance between chaos and order.
- The dynamism axis is an estimate of how much the team or organization likes to work on the edge of chaos or with more planning and defined practices and procedures.
- The personnel axis classifies the type of personnel required to achieve success in a project, according to the

⁵<http://www.versionone.com/> (Verified on May 15th, 2012)

levels of software method understanding defined by [29]. Table I. provides a description of these levels.

- The criticality axis distinguishes the nature of damage of undetected defects [29], and is categorized according to the loss caused by a defect that appears during software execution.

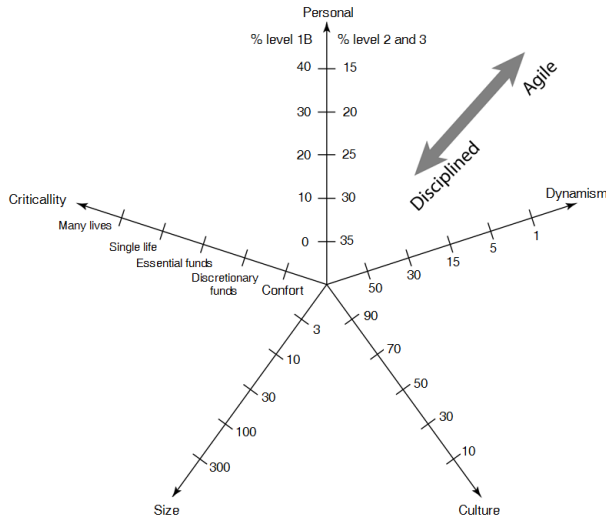


Figure 1. Dimensions affecting method selection [17]

If all the values plotted on the axes are near to the center, it means that the project exhibits agility; if the values are at the periphery, the project has a discipline approach.

Table I
PERSONNEL CHARACTERISTICS - BOEHM & TURNERS MODEL -

Level	Characteristics
3	Able to revise a method (break its rules) to fit an unprecedented situation.
2	Able to tailor a method to fit a precededent new situation. Can manage a small, precededent agile or plan-driven project but would need level 3 guidance on complex, unprecedented projects.
1A	With training, able to perform discretionary method steps (e.g. sizing tasks for project timescales, composing patterns, architecture re-engineering). With experience, can become level 2. 1A's perform well in all teams with guidance from level 2 people.
1B	With training, able to perform procedural method steps (e.g. coding a class method, using a CM tool, performing a build/installation/test, writing a test document). With experience, can master some level 1A skills. May slow down an agile team but will perform well in a plan-driven team.
-1	May have technical skills, but unable or unwilling to collaborate or follow shared methods. Not good on an agile or plan-driven team.

2) *Team agility assessment by Dean Leffingwell*: Leffingwell [12] uses two different types of metrics to assess team agility (agile project metrics and agile process metrics) focusing on several aspects of teams performance: product ownership/management capability; release planning and tracking capability; iteration planning and tracking; team effectiveness; testing practices; development practices/infrastructure. Each category has a set of specific measures that are rated on a scale of 0 to 5 (with 5, the value that better describes agility).

Table II
AGILITY - PLAN-DRIVEN METHOD HOME GROUNDS AND LEVELS OF SOFTWARE METHOD UNDERSTANDING AND USE. [30]

Dim.	Characteristics	Agile	Plan-Driven
APPLICATION	Primary Goal	Rapid value; responding to change	Predictability, stability, high assurance
	Size	Smaller teams and projects	Larger teams and projects
	Environment	Turbulent; high change; project focused	Stable; low - change; project/organization focused
MANAGEMENT	Customer Relations	Dedicated on-site customers; focused on prioritized increments	As-needed customer interactions; focused on contract provisions
	Planning and Control	Internalized plans; qualitative control	Documented plans, quantitative control
	Communications	Tacit interpersonal knowledge	Explicit documented knowledge
TECHNICAL	Requirements	Prioritized informal stories and test cases; undergoing unforeseeable change	Formalized project, capability, interface, quality, foreseeable evolution requirements
	Development	Simple design; short increments; refactoring assumed inexpensive	Extensive design; longer increments; refactoring assumed expensive
	Test	Executable test cases define requirements, testing	Documented test plans and procedures
PERSONNEL	Customers	Dedicated, collocated CRACK* performers	CRACK* performers, not always collocated
	Developers	At least 30 percent full-time Cockburn Level 2 and 3 experts; no Level 1B or -1 personnel**	50 percent Cockburn Level 3s early; 10 percent throughout; 30 percent Level 1Bs workable; no Level -1s**
	Culture	Comfort and empowerment via many degrees of freedom (thriving on chaos)	Comfort and empowerment via framework of policies and procedures (thriving on order)

* Collaborative, Representative, Authorized, Committed, Knowledgeable ** See Table I. These numbers will particularly vary with the complexity of the application

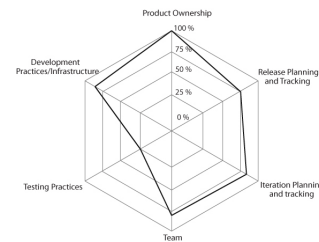


Figure 2. Team Agility Assessment - [12]

The model also uses a radar chart, where each axis represents a metrics category (Figure 2)

3) *Agile assessment by ThoughtWorks Studios* : ThoughtWorks Studios⁶ is a global IT consultancy that in an effort to evaluate the practices in many software development organizations. For more than 17 years, ThoughtWorks has been

⁶<http://agileassessments.com/online-assessments/agile-self-evaluation>, For more information, contact : assessments@thoughtworks.com

pioneering Agile approaches on the world's largest software projects. They have developed a self-evaluation test that helps the software development companies to determine the extent to which the development teams applies agile principles along 9 dimensions, covering management and development practices. The objective of the agile self-evaluation, is to assist the company in the planning for a more thorough assessment leading to an improvement program. It is provided as an online-free access survey with questions related to the following aspects:

- 1) Management Practices
 - a) Requirements Analysis.
 - b) Business Responsiveness.
 - c) Collaboration and Communication.
 - d) Project Management.
 - e) Governance.
- 2) Development Practices
 - a) Simplicity.
 - b) Build Management.
 - c) Configuration Management.
 - d) Testing & Quality Assurance.

After the survey is finished, it provides a report with location of the team profile on a scale that goes from regressive to Agile (Table III lists the profiles). Moreover, the report lists the answers provided by the person who takes the survey, and the typical answers for an agile profiles. An example of the report is in our online appendix ⁷.

Table III
TEAM'S AGILE PROFILE

Agile	Supports ability to change
Ad Hoc	Neither hinders nor contributes to effective agile development
Regressive	Counter-productive to agility and responsiveness.

4) *4-Dimensional Analytical Tool by Asuf Qumer*: The main objective of the 4-dimensional analytical tool [27] is to assess agility and the adoptability of agile methods in software development companies. The model provides a mechanism to measure the degree of agility of any agile methodology quantitatively at a specific level in a process, using specific practices.

The four dimensions are described as follows:

- 1) **Dimension 1 - Method Scope Characterization:** It describes the scopes for the application of the agile methodologies. It is used to compare the methods at a high level. The scopes assessed in this dimension are:
 - a) Project Size
 - b) Team Size
 - c) Development Style
 - d) Code Style
 - e) Technology Environment
 - f) Physical Environment
 - g) Business Culture
 - h) Abstraction Mechanism

Table IV
4-DAT - DIMENSION 2 [27]

Features	Description
Flexibility	Does the method accommodate expected or unexpected changes?
Speed	Does the method produce results quickly?
Leanness	Does the method follow shortest time span, use economical, simple and quality instruments for production?
Learning	Does the method apply updated prior knowledge and experience to learn?
Responsiveness	Does the method exhibit sensitiveness?

Table V
4-DAT - DIMENSION 3 [27]

Agile Values	Description
Individuals and interactions over processes and tools	Which practices value people and interaction over processes and tools?
Working software over comprehensive documentation	Which practices value working software over comprehensive documentation?
Customer collaboration over contract negotiation	Which practices value customer collaboration over contract negotiation?
Responding to change over following a plan	Which practices value responding to change over following a plan?
Keeping the process agile	Which practices helps in keeping the process agile?
Keeping the process cost effective	Which practices helps in keeping the process cost effective?

- 2) **Dimension 2 - Agility Characterization:** This dimension checks the existence of agility in agile methods for process level and method practices level. This dimension is the only one of the four proposed that is quantitative and is assessed with the following notion of agility described by Qumer[27] as "*a persistent behavior or ability of a sensitive entity that exhibits flexibility to accommodate expected or unexpected changes rapidly, follows the shortest time span, uses economical, simple and quality instruments in a dynamic environment and applies updated prior knowledge and experience to learn from the internal and external environment.*". Table IV. explains the topics related with this dimension.
- 3) **Dimension 3 - Agile Value Characterization:** This dimension examines the support of six agile values in different practices of agile methods. Most of the values (4) are extracted from the agile manifesto; the rest are provided by the author based on the study of several agile methods. Table V. shows the base of the third dimension.
- 4) **Dimension 4 - Software Process Characterization:** The fourth dimension examines the practices that support the four components of software process proposed by Qumer [27]. Table VI. lists these four components.

Qumer et al. [27] measures agility in terms of five different variables described in dimension 2: Flexibility(FY), Speed (SD), Leanness (LS), Learning (LG) and responsiveness(RS),

⁷<http://victor.evaccsion.com/Victor/UnalMSc.html> (verified on June 1, 2012)

Table VI
4-DAT - DIMENSION 3 [27]

Process	Description
Development Process	Which practices cover the main life cycle process and testing (Quality Assurance)?
Project Management Process	Which practices cover the overall management of the project?
Software Configuration Control Process / Support Process	Which practices cover the process that enables configuration management?
Management Process	Which practices cover the process that is required to manage the process itself?

the possible value of each variable at a given time may be 0 or 1. A software development method may encompass agility in the design phase, planning phase or in the requirement engineering phase, but not necessarily all three. Thus, the degree of agility (DA) for each of these phases as the fraction of the five agility variables that are encompassed and supported.

$$DA(Object) = \left(\frac{1}{m}\right) \sum m DA(Object, Phase or Practices)$$

Qumer et al. [27] used this approach to measure the degree of agility (at both phase and practice level) using Extreme Programming(XP) their assessment can be found in the online appendix (<http://victor.evaccsion.com/UnalMSc.html>)

B. Agile assessment case studies

1) *Applying an Agility/Discipline Assessment for a Small Software Organization by Phillip Taylor*: Taylor et al. [31] presents the application of the Boehm and Turner's model to assess the agility of Servasport, a software development SME in Ireland. The novelty of this study, is a modification that the authors made to the Boehm and Turners model, adding a new axis for the client involvement over the project. The values that are plotted in the new axis are described as follow:

- On AB: Client is on-site and an agile believer. The ideal situation when a client is fully persuaded of the agile approach and makes themselves available on-site to work with the team.
- Off AB: Client is off-site but an agile believer. They fully understand the nature of agile development and are open to frequent communication.
- On AS: Client is on-site but is an agile skeptic. They may be present with you but have not bought into the agile development approach.
- Off AS: Same as above expect the problem is compounded by the client being off-site.
- Off Uninvolved: Not only is the client off-site but they want no involvement between providing you with initial requirements and getting the right product delivered.

The Boehm and Turner's model extension, presented by [31] is depicted in Figure 3.

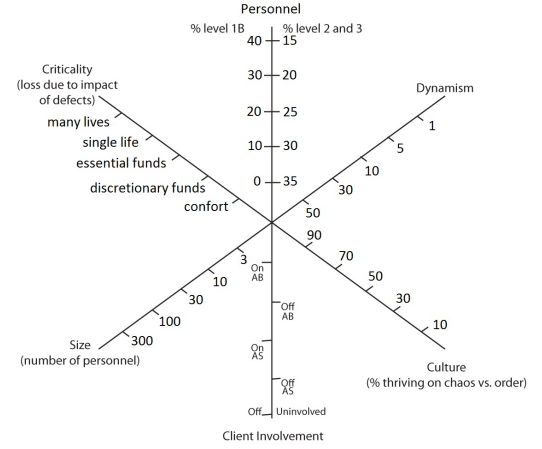


Figure 3. Six critical factors affecting method selection - [31]

2) *Agility assessment of Venezuelan software development SMEs*: Di Paula et al. [28] present a case of study on software development SMEs. The main objective of this case was to make a decision network⁸ to specify the balance between agility and discipline in the software development processes of Venezuelan SMEs. As a result, the decision network indicated that the organizations require to change some of their practices seeking for lower cost, better performance, among other aspects.

Di Paula et al. [28] assessed the five factors described by Boehm et al. [16] using the legal, cultural and organizational context of Venezuelan software development Companies. The conclusions of these study are that the Team size, Personnel and the Culture are the most agile factors found. The Criticality and the Dynamism are in an intermediate level between agility and discipline, also Di Paula et al. [28] expose that the companies need more discipline in their agile processes, mostly when the projects have a high criticality.

V. ANALYSIS OF AGILITY ASSESSMENT MODELS

We found that the information provided by each of the agile assessment models represents different aspects of agility in a company. Boehm and Turner model [16] only explains the agile or discipline level of the projects done by the company. But it does not provide information related to management practices or the environment in which the company develops its projects. The 4-D model [27] is the most complete of the four exposed; although it tries to include the major quantity of aspects related to the entire company, such as general software process characterization, agile values execution and agile practices inside the company, the 4-D model does not provide a clear measure of the agility level in the project.

Another model is the one proposed by ThoughtWorks , which assesses the agility in management and development practices, however it doesn't give an entire diagnosis about the company leaving out the development environment and the agility level of the projects.

⁸Also called an influence diagram, it is a graphical representation of a finite sequential decision problem. (definition from: http://artint.info/html/ArtInt_219.html)

The model proposed by Pikkarainen and Huomos [18] assesses the agility in almost all the company areas, but it was designed for companies out of the range of our study (Big companies). This model uses a lot of information that maybe cannot be assessed in a SME's. For this reason we are not going to use it.

VI. A MODEL FOR MEASURING AGILITY IN SOFTWARE DEVELOPMENT SMEs

With the main purpose of knowing and assessing the actual situation of agility in software development SMEs, we propose a new agility assessment model. This model is based on a set of assessment models discussed in Section 5; in addition, we added some aspects we did not found in those models. Such aspects are agile environment conditions, implementation of the retrospective practice, and a single measure of agility. Table VII. shows a brief resume of advantages and disadvantages found in the models we analyzed.

A. Assessment Stages

The proposed model (Figure 4) assesses the company as an entire entity. We want to cover several aspects related to the software development SMEs: project management, work team practices and the environment where the projects are carried out. We have divided our model in 4 different stages: company management agility assessment, project agility assessment, workteam agility assessment and workspace agility coverage⁹. Thus, we would be able to make a deep assessment in each stage and at the end, we will provide an entire agile status about the companies that belong to the study.

Taking Table VII. as reference, we will explain which model will be used for assessing each stage and also we are going to explain our model to assess the workspace agility coverage, which provides us with a status about how the companies are following the checklists and guides for agile workspaces. The four stages of our model are described below:

- **Agile Project Management Assessment:** For this stage we suggest to use a survey based on the Thoughtworks Studio survey and the 4 DAT Model. As we explained before, the ThoughtWorks Studio survey have a dimension that assesses the management practices inside the companies; this will provide us with information about the agility level related to governance, business responsiveness and other administrative practices. We complement this stage assessment using the fourth dimension in the 4 DAT Model, because it is related to the project management process and the general management process of the company.
- **Project Agility Assessment:** For this stage we suggest to use the Taylor's extension to the Boehm and Turner's Agility and Discipline Assessment Model [30], which includes the customer's participation in the project and his position about agility.
- **Workteam Agility Assessment:** This stage will be assessed with the questionnaire formulated by Leffingwell

[12]. This model is characterized by measuring the teamwork agility through 6 different categories (Product Ownership/Management Capability, Release planning and Tracking Capability, Iteration Planning and Tracking, Team Effectiveness, Testing Practices and Development Practices/Infrastructure). The results will show a percentage of agility level in each category, and it will summarize a unique result giving us the average agility level for the teams evaluated.

- **Agile Workspace Coverage:** Agile workspaces have several characteristics should be considered for helping small agile teams work together more effectively [15]. We propose a model to assess companies workspaces indicating whether the companies fulfill the recommendations according to agile expectations such as:

- Open space : Is important to avoid having separate offices, cubicles, or desks separated.
- Space to hold impromptu group discussions: Is necessary to have a place where the group explore ideas without moving out of its immediate working space.
- Pair programming desks: This expectation is used mainly with the XP agile methodology. Where it must be possible for two people to share the same desk.
- Continuous integration server: The build and test environment should be separated from the development environment, but still accessible.
- Whiteboards, flip charts, and notice boards: These provide plenty of space for people to present information.

Thus, we developed a survey with 25 questions based in different configurations of agile workspaces exposed by other authors [15], [32], [33]. The result will be given as a percentage according to the responses.

The questionnaires and surveys that we designed for each one of the stages presented before, are available at our online appendix <http://victor.evaccsion.com/Victor/UnalMSc.html>

B. Model Definition

In order to gather trusty information, it is necessary to find a method of collection that ensure many accurate data as possible. One approach is the exposed by Paul [34], who uses a quantitative approach for lightweight agile process assessment. This process formulates a set of questions with quantitative metrics as answers and yields numeric results of the agility of project processes. The metrics will be collected using the Goal/Question/Metric method (GQM) , which will measure the characteristics of the overall development process. This method was originally developed by V. Basili and D. Weiss [35].

We want to use this method in several software development SMEs to have a complete idea about the actual situation of agile methodologies implementation and it's results over the time. We defined the measurement goals based upon company goals and transform these goals into questions that can be measured during the assessment. GQM defines a certain goal, refines this goal into questions, and defines metrics that

⁹With "workspace agility coverage", we mean coverage of design decisions that should be taken into account to build an agile workspace

Table VII
ANALYSIS OF AGILITY ASSESSMENT MODELS

Assessment Model	Advantages	Disadvantages
Boehm and Turner's Agility and Discipline Assessment	Deep project analysis	No Administrative practices analysis. No environment conditions analyzed. No agile values assessed.
Agile assessment by ThoughtWorks Studios	Deep Administrative analysis. Deep Development practices analysis.	No environment conditions analyzed. No project deep analysis. No agile values analysis.
Team agility assessment by Dean Leffingwell	Deep team analysis	No agile values analysis No environment conditions analyzed.
4-Dimensional Analytical Tool by Asuf Qumer	Deep analysis of Agile values and practices. Deep Software process characterization.	No environment conditions analyzed. No deep project analysis.

Table VIII
QUESTIONS FOR AGILE ASSESSMENT MODEL

Company Management Agility Assessment	Survey Based on thoughtworks Studios survey and 4 DAT Model (set of questions can be found in our online appendix)
Project Agility Assessment	Boehm and Turner's model with Taylor modification (set of questions can be found in our online appendix)
Workteam Agility Assessment	Survey based on Dean Leffingwell Model (set of questions can be found in our online appendix)
Agile Workspace Coverage	Custom survey, based on agile workspaces definitions (set of questions can be found in our online appendix)

Table IX
METRICS FOR AGILE ASSESSMENT MODEL

Company Management Agility Assessment	Location of the company profile on a scale that goes from regressive to Agile according to management practices .
Project Agility Assessment	Level between agility or discipline in specific projects conducted by the workteam
Workteam Agility Assessment	Percentage of agile practices used by the workteam in software development
Agile Workspace Coverage	Number of agile workspace guidelines accomplished by the company over the total of required guidelines.

should provide the information to answer these questions. By answering the questions, the measured data defines the goals operationally [36]. Our general goal is to measure the agility level of Software Development SMEs. We defined also four subgoals, each one related to one of the stages of our model:

- Measure the agility level of SMEs in project management.
- Measure the project agility or discipline in SMEs.
- Measure the workteam agility.
- Measure the agile-workspace guidelines coverage.

Table VIII. describes the set of questions that we defined for each stages. For all the stages, except for agile workspace coverage, we will use the metrics provided by the assessment model of each stage. These metrics are listed in Table IX.

To provide a unique view of agility in the company we followed the same method used by the related models and propose a radar-chart with four axes; each axis represents a

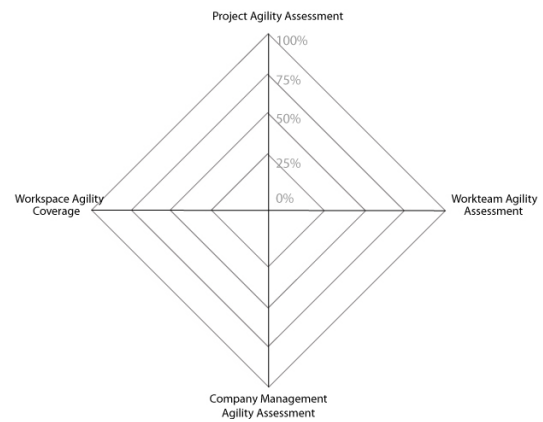


Figure 5. 4 Axis Final Radar Chart.

stage of our model (Figure 5).

These metrics will provide information about the behaviour of the company being analyzed, Each one represents each stage of our model. Analyzing the company management agility metrics, we will obtain the necessary information in a defined range about the practices applied by the management staff. Project Agility metrics will locate our study in the real status of the project development, providing the agile level used in it based on Boehm's variables. Workteam agility metrics involve all the information about the agile practices accomplishment by the teamwork and the results obtained in their usage. Agile workspace coverage metrics will provide a number of agile workspace guidelines accomplished by the company over the total of required guidelines.

After studying the results obtained, the main intention of the model is to give an accurate feedback to the companies studied, showing which are their strengths and suggesting advices for the lacks found. This information should be provided to the companies in a general meeting, with all the people used in the study.

VII. CONCLUSIONS AND FUTURE WORK

There are some studies conducted to assess an agility degree in a specific field of a company, but no one tries to have a

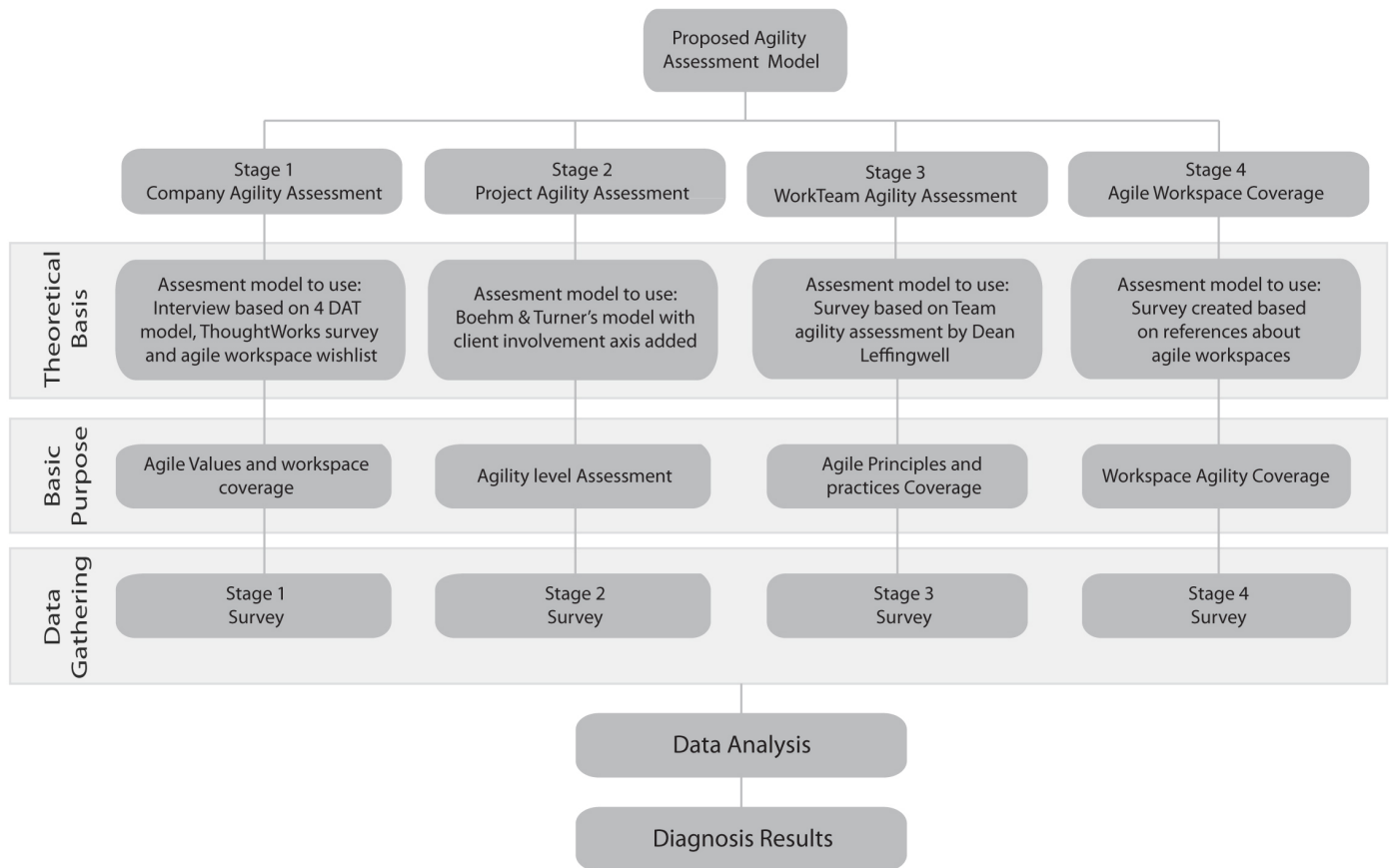


Figure 4. Proposed agility assessment model

complete range about agility in the entire company, that's why a new assessment model could integrate all the independent fields evaluated and be complemented with a new set of parameters allowing assess aspects not related with the studied models.

The agile culture is gaining popularity becoming one of the most named topics in software development. This can be seen through the number of people that is transitioning to agile methodologies and the companies that are beginning to use them in their processes. Thus it is necessary have in mind all the challenges that lead to implement a new process in a company; factors like the integration of agile projects with an existing project environment are aspects that can not be avoided.

We do not have official reports about transition to agile practices by Software Development SMEs in Colombia, and Latin-america however we know by unofficial conversations with other professionals, that transition to agile (adoption and transformation) is increasing. Thus, because successful transtions to agile methodologies should be assessed by SMEs, we proposed in this paper a model that assess several dimensions of agility in a company. We guess that this model will provide a general view of agility in the company and could allow companies to compare their agility levels and assess how successful are their transition-to-agile projects in terms of agile values, practices, and philosophy. Therefore, future work

will be to validate our model with a representative sample of Software Development SMEs in Colombia.

REFERENCES

- [1] Z. J. Acs and L. Preston, "Small and medium-sized enterprises, technology, and globalization: Introduction to a special issue on small and medium-sized enterprises in the global economy," *Small Bus.Econ.*, vol. 9, pp. 1–6, 1997.
- [2] H. H. Schröder and J. Kraaijenbrink, "In: Knowledge integration-the practice of knowledge management in small and medium enterprises. physica-verlag hd," 2006.
- [3] M. Consulting, "Manpower, education and trainingstudy of the irish software sector," *Report submitted to the Software Training Advisory Committee and FAS*, 1998.
- [4] I. Richardson and G. Avram, "Having a foot on each shore , bridging global software development in the case of smes," *2008 IEEE International Conference on Global Software Engineering*, 2008.
- [5] Proexport, "Sector de software y servicios ti," http://www.slideshare.net/inviertaencolombia/sector-servicios-de-ti-proexport?src=related_normal&rel=1187105, 2010.
- [6] I. y. t. Ministerio de Comercio, "Programa midas - desarrollando el sector de ti como uno de clase mundial," tech. rep., Julio 2008.
- [7] A. G. Rodriguez, *La Relidad de la Pyme Colombiana, Desafio para el desarrollo*. FUNDES Internacional, 2003.
- [8] J. J. Sánchez and J. Osorio, "Algunas aproximaciones al problema de financiamiento de las pymes en colombia," *Scientia et Technica Año XIII*, pp. 321–324, 2007.
- [9] Forrester, "Lean software is agile, fit-to-purpose, and efficient," tech. rep., Forrester, December 2008.
- [10] M. Linares-Vásquez and J. H. Aponte, "Metodologías Ágiles de desarrollo: Un panorama general," 2007.
- [11] T. Dybå and T. Dingsøy, "What do we know about agile software development?," *IEEE Computer Society*, 2009.

- [12] D. Leffingwell, *Scaling Software Agility - Best Practices for Large Enterprises*. Addison Wesley, 2007.
- [13] S. Nerur, R. Mahapatra, and G. Mangalaraj, "Challenges of migrating to agile methodologies," *COMMUNICATIONS OF THE ACM*, vol. 48, 2005.
- [14] S. W. Ambler, "Surveys exploring the current state of information technology practices." <http://www.ambysoft.com/surveys/>.
- [15] W. Stott and J. Newkirk, *Visual Studio Team System: Better Software Development for Agile Teams*. Addison-Wesley Professional, 2007.
- [16] B. Boehm and R. Turner, *Balancing Agility and Discipline - A Guide for the Perplexed*. Addison-Wesley, 2004.
- [17] B. Boehm and R. Turner, "Observations on balancing discipline and agility," 2004.
- [18] M. Pikkariainen and T. Huomo, "Agile assessment framework," *Information Technology for European Advancement*, pp. 1–44, 04 2005.
- [19] E. Derby and D. Larsen, *Agile Retrospectives. Making good teams great*. Pragmatic Bookshelf, 2006.
- [20] J. Highsmith, *Agile project management*. Addison Wesley, 2004.
- [21] C. Larman and B. Vodde, *Practices for Scaling Lean and Agile Deve*. Addison-Wesley, 2010.
- [22] S. S. E. Woodward and M. Ganis, *A Practical Guide to Distributed Scrum*. IBM Press, 2010.
- [23] C. Schätz, *A Methodology for Production Development*. PhD thesis, Norwegian University of Science and Technology, 2006.
- [24] M. Sahota, *An agile adoption and transformation survival guide: Working with Organisational Culture*. InfoQ, 2012.
- [25] VersionOne, "5th annual state of agile development survey final summary report," 2010.
- [26] A. Mahanti, "Challenges in enterprise adoption of agile methods," *Journal of Computing and Information Technology*, vol. 3, p. 197 206, 2006.
- [27] A. Qumer, "Measuring agility and adoptability of agile methods: a 4-dimensional analytical tool," *IADIS International Conference Applied Computing*, 2006.
- [28] M. P. L. M. George Di Paula, Dakar Parada, "Agilidad y disciplina del proceso de desarrollo de software para las pequeñas y medianas empresas (pymes) y las cooperativas en latinoamérica. caso: Venezuela," *VII Jornadas Iberoamericanas de Ingeniería del Software e Ingeniería del Conocimiento*, vol. VII Jornadas Iberoamericanas de Ingeniería del Software e Ingeniería del Conocimiento, January 30 - February 1 2008.
- [29] A. Cockburn, *Agile Software Development: The Cooperative Game*. Addison-Wesley, 2001.
- [30] R. T. Barry Boehm, "Balancing agility and discipline: Evaluating and integrating agile and plan-driven methods," *26th International Conference on Software Engineering*, 2004.
- [31] P. S. Taylor, D. Greer, P. Sage, G. Coleman, K. McDaid, I. Lawthers, and R. Corr, "Applying an agility - discipline assessment for a small software organisation," *J. Munch and M. Vierimaa*, pp. 290–304, 2006.
- [32] M. Cohn, "The ideal agile workspace." <http://www.mountingoatsoftware.com/blog/the-ideal-agile-workspace>, March 2009. verified on May 16th, 2012.
- [33] K. Beck, *Extreme Programming Explained*. Addison-Wesley Professional, 1999.
- [34] J. Paul, "Quantitative approach for lightweight agile process assessment," Master's thesis, UNIVERSITY OF TURKU, 07 2008.
- [35] V. R. Basili, G. Caldiera, and H. D. Rombach, "The goal question metric approach," *Encyclopedia of Software Engineering*, vol. 1, 1994.
- [36] R. V. Solingen and E. Berghout, *The Goal/Question/Metric Method: a practical guide for quality improvement of software development*. McGraw Hill, 1999.