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Software Reliability as User Perception

Application of the Fuzzy Analytic Hierarchy Process to Software Reliability Analysis

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Abstract—**Software Quality is a multidimensional concept for which Reliability is considered as a key attribute. Notwithstanding, due to its conceptual complexity, there is no common agreement on what Software Reliability is, thus different stakeholders use a variety of Software Reliability views. With the aim to improve our understanding of what Software Reliability means for industrial stakeholders as well as that of contributing to enhance the industrial applicability of Software Quality Models we propose approaching Software Reliability analysis by using structural model based on representative International Standards, which are industry-oriented. As analysis method, since interested on stakeholders' vision of Reliability we will apply the Fuzzy Analytic Hierarchical Process (FAHP) which is designed to manage human assessment, always characterized by a certain degree of vagueness and subjectivity. The rationality of the proposed model and feasibility of the analysis method is proved by the application on a very large industrial system which provides empirical evidence on the conceptual descriptiveness capturing stakeholders' views and industrial applicability in an efficient manner.**

Keywords—Empirical Software Engineering, Fuzzy Analytical Hierarchical Process, Quality Analysis and Evaluation, Software Reliability.

1. INTRODUCTION

This work is concerned with a major topic in Software Engineering (SE); that of the Software Quality and more specifically on Software Reliability which according to J. Musa [1] is, "probably the most important of the characteristics inherent in the concept Software Quality". From Software Engineering perspective Software Reliability is the crucial factor as regards estimating both software quality and software cost [2]. David Garvin analysed in his now classic work [3] how Quality is perceived from several domains, presenting a view of quality as an abstract concept that comprises five different perspectives; transcendental, user-based, product-based, manufacturing and value-based perspectives. Quality (and Reliability) as a concept is difficult to define and understand [4] as well as it is characterized by a strong subjective element, which need to be taken into account when modeling Quality or Software Reliability. Investigating means of capturing this user-based dimension of Software Product Reliability is the main aim of this work. This is important in order to increase end-user satisfaction with the delivered products.

ISO 14598-1 [5] defines External quality as the extent to which a product satisfies stated and implied needs when used under specified conditions. As N. Bevan remarks in [6] this moves the focus of quality from the product in isolation to the satisfaction of the needs of particular users in particular situations. However, if different groups of users have different needs, then they may require different characteristics for a product to have quality for their purposes. Assessment of quality thus becomes dependent on the perception of the user. Garvin [3] defines *User perceived quality*. However, [4] there is a more fundamental reason for being concerned with user-perceived quality, products can only have quality in relation to their intended purpose.

In industry valuable model have to, in addition to being founded on sound assumptions, capture the phenomena complexity and be demonstrably accurate, being practical and cost effective since the main goal of industrial model is informing the decision making process in a real-world context. This is clearly challenging. The work of Standardization Organizations are good examples of the necessary efforts to achieve such models, although they do not appear to have had a great impact in industry with just a few works on Standard Based Software Reliability Modeling (SB-SRM) and less real world application studies published (or at least industry is not reporting on its application), and most model application works having, to date, focused on academic experiments [7] rather than industrial experiences. This is surprising given the relevance of

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such International Standards in industry. Work needs to be done to afford this situation in order to enable industry to effectively apply Quality Models to industrial practice. In a previous work [8] we have investigated this issue to conclude that, among other hindrances, it is necessary to consider Reliability from different perspectives in order to meet the variety of stakeholders' needs.

Our main aim on this research is to verify the industrial applicability as well as the conceptual descriptiveness of the previously [8] proposed structural SB-SRM model. Industrial applicability is related not only to intrinsic attributes like soundness or accuracy but mainly with two essential extrinsic aspects; its ability to fit into the organization process with a minimum impact and minimal needs on resources (efficiency) and the capability to provide proper answer to user's stated or implicit needs (effectiveness).

The remainder of the paper is organized as follows: Section 2 summarizes the related work, presents our proposed model and the Fuzzy AHP analysis framework. Section 3 presents our application in a real-world industrial set-up. Section 4 reports on the results and their interpretation, empirical outcomes are analyzed and possible threats to validity are presented. Finally, Section 5 sets out some conclusions and future works.

2. BACKGROUND AND PREVIOUS RELATED WORK.

2.1 Software Product Reliability in an Industrial Setup

The Quality Model is a tool to produce the right product. In that sense Tony Hoare says that "The most important property of a program is whether it accomplishes the intentions of its user" and J. Musa claims [1] that Software Reliability concerns itself with how well the software meet the requirements of the customer, in the same vein in [9] we read; "Software quality is the degree to which a system, component or process meets the specified requirements and the needs or expectations of the customer or user" also in the seminal work on Dependability [10] we read that Reliability is the continuity of a correct service. Also on International Standard SQuaRE [11, 12] it is explicitly stated the need of considering the different stakeholders point of view and needs when analyzing Software Product Quality. The Quality Models provide a framework with which to collect stakeholder needs. Among the documents in the ISO/IEC standard the 25010 "Quality Model" defines a product quality model composed of eight characteristics which are further subdivided into sub-characteristics. This model is understood as a structural model that SQuaRE defines as; "defined set of characteristics, and of relationships between them." Thus in this research modeling means analyzing the components and their relationships instead of reducing the observable phenomena into a set of mathematical formulae. On the other hand, industry needs clear models and methods that are straightforward to apply in order to be useful to inform the decision making process in a real world context with a minimum need on resources and a maximum of results.

It is from this perspective that we approach the topic of Software Product Reliability Modelling and have thoroughly investigated the available literature [8] to find out that the main obstacles for a broad industrial application of SB-SRM are related to the inherent conceptual complexity and its associated variety of definitions as well as the lack of methodologies straightforward to apply in a real-world context without failing to capture stakeholder's expectations.

The complexity of the Reliability concept, which is characterized by its multiples facets, is shown in the majority of the works on this topic but several works [13, 14, 15, 16] specifically tackle the conceptual analysis of software reliability and related concepts. As mentioned, one of the more controversial issues is the definition of Software Reliability itself and the variety of related concepts proposed in the different standards. In [13] it is pointed out that: the comprehensive evaluation of the software is a complex issue, it is difficult to carry out proper evaluations and different methods have many different results, the authors present a method for evaluating reliability/dependability (the two terms are used interchangeably) with reference to the quality model of ISO/IEC 9126. In [14] the authors analyze the variety of reliability views and propose to harmonize the treatment in different standards (ECSS, ISO9126 and IEEE-stds) into a generic standard-based reference model in which reliability is expressed as a set of functional requirements and is therefore implementable and measurable. Also, some works [15,16] point to a possible lack of completeness of the models

Our proposed strategy to overcome these hindrances will be based on SQuaRe proposed hierarchy layout refurbishment in the context of adherence to International Standard proposal to tackle the general issue of complexity and the explicit treatment of Reliability as user oriented concept in order to capture the variety of stakeholders' viewpoints.

We have already mentioned that Software Reliability concerns itself with how well the software meet the requirements of the customer, also that

Reliability is the continuity of a correct service. That is, a system will be reliable to the extent that it is available whenever it is required for use and behaves as expected by its users. Adhering to ISO/IEC vocabulary Reliability is, therefore, a certain function of Availability and Maturity in which maturity summarizes the correctness of behavior that is consistent with stakeholders´ expectations.

Maturity means then that user expectations are met and thus no changes or corrections are consequently required, which is Stability as understood on IEEE 982.1 [17] when defining the Software Maturity Index. Fulfilling user expectations also imply a system that permits an easy and flexible use of the facilities, which can be mapped to Robustness in the terms of IEEE 610.12. This is directly related to the correctness of implementation since Robustness is understood [9] as the degree to which a system or component can function correctly in the presence of invalid inputs or a stressful environment. In summary, Maturity is made up of Stability and Robustness. On the other hand, the Availability of a system depends on how much it fails as regards the effort required to repair it. Availability is thus a certain function of a system´s Fault Tolerance, which determines whether a fault will manifest itself as a failure and its Recoverability, which accounts for the recovery efforts after failure. The following table I depicts this structural model.

TABLE I. STRUCTURAL SOFTWARE PRODUCT RELIABILITY MODEL

RELIABILITY: Degree to which a system, product or component performs specified functions under specified conditions for a specified period of time			
Maturity Degree to which a system, product or component meets stakeholder's needs under normal operation.		**Availability** Degree to which a system, product or component is operational and accessible when required for use.	
Stability Degree to which a system, product or component requires of modifications after release as result of defects presence or because of new, missing or wrong requirements	**Robustness** Degree to which a system or component can function correctly in the presence of invalid inputs or a stressful environment.	**Fault Tolerance** Degree to which a system, product or component operates as intended despite the presence of hardware or software faults	**Recoverability** Degree to which, in the event of an interruption or a failure, a product or system can recover the data directly affected and recover the desired state of the system

2.2 Capturing the User's experience. Fuzzy AHP suitability for SB-SRM

Being one of our primary goals the development of models considering the user-based Quality dimension we choose as analysis framework a suitable way to capture Stakeholder's needs. It is in this context that we consider applying, as measure aggregation strategy, a recognized and widely used approach, the Analytical Hierarchy Process (AHP) [18, 19, 20, 21], which is a well-known measure theory and a technique for the evaluation of complex concepts. AHP has a variety of applications [19] in economics, business, social sciences and engineering.

AHP offers a number of advantages that makes it suitable for our purposes, in particular it's easy to use and able to yield reliable results even in the presence of errors in the elicited opinions but it is also know that presents limits to capture de characteristic vagueness of human thinking. In order to overcome this limitations the Fuzzy AHP approach was introduced by Laarhoven and Pedrycz [22] as a merger of the classic AHP and Fuzzy logic concepts [23, 24] and tools to gain advantage of both and, therefore, addresses the above mentioned problems. There are several FAHP methods reported in the literature [25]. In this work we will make a rather simple application since our objective is not on the Fuzzy AHP technique itself but on the model suitability verification.

The FAHP is developed along three main steps: First, the problem has to be modelled into a hierarchy which is fundamental to the process of the AHP. Hierarchy indicates a relationship between elements of one level with those of the level immediately below. Once the hierarchical model has been built data are collected from experts or the concerned users. The objective is comparing the hierarchy elements to one another with respect to the impact on their parent node. This is achieved by means of the expert panel's answers to questions of the general form, "How relevant is element A as regards to element B?" known as "pairwise comparison". Then, these pairwise comparisons gathered at previous step are now arranged into the comparison matrix at each level and according to the hierarchy structure. A simple but illustrative example of its application can be found on [21] as well as some more elaborated ones in [20].

3. INDUSTRIAL ENVIRONMENT APPLICATION

The experimental application of the proposed framework to an industrial example comprises three stages methodology as depicted on table II. First we will define the case as well as each of the required elements then we will gather the field data in this particular case by means of interviews to an experts committee. Finally we will compute the model's parameter and run an example of application to Reliability analysis.

TABLE II. METHODOLOGY

Research Definition	Defining the problem and objective Developing the problem into a hierarchy Establishing a group of representative stakeholders Agree on the linguistic variables
Gathering Field Data	Gathering each stakeholders assessment a) On model components relative relevance b) On under study system behaviour Computing consistency Index Consensus
Model Computation	Model parameterisation; the weight vector. User perception assessment.

3.1 Research Definition.

This work is a study which is conducted to investigate the efficiency and effectiveness of SB-SRM in an industrial setting, with particular focus on the user-based quality and how can capture the stakeholders view on the topic. The dataset was collected from a lead European Space Industry Company (ESIC, real name concealed for confidentially reasons) and from of a large legacy real-time industrial software system. The software product under study is about fifteen million lines of code implemented as a middleware based open system and running in a distributed architecture of about one hundred nodes. It makes part of a larger Monitoring & Control System (MCS).

The hierarchical model is the one proposed and justified on section 2.1 which constitutes the object of the research. A panel of experts is formed based on their knowledge, skills and experience on the maintenance and operation of the aforementioned system. The participants involved are three Technical Managers from the ESIC IT department and six senior professionals from software development division within an Engineering Company which is a major player in the global Space & Defense European market and partner of ESIC on MCS maintenance. Aged between 30 and 45 years, they all hold high college degrees in computer-related areas and have from 10 to 15 years of IT managing experience at different levels.

The expert panel is asked to make pair-wise comparisons of the importance between each pair of sub-characteristics in the SB-SRM model. The comparison is in the form of linguistic variables and was done after instruction from the principal researcher on how interpreting the comparison scale. That leads to the agreement on linguistic variables as presented on first column of table III.

Finally the FAHP method implies converting the linguistic variable to fuzzy numbers [24] to which apply the computations. In this work, Triangular Fuzzy Numbers (TFN) are used to represent those subjective comparisons. For doing so a scale definition as the one proposed by Chen [25,26], is required to convert such linguistic variables into TFNs. They are shown in Table III.

TABLE III. FUZZY ASSESSMENT

Linguistic variable	Triangular Fuzzy	Reciprocal Triangular
Equally important	1,1,1	1,1,1
Intermediate values	1,2,3	1/3,1/2,1
moderatelly important	2,3,4	1/4,1/3,1/2
Intermediate values	3,4,5	1/5,1/4,1/3
Essentially import	4,5,6	1/6,1/5,1/4
Intermediate values	5,6,7	1/7,1/6,1/5
Very strong importance	6,7,8	1/8,1/7,1/6
Intermediate values	7,8,9	1/9,1/8,1/7
Absolutelly inportant	8,9,10	1/10,1/9,1/8

Since the application of the FAHP algorithm requires the use of reciprocal numbers they are, by convenience, also detailed in the table.

3.2 Gathering the Field Data.

The participants were asked to provide their assessment on the basis of the aforementioned definitions after been instructed on the intentions and on the significance of the assessment scale, notwithstanding without awareness on the specific model layout, this in order to avoid bias or influencing them on their judgement and so improving the empirical validity. They provided, thus, a set of pairwise assessment like the ones from participant "A" presented in Table IV and Table V in its final form after re-arrangement according to the structural model under study.

TABLE IV. ASSESSMENT EXAMPLE

A	Maturity	Availability
Maturity	1,1,1	5, 6, 7
Availability	1/7,1/6,1/5	1,1,1

TABLE V. ASSESSMENT EXAMPLE

A	F.Tolerance	Recoverability	Robustness	Stability
F. Tolerance	1,1,1	3,4,5	1/3,1/2,1	1,1,1
Recoverability	1/5,1/4,1/3	1,1,1	¼,1/3,1/2	3,4,5
Robustness	1,2,3	2,3,4	1,1,1	2,3,4
Stability	1,1,1	1/5,1/4,1/3	¼,1/3,1/2	1,1,1

Those data need to be reviewed in order to ensure the internal consistency of each of the provided set of pairwise comparison. Inconsistent data will be rejected. T.L. Saaty [18] proved that for consistent reciprocal matrix, the largest eigenvalue λ_{max} is equal to the size of the matrix, $\lambda_{max} = n$. Then he gave a measure of consistency, called Consistency Index as deviation or degree of consistency using the following formula:

$$CI = \frac{(\lambda max - n)}{n-1} \quad (1)$$

This largest or principal eigenvalue is obtained from the addition of products between each element of the eigenvector and the sum of columns of the reciprocal matrix. In this approach, each triangular number is transformed to a non-fuzzy number, we choose the modal value just for simplify the computation. The eigenvector is obtained by dividing each element by the sum of its column then adding by rows and normalizing by the matrix size. Finally, the consistency ratio (CR) is defined as a ratio between the consistency of a given evaluation matrix and consistency of a random matrix: $CR = CI/RI(n)$ Where *RI(n)* is [19,20] a random index that depends on *n*, as shown in Table VI.

TABLE VI. RANDOM INDEX

n	3	4	5	6	7	8	9
RI	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Applying the above to the first of our comparison matrix, Table V, we obtain the normalized comparison matrix show on table VII.

TABLE VII. NORMALIZED COMPARISON MATRIX

0.2	0.14	0.36	0.285
0.6	0.428	0.36	0.285
0.1	0.214	0.181	0.285
0.1	0.214	0.09	0.142

From which we compute the eigenvector:

W= (0.24265, 0.41825, 0195, 0.1365)

Then the principal eigenvalue is: $\lambda_{max} = 4.2018$

from where CI=0.06726 as per equation (1)

and finally CR=0.0747 ≤ 0.1

Thus the assessment from contributor A is consistent enough as to be considered in the analysis. The same was done for the rest of the contributions obtaining similar values. All contributions were accepted as input to the model, thus entered in the next step, which is the aggregation of the individual assessments into a unique set named "consensus".

For the aggregation of every participant assessment into a single consensual judgement matrix there is a variety of proposal available in the literature, we chose by simplicity the geometric mean as explained in [27, 28] which is one of broad application. In summary this approach consists in, for triangular fuzzy numbers in the form (l_i, m_i, u_i), choosing the minimal value among the lower elements l_i, the maximal among the u_i upper elements and the geometric mean of the m_i modal values. We proceed in that way and, taking into consideration the layout of the proposed SB-SRM, we obtain the following set of matrix, tables VIII, IV and X, which sum-up the stakeholders assessment of the under analysis system.

TABLE VIII. FIRST LEVEL ASSESSMENT

L1	Maturity	Availability
Maturity	1,1,1	0.25, 1.59, 5
Availability	0.20, 0.69, 4	1,1,1

TABLE IX. SECOND LEVEL ASSESSMENT

L2a	Robustness	Stability
Robustness	1,1,1	2, 3, 4
Stability	0.25, 0.33, 0.5	1,1,1

TABLE X. SECOND LEVEL ASSESSMENT

L2b	F.Tolerance	Recoverability
F. Tolerance	1,1,1	0.33, 1.26, 5
Recoverability	0.2, 0.79, 3	1,1,1

Where L1 denotes the conceptual Level 1 and L2a and L2b both branches on the second level of the hierarchy depicted on table I.

3.3 Model parameterization and application.

There are several methods to compute the fuzzy final weights representing the global assessment. It consists in an extension of Saaty's procedure to fuzzy reciprocal matrices, and was first introduced by van Laarhoven and Pedricz [22]. Other researchers developed more accurate methods although choosing one method rather than another does not change or invalidate the model we're assessing on this work

We determined the fuzzy weight vectors by using geometric mean technique [29] First geometric mean is computed by rows and then it is normalised. In our model it is particularly simple since the proposed layout leads to small matrix as we have seen before. Then those triangular numbers are translated onto crisp or "de-fuzzified" values, for doing so there is a variety of means reported in the literature, we will apply the simple centroid method. Then, those crisp values are normalized. Results are in table XI.

TABLE XI. THE GLOBAL WEIGHT VECTOR

Characteristic	Fuzzy vector	Crisp value
Maturity	0.118, 0.603, 2.35	0.694
Availability	0.105, 0.397, 0.851	0.3059
Robustness	0.52, 0.752, 1.05	0.7429
Stability	0.184, 0.248, 0.372	0.257
F. Tolerance	0.229, 0.58, 2.193	0.6201
Recoverability	0.179, 0.42, 1.239	0.3798

Finally we obtain the complete structure of relative importance of each element in our structural model accordingly to stakeholder point of view as it is show in table XII. Those are the model parameters for this case of application.

Once the model is properly parameterized we can afford the assessment of the user perception.

TABLE XII. COMPUTED RELATIVE IMPORTANCES

Local Weights		Global Weights
w_M= 0.694	w_{St} = 0.257	W_{St} = 0.1783
	w_{Rb} = 0.7429	W_{Rb} = 0.5155
w_A = 0.3059	w_{Ft} = 0.6201	W_{Ft} = 0.1897
	w_{Rc} = 0.371	W_{Rc} = 0.1135

The experts committee was also asked to give their assessment on the exhibited performance for the same attributes for which they gave the relevance judgment. This interview was performed in a different time to avoid bias on the empirical data due to a feedback effect. One of the committee members did not complete this task. Here after in table XIII the provided answers after standard linguistic variables translated into Triangular Fuzzy Numbers.

TABLE XIII. USERS QUALITY PERCEPTION

	Reliability	F. Tolerance	Recoverability	Robustness	Stability
A	6,7,8	5,6,7	6,7,8	7,8,9	6,7,8
B	4,5,6	6,7,8	6,7,8	4,5,6	6,7,8
C	6,7,8	4,5,6	6,7,8	4,5,6	6,7,8
D	7,8,9	6,7,8	6,7,8	6,7,8	7,8,9
E	8,9,10	5,6,7	6,7,8	6,7,8	5,6,7
F	7,8,9	6,7,8	6,7,8	6,7,8	7,8,9
G	7,8,9	6,7,8	6,7,8	6,7,8	7,8,9
H	7,8,9	6,7,8	6,7,8	6,7,8	7,8,9

Those data are summed-up into a unique global assessment, consensus, in the same way as it was previously done for the relevance parameters. The outcome is in the following table XIV.

TABLE XIV. FAHP CONSENSUS ON USER PERCEPTION

Reliab	F. Tolerance	Recover	Robustness	Stability
4, 7.1, 10	4, 6.48, 8	6, 7, 8	4, 6.543, 9	5, 7.34, 9

Values which are subsequently de-fuzzied by means of the centroid method to obtain an assessment expressed in crisp values, table XV, which we use as input to our proposed structural model.

TABLE XV. DE-FUZZIFIED CONSENSUS

Reliability	F.Tolerance	Recoverability	Robustness	Stability
7.03	6.16	7	6.51	7.11

4 RESULTS ANALYSIS

From the obtained results, and in order to evaluate in which extent the proposed structural model is able to capture the stakeholder vision we compute Reliability from table XII parameters and table XV user assessments then compare the result to the user consensus on Reliability recorded in table XV.

$R = W_{Ft}$ x6.16+ W_{Rc} x7+ W_{Rb} x6.51+ W_{St} x7.11= 6.6

R= 0,1897x6.16+0.1135x7+0.5155x6.51+0.1783x7.11= 6.6

This outcome means that the deviation between the user perceived Reliability (7.03) and the one derived by the model and proposed framework (6.6) is of roughly a 5% In other words, In that simple, but recognized and well founded way, we are actually capturing the view on Reliability for the particular group of stakeholders for which this expert's panel is representative.

Study Findings

As mentioned this work is conducted with the aim of analyze the suitability, in terms of efficiency and effectiveness of the SB-SRM approach in an industrial setting, with particular focus on the user perception on the delivered Quality and how can capture the stakeholders view on the topic. Industrial applicability is related not only to intrinsic attributes like soundness or accuracy but mainly with two essential extrinsic aspects; its ability to fit into the organization process with a minimum impact and minimal needs on resources (efficiency) and the capability to provide proper answer to user's stated or implicit needs (effectiveness).

In terms of effectiveness the presented analysis has shown a good agreement between the global perception as stated by the users and the outcome obtained by the proposed framework. We conclude that this constitutes valuable empirical evidence on the correctness of the proposed model, notwithstanding additional evidence is yet required.

In terms of efficiency, the developed exercise has shown the ease of application without introducing overloads in the process, although it suggests the use of ad hoc support tools in order to lighten even more this impact. The model is conceptually simple and clear which facilitates dealing with ambiguity and discussion about the definition of high level concepts by providing an agreement between the parties when using this framework as an analysis tool.

All this promotes the capability of this proposal to fit into the organization process with a minimum impact and minimal needs on resources but providing an appropriate descriptiveness and agreement with stakeholder's expectation as to constituting a suitable engineering tool.

Empirical Validity

On the following we present some potential threats to validity, according to [30] and how we addressed them in order to mitigate its undesired effects. The major threats to validity correspond to the main dimensions of the validity: Construct, Internal and External validity.

Construct Validity. Refers to the aspect of validity that reflects to what extent the observations considered into the analysis represent what the researcher intend to investigate. In our analysis the construct validity is ensured by the high expertise profile of the expert committee members as well as the use of explicitly stated definitions for the concepts under study which largely contributes to a common understanding. Internal validity: Due to the characteristic of the presented study internal validity threats do not apply. This aspect of validity is of concern when causal relations are examined, which is not the presented case. The external validity is concerned with to what extent it is possible to generalize the findings. In the examined application the focus was put in a particular class of stakeholders.Further generalizations would imply selecting experts from other contexts, for example, the under study system end-users or the organization's board of directors.

5 CONCLUSIONS AND FUTURE WORK

This work reports on an industrial application of a structural model for software product reliability which is conducted to investigate the suitability of the SB-SRM approach in an industrial setting as a tool for Software Reliability analysis as well as provides experimental evidence on the suitability of applying SB-SRM approach to capture the users perception of Quality.

Efficiency and effectiveness are essential in real-world operations. If a product or service doesn´t perform to higher standards (effectiveness) with the least amount of resource necessary (efficiency) it will not be applied or will be replaced with something that does. Thoroughly testing large and very large systems is un-economics and most of times unnecessary, such testing strategies have their place in life-safe critical systems or for elements of particular criticality on other cases but in most of the projects we could consider the role of the engineer will be on assessing Product Quality avoiding such comprehensive testing. Such is the nature of engineering. Alternatives can be developed, like the one we have presented on this work, which starting on user satisfaction as a goal will inform the technical management for the development and evolution of the Software Product within the constraints of the allocated resources.

Future work include the extension of the presented approach to cope with another relevant issue when assessing software product quality, making the link between the very high nature of the available models and the low level software product properties and attributes in a sound understandable and simple manner.

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