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Research Article

Evaluation of Innovation Maturity Model (IMM) Framework on Assessment of Software Development Projects

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Keywords

Innovation Maturity Model,
Software Development,
Project Management,
IT Startups.

Abstract

Innovation Maturity Model (IMM) creates the ability to improve and find the position of the innovative software ideas in a more organized way through segments with specific processes which defined to evolve and measure the capability of the core idea. The creation of this framework has been done by exploring related frameworks; such as open innovation process model, Fugle innovation model, capability maturity model and perception of innovation in companies model. Therefore this paper seeks the contribution to evaluate the practical usefulness of the designed framework and proposes possible improvement roadmap of Innovation Maturity Model concept.

1. Introduction

Kong et al., [1] mentioned in his research paper on evaluation of “Technological innovation capability” that innovation is the main driving force of enterprises sustainable growth. Therefore to manage and assess innovations, tailoring a framework for software development innovative projects and validating it by the key practices to evaluate it, to find out whether the created framework satisfies the goals of the key process, has vital necessity in software industry [2].

The failure of innovative software projects has direct relation to understanding the potentials and risks of the idea [3]. Therefore accurate assessing of the novel innovation concept and defining a framework which fits the industry needs, is a critical subject to many researches (e.g. capability maturity model in Hang et al., [4] and framework for CoPS in Chen et al., [5]) paper). Lack of existence of a customized framework for assessing and evaluation innovative software projects before development, lead the authors to make first version of IMM through a Change Management research project within Gothenburg University. A framework that assesses and places the innovative idea through several processes reduces uncertainty and gives a great base to manage innovation and greater return of investment (Andersson, et. al., [1]). Innovation Maturity Model (IMM) creates the ability to improve and find the position of the innovative software ideas in a more organized way through segments with specific processes which defined to evolve and measure the capability of the core idea. The creation of this framework has been done by exploring related frameworks; such as open innovation process model, Fugle innovation model, capability maturity model and perception of innovation in companies model (PIC)

According to Sorensen [6] paper, the creative theoretical framework without experimental cases has no value. Therefore this paper seeks the contribution to evaluate the practical usefulness of the designed framework and proposes possible improvement roadmap of Innovation Maturity Model concept. It argues usage of framework by applying it to the empirical cases within industrial software projects in software industry by an evaluation framework. Hence, two industrial cases have been chosen by the authors in cooperation with the industrial partners. By assessing these cases with IMM, the authors understand the weaknesses of the framework for omitting and highlight the strengths for distributing the IMM into industry as result of this paper.

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2. Evaluation of Framework

Evaluation and measuring strengths and weaknesses of such frameworks needs the creation of an actual model to follow. This model should approach data collection with the methods and tools which have been put into the evaluation framework and get the result from the evaluation process.

2.1. Statement on Evaluation Model values

The Innovation Maturity Model (IMM) is a primary version of the framework. Despite all other similar assessments which is evaluating on public and distributed frameworks, this evaluation accomplished to light a clear roadmap of improvement for releasing a public and practical version. By considering several models for evaluation model we have finally intend to apply Feature-Based evaluation. [8].

According to our research Feature-Based evaluation has been used to identify the relevant issues for initiating the measurement which suits current version of IMM.

There are two important factors that should be considered during the evaluation assessment. First one is People (e.g. teams who are involved in projects or stakeholders) and the second one is processes (e.g. set of methods and tools provided in each segment of IMM) that the evaluation model seeks to measure its capabilities and find out its strengths and weaknesses during the evaluation procedures. According to TongShi and JiShunZhu study [9] on an assessment framework in software development process, they mentioned that “People are the most important ingredient of success. A good process will not save the project from failure if the team doesn't have strong players; but a bad process can make even the strongest of players ineffective” [9]. Therefore during defining this evaluation model, these factors have been considered to have an approach for putting these two factors in the center of our focus in IMM evaluation. This led us to evaluate identified features and relevant issues in two main perspectives. To evaluate people factor we intend to use values for considering the overall impression of using IMM from people prospective and for considering processes we considers each segment’s processes separately to have better measurement for this prospective as well.

This paper intend to use Capability Maturity Model objectives to follow measurement for identifying set of relevant features which a proper framework needs for distribution to software industries and being applicable for different people at different organizations.

The Capability Maturity Model (CMM) developed by the Software Engineering Institute at Carnegie Mellon University. CMM provides software organizations with guidance for “gaining control over their process for software development and maintenance and for establishing a plan for maturing the software organization into higher levels of software engineering excellence” [2]. It basically consists of five maturity levels i.e. initial, managed, defined, quantitatively managed, and optimizing (Saikh et al., 2009).

By considering CMM activities and technical report for validating each new tailored framework for presenting to industry in each report we understood that their key practices, values and questioners could be tailored to be used for defining a questionnaire and survey as part of overall usability evaluation of IMM which intend to use in software products as part of organizational perspective. Drew [2] research mentions "The key practices define a comprehensive process that is appropriate for large, complex systems for critical application. Instantiating the key practices for other systems may mean tailoring them. . . . The pertinent question is whether the implementation of the key practices satisfies the goals of the key process area." [2]

According to the Software Engineering Institute (SEI) report on key practices of capability maturity model, CMUEEI-91-TR-25, this model developed an initial version of a maturity model and maturity questionnaire at the request of the government and with the assistance of the MITRE Corporation. Throughout the development of the model and the questionnaire, the SEI has paid attention to advice from practitioners who are involved in developing and improving software processes. Based on their objectives that have been provided, we identified some relevant factors that need to be evaluated by teams to give an overall view of IMM usage in cases. These factors should mainly “reflects the needs of individuals performing” software process assessments, or “software capability evaluations”; the identified factors should also consider the level of well “documented” definition of the model; and the capacity of the current version to be “publicly available”. This insight has been gained by: Studying the supportability of modeling for “performing and observing process assessments and software capability evaluations, analyzing change requests” and collaboration with industry to get feedback from industry reviewers. Using this knowledge led us to create the survey for this section and these mentioned characteristics such as modeling definition, scalability, traceability, understandability, and level of refinement and maturity of model were the fundamental of determination of features for evaluation in overall impression survey factors [8].

Alongside by overall values which need to be evaluated in the whole framework, its staged by stage approach needs to evaluate intensively. This can be assessed by segment evaluation of identified metrics by the teams whom working on case assessment.

This segment evaluation assessment defined based on set bases that include speed, quality, flexibility, improvement, pro-activity and profitability. Their definition in TongShi and JiShunZhu study [9] on an assessment framework in software development process is: “Speed: concept-to-cash time or the time it takes to respond to perceived customer Flexibility: the ability to adapt to variable customer requirements. Quality: products and services that satisfy customer expectation over lifetimes. Improvement: successful exploration of new ideas for products, services and procedures. Proactivity: the ability to influence and predict market trends. As well profitability: The expense of resources required to produce goods or services to satisfy a market need”[9]. Therefore these metrics has been identified as basis for segment evaluation and their description adapted to IMM needed values that mentioned in designed survey as part of IMM empirical evaluation design (Appendix 1).

2.2. The Empirical Evaluation Model design

This evaluation framework had been defined to evaluate the IMM. This evaluation framework designed and conducted in five phases [8]:

The first phase consists of identifying a set of relevant issues and metrics to be measured by the empirical evaluation. We have used literature review and model-based approach to identify this then among relevant models evaluation (e.g. agile process evaluation assessment in [9] paper and CMM evaluation assessment in Drew's paper [2]) each metric and issue has been discussed to tailor for covering the evaluation of IMM (in previous section).

The second phase is training teams who want to participate in case study assessment. This training consists of teaching the concept of IMM and showing how is the proper use of the framework to them.

The third phase is use of IMM to develop the case studies by the trained teams. This case assessment needs to be done by the teams independently to give more accurate evaluation result.

The fourth phase is to evaluate identified relevant features by the teams. A survey has been created (appendix 1-Survey) to analyze their experience by giving the rating tables for each selected features in two sections: 1) Segment Analysis 2) Overall analysis

The fifth phase is discussing the results and drawing conclusions about strength and weaknesses of IMM.

3. Research Approach

3.1. Research Setting

This research paper has been conducted as a further research on Innovation Maturity Model. Since the first version required measurements on its capabilities this empirical evaluation has been defined to measure competences and flexibilities of IMM by applying selective cases on it.

Refer to existing related studies [10] the involvement of company and universities in doing their research regarding of new processes and frameworks within Software development might gave the new idea therefore the authors contacted over 100 companies within the industry in Nordic countries and United states to select case studies and individual reviewer for evaluating the capability of the IMM as a framework for public use in industry. Among received collaboration requests from companies, this research finally conducted by two main case studies under mentorship of Pax and Liberta Company located in Gothenburg city and Gothenburg University as main contributors and also Ericsson Innovation Center in San Jose for reviewing the IMM and feedback on overall impression of the concept.

3.2. Research Process

The first stage in the methodology was the research design phase. It initially involved a review of the published literature in the area of IT innovations and evaluations of similar frameworks in software development. This identified research need and resulted in the development of hypotheses, which relate to the evaluation model and its identified metrics and issues for consideration. By reviewing Irani research process [11], a model building process then commenced that resulted in the development of an evaluation framework. This was then followed by the case study and analysis of the results as our research strategy [11].

The assessment consists of using a survey as evaluation of IMM on case studies and then discusses the ratings and feedbacks by data analysis method (see section 3.3). Survey research is the most adequate technique to accomplish empirical analysis due to the lack of theory available in our fields of study. To test the structure introduced in the IMM model, it was necessary to design a survey instrument in order to gather data from software companies. We identified and discussed the issues and metrics (see section 2). The survey was sent to companies whom are contributed to the case studies. We received the feedback, which enabled us to make corrections to the framework which can provide a more comprehensive evaluation [9][12].

We have used terminology for ratings according to similar evaluations researches. Those are stands for something as: 1 stands for "very bad" in terms of usability of that metric, 2 for "bad", 3 for "fair", 4 for "good" and 5 for "very good". And in overall impression the measurement concept ratings defined as "very well supported", "not well supported" and "not supported" and the feedback on this part can hold the concerns of model definition of IMM.

The evaluation include specific characteristic of similar evaluation metrics (e.g. CMM, Open Innovation Model and Agile process evaluation [9].

In order to start the evaluation process teams trained in terms of workshops on IMM on a week sessions by daily basis and provided by the required materials on the concept(previous research on change management project) then cases has been applied by the teams independently to get their pure experience on using IMM. The description of the novel innovative software cases coming as follows:

- *Case study one:* Team Blue worked on a web application Project which is the first content delivery engine.
- *Case study two:* Team Red worked on a crowd Sourcing platform in software development projects.

The collected data from surveys and feedbacks on IMM then analyzed and the discussion has been written as the conclusion of this empirical research paper.

3.3. Data Collection and Analysis

The data has been gathered from surveys which sent to our collaborators for applying their case studies to IMM. The minimum number of cases for accomplishing the research was two innovative software ideas and in each teams involved in cases, at least two members required to be able to fill the survey during applying cases. By having more than one case, there is a possibility to study different result from different teams. Also it is possible to realize which results are more precise. According to [13] there is a need of having more than one member in a team to be able to find out errors and having precise data. Thus in each project two members participate the study.

3.3.1. Process of Segment Analysis

This process consists of several phases to analyze the collected data from segment measurement section in survey. These phases consists:

- *Precise Data Selection:* For this research desired precision value assumed 1. Therefore for each case, the ranks that has the same value by both members and also ranks with 1 value differentiation has been selected as precise data.
- *Metric Sorting (H/L)*: after selecting the precise data, the average has been calculated from the precise data in Eq. (1)

$$\bar{x} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i \tag{1}$$

(x stands for rate (from 1 to 5 based on definition) for each metric, i stands for each metric, n stands for number of metrics)
The average below 3 considers as Low(L) and higher than 3 considers as High(H) in that metric which then match with the definition of that metric in evaluation survey
- *Reconciling segment parts with metrics*: by comparing the metric sorting the Low part can be considered as segments in IMM that needs improvement based on studied cases. By analyzing the meaning of metrics and realizing the segment part by part and finding related parts of segment to the metric, it is possible to realize the weak point of segments based on Low ranked metric on that segment. During analyzing segment parts and metrics, considering participant feedbacks helps to expedite reconciling segment parts with metrics.
- *Concluding weakness points:* Participates has ranked six metrics for each segment. Root cause of low ranking is not only IMM but also it can be the problem with understanding of IMM. To evaluate IMM it is important to identify those low ranked metrics that are because of misunderstanding or poor description of IMM in documents and workshops. In this last phase of Segment Analysis the goal is to identify weak points of IMM segment the way they are not the way they have been taught.

3.3.2. Process of IMM Overall Analysis

This process consists of several phases to analyze the collected data from overall measurement section in survey. These phases consist:

- *Aspect Categorization*: Survey consists of Overall Impression which aims to evaluate participants overall impression of IMM on eight different factors. Therefore a list of ten items has been created to cover different factors. Each aspect (see survey - section overall impression) has been identified for specific factors which listed as follows.

Table1. Data transformation from Aspects to Factors

# Number of Aspect	Targeted Factors
1	Understandability, Modeling Definition
2	Performance, Level of refinement
3	Level of refinement, Level of Maturity of Modeling
4	Modeling Definition, Level of Maturity of Modeling
5	Traceability, Understandability
6	Scalability, Public Usability
7	Modeling Definition, Level of refinement
8	Level of Maturity of Modeling, Traceability
9	Public Usability, Scalability
10	Performance - Public Usability

Participants selected among 3 choices the level that IMM Support the item. Since each item has defined to cover two or three factors, therefore participant's choice for an item be distributed for covering factors. The result is a list of factors and number of choices made by participants indirectly (through items).
- *Precise Data Selection*: to be able to build analysis based on precise data the need for data selection arises. In this phase by assuming 75% precision value, results evaluate and non precise data be omitted. This precision measurement applies for each case separately. It means the choice (among 3 choices) that has more than 75% selected by each team will be assumed as a precise selection of that team for the Factor. If a team has less than 75% selection of each choice for a Factor, that Factor assumed as no data from the team.
- *Concluding weakness points*: by analyzing the transformed data into one table indexed on Factors, the weakness points can be highlighted and discussed by 75% precision value.

3.4. Limitation of the study

This research is limited with certain numbers of case studies to accomplish IMM evaluation. Besides, number of companies is limited to one company in case assessment and one company in reviewing the IMM concept. Due to limitation of time for completing this research paper number of identified metrics and issues (which identified from relevant literature review) are limited for given survey. (See Appendix 1 – Survey)

4. Discussion

4.1. Innovation Maturity Model

IMM (Figure 1.-detailed view) consists of three phases with 6 segments. First phase is *Novelty assessment* which considers the idea to identify whether it is innovative or not. It aims to have an overall overview of innovation concept based on core idea. The second phase is *Innovation assessment*. This phase (through its 4 segments: Concept analysis, External factor analysis, Specification analysis, Development in market) utilize concept overview to categorize the innovation concept in order to create profile of the innovation. A profile includes specification of innovation and its target market. By analyzing the profile its purpose is to analyze characteristics and create a characteristics map of innovation. At the end of this phase positioning of innovation will be designed from characteristics map. The last phase is O*ptimization*. Within this phase, method used to improve the innovation in an approach that is addressed by suggestions based on the assessment of concept and its position found in last segment. And the iteration of improvement would be continued [7][15].

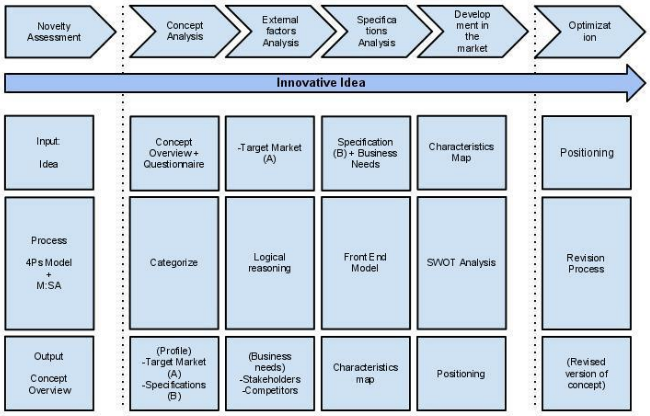

Figure 1. Detailed View

4.2. *Segment Evaluation Analysis*

Goals of this research are; first, what part of IMM needs improvement and second; in which way they needed to be improved.

The survey has been conducted for each segment on six metrics.

For this research desired precision value assumed 1. Therefore for each case, separately, the ranks that have the same value by both members and also ranks with 1 value differentiation have been selected as precise data. The average which has been calculated from data (see appendix 2 - segment result) for each segment separately in each metric show the prioritization for finding out the weakness points that needed improvement in next version of IMM.

Values below 3 are considered as Low. Values equal to or greater than 3 has considered as High. Values which do not have data from both cases and all participants have not been counted. Thus uncounted values marked with dash in the results. Table 1 shows the result briefly.

Table 2. Presice Result

	Novelty Assessment	Concept Analysis	External Factor Analysis	Specification Analysis	Development in Market
Quality	**H**	**L**	**H**	**L**	**H**
Improvement	**H**	**H**	**H**	**L**	**H**
Pro-activity	**H**	**L**	**H**	-	**H**
Flexibility	**H**	**L**	**H**	-	**H**
Speed	-	**L**	**H**	**L**	-
Profitability	-	**H**	**H**	**H**	**H**

Those values that ranked H in cells showed that there was efficient theory/method provided in each segment regarding that metric to accomplish required outcome

4.2.1. *Weaknesses in Metrics*

To understand the root of weakness in each segment there is a need to understand what the meaning is of to be Low in each metric.

According to definition of each metric, low rank for each metric has described as following;

Low in Quality: The process does not produce expected output.

Low in Improvement: The process does not lead the idea to product, service or any procedure.

Low in Pro-activity: The process does not help to predict new data regarding the idea

Low in Flexibility: The segment does not cover wide variety of different innovative ideas.

Low in Speed: Two root causes of low speed are; input preparation, and understanding and applying the process. Since input on each segment is part of output of other segment, the process description and applying time is assumed as main factors of Low rank in Speed.

4.2.2. *Reconciling Segment Parts with Metrics*

As it has shown in table 1, Concept Analysis segment and Specification Analysis segment are two segments in IMM that needs improvement based on studied cases. Dash lines in table 1 shows that data which the research has been collected (via survey) from the teams couldn't show precise result (either one team or both).Therefore it needs re evaluation.

In this part weak part of segments has been recognized based on Low marked metrics and segments' definition.

Concept Analysis: The process of Concept Analysis is categorizing the idea and producing output from Profile of each Category. Thus Low Quality which point out weakness in expected output. By studying output of this segment from participants it shows that description of each category's profile was not fully cover description of how to reach target market and specifications to shape the Innovation Profile as segment output. Thus the weak point is the profile description on target market and specification.

Low rating on pro-activity for this segment, Concept Analysis, clarify that the output of this segment does not contain anticipatory information or data. Therefore category profiles are weak on providing anticipatory parameters as part of target market or idea specification.

Concept Analysis categorizing allows to categorize the idea among four predefined categories. Low value in Flexibility metrics which means not covering variety of different ideas shows that these four categories does not cover wide variety of ideas.

In Concept Analysis segment, there are descriptions for each category to make team members be able to assay the idea and realize which category match the idea. By rated Low the Speed metric on this segment, it shows that the description of categories are not well described, based on Low Speed description in 4.2.1.

Specification Analysis: Specific Analysis segment uses Front End Model for process the segment's input and produces Characteristics Map as output. Low rate in Quality shows that the weak point in this segment placed at definition of Characteristics Map, which is not clear.

In this segment of IMM, Specification Analysis, Front end model simply compares the innovative idea's specification with stakeholder needs and competitors' specifications. The result of this process is a list of all characteristics regarding the idea whether exists or not exists in the specification, stakeholder needs, and competitors'. By studying characteristic maps that participants from 2 studied cases generated, it shows that they have not created characteristic map instead another version of specifications. This shows that Low rank on Improvement metric for this segment comes from misunderstanding of characteristic maps definition. Thus definition of characteristic map is a weak point in the Specification Analysis segment.

Low rank on speed metric shows that understanding of process, Front End Model, has taken more than expected time of participants. By reviewing comments on this segment it shows that time consumption on this segment is because of the nature of segment which involve with interviewing others involve with competitors and also interviewing stakeholders. Since the nature of the process is time consuming, the Low in speed on this segment can be not be considered as a weak point of IMM segment.

4.2.3. Segments Weakness Points

By putting all analyzed information from part 4.2.2 into a table (table 2) it shows that there are two types of weakness in this analysis; first, weakness in describing IMM segments and second, weakness in definition of segments.

Table 3. Weakness points

Segment	Part	Weakness Reason	Affected Metric
Concept Analysis	Profile	Not well described	Quality
		Does not produce anticipatory output elements	Proactivity
	Category	Does not cover variation of ideas	Flexibility
		Not well described	Speed
Spec. Analysis	Characteristic Map	Not well described	Quality
		Not well described	Improvement

Yellow rows in table 2 are de facto weaknesses of IMM and white rows are weakness in presenting, describing IMM. The result shows the main problem in IMM lies on Concept Analysis segment. This is from viewpoint of analyzing the model itself but not the way it has been described or documented.

4.3. Overall Analysis

In overall expression results from survey, each item has been designed to represent two or three Factors. By transforming results from Overall Expression Form to a list of Factors, table 3 has been generated.

Table 4. Categorized Result

Factors	#	Well Supported	Not Well Supported	Not Supported
Understandability	1,5	RRR	RBBBB	
Performance	2,10	RRRBB	RBB	
Level of refinement	2,3, 7	RRRR	RRBBBBBB	
Modeling Definition	1,4, 7	RRR	RRRBBBBB B	
Traceability	5,8	RRR	RBBBB	
Scalability	6,9	RRRRBBB	B	
Level of Maturity of Modeling	3,4, 8	RRRR	RRBBBBBB	
Public Usability	6,9, 10	RRRRRRBBBB B	B	

In this table, each red/blue block represents one participant answer to the overall expression result. For example; items number 1 and 5 are covering Understandability. Both participants from Blue team had answered both questions as 'Not Well Supported' therefore there are four answers on Understandability from team Blue. One participant from team Red has answered 'Not Well Support' on item 5 and 'Well Supported' for both item 1 and 5. The other member of team Red 'Well supported' on items, 1 and 5. Thus there are three red block on 'Well Supported' for Understandability to represent results. By assuming 75% precision value it is possible to remove non-precise results from table. This precision applies on each team separately to support differentiation of each case. For instance, on Public Usability team Red has 100% 'Well Supported' but team Blue has 83.3% 'Well Supported' and 16.7% 'Not Well Supported' so by more than 75% precision Blue team has 'Well Supported'. But in Modeling Definition Factor, Red team has 50% 'Well Supported' and 50% 'Not Well Supported' which does not satisfy our 75% precision assumption. Therefore this result has been omitted in shaping Table 4.

Table 4. Results

Factors	#	Well Supported	Not Well Supported	Not Supported
Understandability	1,5	Red Team	Blue Team	
Performance	2,10	Red Team		
Level of refinement	2,3,7		Blue Team	
Modeling Definition	1,4,7		Blue Team	
Traceability	5,8	Red Team	Blue Team	
Scalability	6,9	Both Teams		
Level of Maturity of Modeling	3,4,8		Blue Team	
Public Usability	6,9,10	Both Teams		

Table 4 shows that Overall Expression Factors of IMM can be divided into 3 categories. Green cells shows that Scalability and Public Usability in IMM is Well Supported. White and yellow cells show factors which are not 'Well Supported' or 'Not Well Supported' by absolute majority of participants. But whole table shows that none of factors has been marked 'Not Supported' by any participants at all.

5. Conclusion

The research starts to approach the research question of what are the weaknesses of the initial version of IMM in real projects within the software industry.

By designing an evaluation framework and using feature-based evaluation method, the authors' intent to apply two cases from selected contributors to IMM by two different teams. The result of their measurement has been gathered from a designed survey. Afterwards results formalized as data for further analysis by the researches.

After analyzing the data in two different dimension; segment analysis and overall analysis findings showed that in segment analysis, 'Concept Analysis' identified as the weak point; 'Profile' part of segment process does not produce anticipatory output elements and 'Categories' does not cover variation of ideas. The overall analysis showed that none of the factors identified as 'Not Supported' and two factors, Scalability and Public usability, have identified as 'well Supported' by absolute majority. These factors show the overall capability of IMM in industry.

6. Future Work

Despite this fact that more cases in software development are needed to assess by the IMM and their overall impression could be an area to future research in this domain but we want to propose a roadmap to follow this research by considering the IMM segment by segment. The future research can measure each segment and suggest an enhanced process and metrics at the end which lead to a new version of IMM that can increase its strengths significantly. The framework also could be applied in different software development projects in wide variety of areas from IT industries to smart transport systems and even in Machine Learning [16] and Neural Network projects [17].

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