Needs Oriented Framework for Producing Requirements Decision Material - NORM

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Abstract

The need of understanding and supporting requirements engineering decisions in market-driven product development is motivated by the complexity and economical impact of these decisions. While being a key for success, correct and timely decisions are dependent on the availability and the quality of decision material (requirements, business cases, cost-value estimations etc). This paper presents a needs-oriented framework (NORM) for identifying and assuring the creation of appropriate decision material for RE decisions. NORM is based on analysis of the applied RE process and characteristics of separate RE decisions, focusing mainly on pre-project activities. The framework is developed in close cooperation with industry with the intention to ensure that resources are spent on producing just-the-necessary information at the right time and to be able to monitor and control this production effort.

1. Introduction

Requirements engineering (RE) is a decision rich activity, and RE decision support as a field has received increasing attention as RE for market-driven product development (further on referred to as MDRE) has gained ground [1-8]. Many sources report on decision making in RE and motivate the importance of proper decision support, especially in MDRE.

Decision making in MDRE is considered to be complex, even described as a so called "wicked problem" [1]. In addition, the complexity of pre-project decisions is not made easier as they are often based on high-level abstract requirements and uncertain estimates [2]. When it comes to correctness of pre-project RE decisions in market-driven environments evidence suggests that only 25-50% of decisions regarding requirements selection are correct [3].

Decisions are based on underlying information - decision material, and the quality of a certain decision is largely dependent on the quality (completeness and correctness) of the provided decision material [4].

Decision material for MDRE decisions can be seen as a collection of requirement descriptions together with accompanying information such as requirement business value or cost and effort estimations connected to a specific requirement [5, 6]. Because of the economical impact of RE decisions for companies practicing market-driven development [7], appropriate contents and level of specification of RE decision material is especially important. Acquiring appropriate and high-quality decision material is associated with costs of analyzing pre-project requirements, meaning that a company needs to take a risk by investing in analysis of the requirements that might not be implemented in the end. Thus in this situation the challenge is to find a good-enough quality level of the decision material which can be acquired within the allowed budget for the pre-project decisions.

Traditional requirements engineering practices and frameworks for defining a process that produces high-quality requirements, such as CMMI, provide limited help for companies practicing market-driven development since they are not designed to consider the characteristics of MDRE [8-10], or to cater for information needs and constraints of pre-project decisions common to MDRE [11]. For example, when performing initial selection of pre-project requirements it is not feasible to achieve classical requirements quality goals (unambiguous, clear, detailed and verifiable) due to the large volume of incoming requirements. Moreover achieving these quality goals may not be necessary for the purposes of initial requirements selection. At this stage a high-level

requirement formulated in such a way that it clearly shows the business value and potential benefits may be all that is needed.

This paper presents a requirements engineering framework called NORM (Needs Oriented framework for producing Requirements decision Material). NORM is developed in close cooperation with industry. NORM aims to assist companies in finding appropriate level of detail of decision material for pre-project RE decisions by providing a framework for capturing needs and constraints at different decision points. The paper is structured as follows: Section 2 provides a short background of MDRE. Section 3 introduces NORM and its steps. Section 4 provides details on NORM initiation and usage and finally in Section 5 we discuss NORM and conclude the paper.

2. Background and Challenges - MDRE

Studies of companies practicing market-driven software product development have shown that while there are similarities between bespoke and market-driven RE practices, there are some critical distinguishing factors that make MDRE even more complex [6-8, 12].

In typical market-driven software development the development organization is the main stakeholder and owner of the developed product(s). The product evolves over time and new functionality is added and offered to the general market through consequent product releases. In this type of development the development organization takes all risks and is responsible for development costs of the product. Delivering the right set of functionality when the market is ready for it is critical for the success, and profit is measured in terms of e.g. volume of sales, market share, and product reviews. As illustrated in Figure 1, market-driven development is largely product focused and many important activities are performed prior to the initiation of the development projects (i.e. pre-project). The goal of pre-project activities is to catch, analyze, select and plan requirements for future releases of the product. Pre-project activities should result in a prioritized list of requirements that are assigned to a specific release. These requirements are then realized through one or several development projects [13-16].

Pre-project decisions in market-driven product development are often perceived as very complex. This complexity is explained by large volumes of requirements that need to be considered, a variety of different criteria that need to be taken into account before a selection of the requirements can be made, as well as the challenge associated with taking decisions based on the uncertain decision material such as uncertain cost and value estimations [2, 7, 12, 17, 18].

The importance of correct decision making pre-project is acknowledged and highlighted by both industry and academia [6, 7, 12, 14, 19] , however the question of how to best support pre-project decisions and how to find appropriate level of analysis without risking wasting effort on large number of candidate requirements that will not be included in a product remains open. The framework described in this paper addresses this problem by suggesting a structured, step-by-step approach for identifying appropriate decision material for pre- project RE decisions.

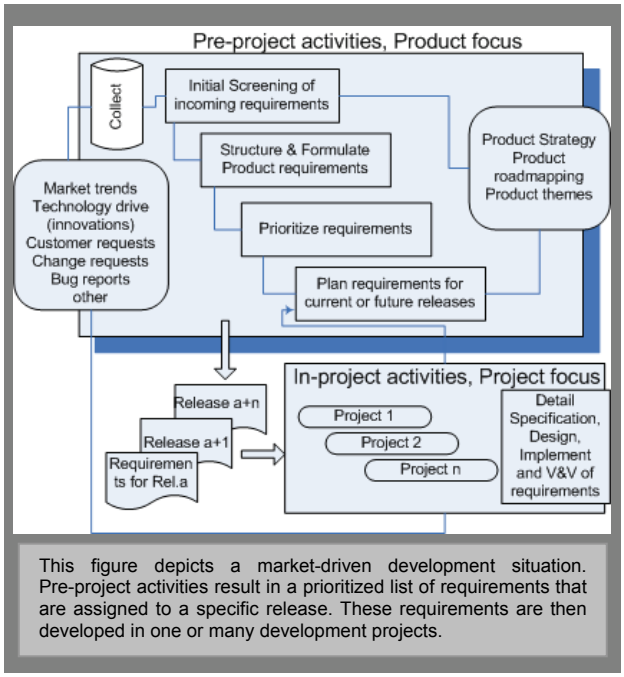

Figure 1.Overview of market-driven software product development process

3. Needs Oriented Framework for Producing Requirements Decision Material (NORM)

NORM was initially formulated in collaboration with Ericsson AB in Karlskrona, Sweden. Ericsson is one of the world's leading companies in the telecommunication business providing a wide range of products and solutions. The company operates in a market-driven context where the products are sold as generic solutions offered to an open market, although customized versions of the products are also developed and sold to key customers.

The research methodology behind the development of NORM framework has closely followed the model of technology transfer between academia and industry suggested by Gorschek et al [20]. Figure 2 presents an overview of the process. Steps 1-4 are already finalized, whereas steps 5 and 6 are in the planning stages (future work).

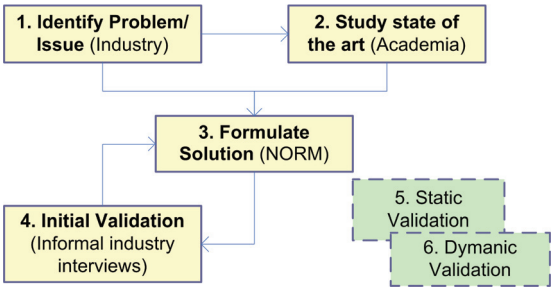

Figure 2. Applied research methodology

The initial problem was identified through discussions with, and assessments at, Ericsson, where the issue of knowing the appropriate level of analysis of pre-project requirements, and finding a good-enough level and detail of requirements and their specification was highlighted. The study of state-of-the-art indicated that while the identified problem was relevant in the MDRE context (see Section 2), existing RE models for decision support in MDRE ([4, 5, 18, 21]) do not directly address the problem of finding just-the-necessary decision material for pre-project decisions. This motivated the formulation of the NORM framework.

NORM aims to help companies both to identify important pre-project decisions that involve requirements analysis, as well as specify the Appropriate Decision Material (ADM) for each decision. ADM defines appropriate contents and level of detail of decision material. It also defines reasonable amounts of effort that can be spent on requirements analysis prior to each decision.

One of the main ideas behind NORM is to involve and use the experience of professionals and experts at the company who work daily with pre-project RE decisions. In this way NORM is using an inductive approach, allowing practitioners to use their expertise and knowledge in order to identify ADM of the practiced decisions. NORM utilizes the following roles: *Decision Makers* and *Decision Material Provides*. A *Decision Maker* is a person who takes a decision and is responsible for the outcome of a decision, for example a product manager. A *Decision Material Provider* is a person who provides information that a decision is based on, for example system expert or a business analyst.

NORM consists of two stages. The first stage is concerned with the identification of pre-project RE decisions and their characteristics. The second stage analyses the identified characteristics of a specific decision in order to define appropriate decision material - ADM for it (see Figure 3). In the following sections we go through the steps of NORM in further detail.

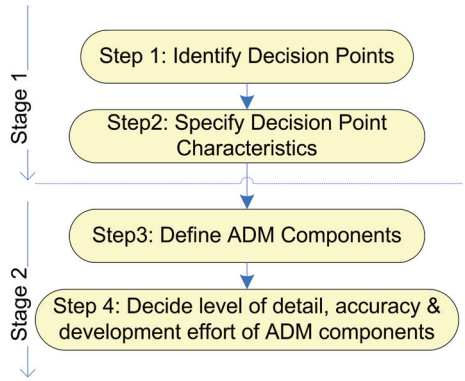

Figure 3.NORM steps

3.1. Identify decision points (Step 1)

In NORM RE decisions are represented by different decision points, which occur at certain points in time. Decision points can be identified via analyzing the actual process used and isolating major pre-project steps, milestones etc. For example for a company practicing a MDRE process descried in Figure 1 the following decision points can be identified: Initial Screening, Prioritization and Release planning (see Figure 4). These decision points are quite generic since they are identified based on generic MDRE process as described in literature [6, 7, 12, 14, 19].

Step 1: Identify Decision Points
Focus: Major decisions **Sources:** Process analysis and interviews of the practitioners
Example: Initial Screening, Prioritization, Release Planning

Figure 4.Identifying decision points

Analysis of a pre-project RE process of a specific company may result in different decision points having different granularity and character. The general guideline though is to focus on major process steps and decisions since identifying micro decisions may require much effort. The decision points that are identified through the process study should be communicated to the practitioners in order to 1) Confirm the correctness of a selection; 2) Appoint

relevant persons that can take on a role of *Decision Maker* or *Decision Material Provider* in the following NORM steps.

3.2. Specify decision point characteristics (Step 2)

In the second step, the characteristics of the decision points are captured through the attributes: *decision purpose*, *decision criteria* and *constraints*.

Decision purpose: This characteristic describes the ultimate goal of a decision. Information about this attribute is obtained from two different sources: *Decision Makers* and *Decision Material Provider*. Identifying the decision point goal from these sources allows establishing that the Decision Maker and Decision Material Provider have the same understanding of the decision point. Figure 5 provides an example of how a decision purpose can be formulated in case of "Initial Screening". This decision point and definition of its goal is based on the current understanding of pre-project MDRE steps in literature [7, 10, 12, 15, 22] and will be used as a working example illustrating NORM steps through the paper.

Step2: Specify Decision Point Characteristics		
2.1 Decision Purpose	**2.2 Decision Criteria**	**2.3 Constraints**
Decide which of the candidate requirements are interesting enough to consider for further analysis	- Alignment with product strategy - Expected benefit of a requirement (value vs. cost)	- **Max-Effort**: 10% of available yearly burget for pre-project activities - **Requirements Volume:**150-200 Requirements in 6 months - **Req. Specification state:** Mostly feature level
Sources: Decision-Makers and Decision Material Providers		

Figure 5.Example of specifying decision point characteristics

Decision criteria: This characteristic intends to capture the applied approach for taking a decision, which in turn forms a ground for identifying information need of a decision. In NORM the specifics of an applied decision approach is collected from *Decision Makers*. For example as shown in Figure 5 for decision point "Initial Screening" only requirements that provide higher value than implementation cost and requirements that are aligned with the product strategy will be selected. A decision criterion is thus the following: 1) Alignment with product strategy (defines a future direction of a product, which areas are considered important, etc); 2) Expected benefit of a requirement defined as a balance between value provided by the requirement (for example expected sales, revenue or cost savings provided by a requirement) and cost associated with implementation of a requirement.

Constraints: This characteristic helps in establishing realistic expectations and identifying an appropriate level of detail of decision material contents. As shown in Figure 5, NORM considers the following constraints: *Maximum Allowed Effort* for analyzing candidate requirements in pre-project stages (further on referred to as *Max-effort*), *Requirements Volume* and *Requirements Specification State*. *Max-effort* refers to the limitation based on budget considerations and describes how much a company can or is prepared to invest in the candidate requirements that may or may not be included in a certain product release. *Requirements Volume* represents the average number of requirements that are considered at a decision point within certain period of time, for example within a month, quarter or a budget year. It places limitations on how much analysis can be done per requirement. *Requirements Specification State* describes abstraction level of the requirements. This constraint affects how much analysis a requirement will require and places limitation on how many requirements can be considered within the defined *Max-effort* (for example abstract or high level requirements may require more technical investigation than requirements that are on functional level and are clearly described [18]).

3.3. Define ADM components (Step 3)

In this step the goal and decision criteria of a decision point as defined in Step 2 are analyzed in order to define ADM components. ADM components describe what type of information has to be available prior to a decision.

Step 3: Define ADM Components
Component type 1: Requirement Description **Example:** The system should provide real-time performance monitoring functionality
Component type 2: Requirements associated items **Example:** Value analysis result; Cost evaluation result; Analysis of requirements alignment with product strategy

Figure 6.Example of ADM structure for "Initial Screening"

ADM consists of two types of components: the requirement description itself and requirements associated items. The later represents decision support material that is produced based on the description of

the requirement. This material can take the form of a short technical report (e.g. a pre-study), a cost and risk evaluation or a business case of marketing material testifying to the potential of a certain requirement. The exact selection of the associated material depends on the information needs of the decision point in question. For example in the case of the decision point "Initial Screening" the goal and decision criteria of this decision point (see Figure 5) indicate the necessity of the following associated items: requirements value analysis result, cost evaluation result and analysis of requirements alignment with product strategy (see Figure 6).

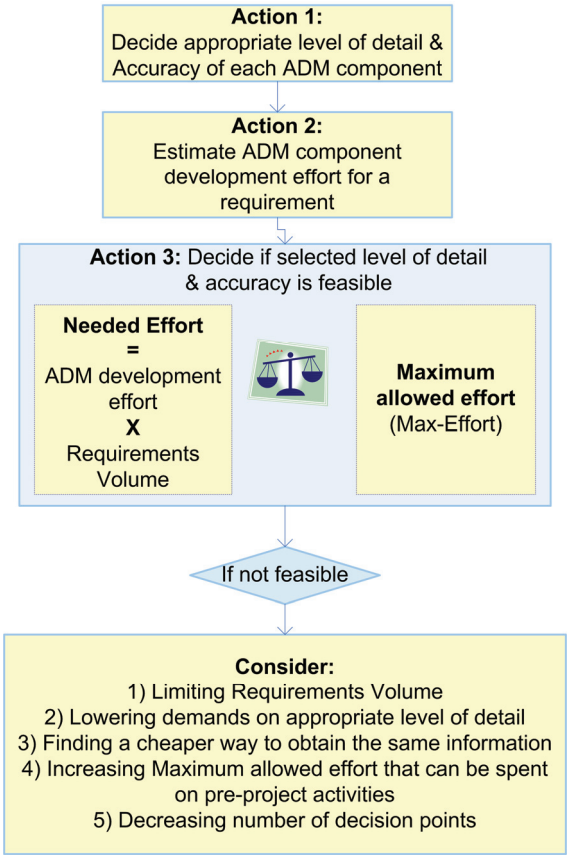

Figure 7.Overview of actions in Step 4

3.4. Decide level of detail, accuracy & development effort of ADM components (Step 4)

The goal of this step is to define an appropriate level of detail and accuracy as well as an appropriate development effort of ADM components of a certain decision point. Figure 7 provides an overview of actions required in this step. The sections below provide further information on each action.

Action 1: *Decide appropriate level of detail & accuracy of each ADM component:* In this action the decision makers are asked to identify the minimum required level of information detail and accuracy in each ADM component that will suit the information need of a decision point. This is achieved by comparing different pre-defined alternatives for each component and pinpointing the most suitable alternative(s). An example of pre-defined alternatives for cost evaluation is presented in Table 1.

Table 1.Pre-defined alternatives of information detail and accuracy for cost estimation

Cost estimation alternative	Associated technical analysis
Alternative 1: Cost estimate allows classification between High, Average and Low cost.	High level feasibility analysis defining requirements impact on existing product architecture and associated complexity.
Alternative 2: Cost estimation allows estimation between the intervals defined in person-hours. Example of intervals may be less than 1000 person-hours, between 1000 and 3000 person-hours and more than 3000 person-hours.	Identification of affected system parts and more detailed picture of associated complexity.
Alternative 3: Cost estimation allows defining a point estimate (for example 500 person-hours) with 80% accuracy.	List of possible solutions are defined allowing to choose the most suitable solution.
Alternative 4: Cost estimation of a requirement is not allowed to exceed a certain number, for example 200 hours and should be to 80% accurate.	Implementation proposal is available.
Alternative 5: Cost estimation of a requirement is not allowed to exceed a certain number, for example 100 hours and should be to 95% accurate.	Detailed design is available.

Table 1 provides different alternatives of cost estimations that are ordered according to how much detail and accuracy they provide. The first alterative provides least detail and accuracy while the last alternative offers most detail and accuracy. For each cost estimate alternative, Table 1 also provides information on extent of technical analysis that may be required in order to obtain the given cost estimate. The information on technical analysis should be used when estimating the average effort of conducting such analysis (see Action 2).

NORM intends to provide pre-defined alternatives for the level of detail and accuracy for cost estimation (as shown in Table 1) and value analysis of candidate requirements since these associated items are most common and widely used in pre-project RE decisions

[5] [21, 23]. These can then be used as a base to develop customized pre-defined alternatives that are suitable for the specifics of the applied process of a company using NORM.

In the case of decision point "Initial Screening" the usage of pre-defined alternatives may follow the following scenario: In order to identify the appropriate level of detail and accuracy of cost estimations, the decision makers consider the alternatives presented in Table 1. The goal is to select the alterative that will require least effort but will still provide good-enough decision material for them. For example decision makers may reason that alternative 2 from Table 1 will provide them with good-enough information to conduct comparisons between value and cost of candidate requirements and thus determine expected benefit of a requirement as required by the decision criteria described in Step 2.

Action 2: *Estimate ADM component development effort:* In this action the persons that are responsible for producing a specific ADM component (Decision Material Providers) are asked to estimate the required effort of developing the ADM component according to the selected pre-defined alternative per requirement. This estimate is based on the Decision Material Provider's experience. The estimate is supposed to consider the *Requirements Specification State* constraint defined in Step 2 of NORM, since the abstraction level of a requirement may affect the required effort for producing decision material [18]. For example in the case of decision point "Initial Screening" the ADM production effort estimate should take into account that according to the characteristics of this decision point most of the requirements prior to taking a decision are on a feature level. ADM development effort is measured in person-hours.

Action 3: *Decide if selected level of detail & accuracy is feasible:* In this action the estimate for ADM component development effort that was obtained in the previous action is multiplied with the average number of requirements at a decision point defined in the constraint *Requirements Volume* (see Step 2). The obtained figure is then compared with the maximum allowed effort defined by the constraint *Max-effort* (see Step 2). This comparison allows deciding if the selected level of detail and accuracy of an ADM component is feasible or not (see Figure 7).

In case developing ADM according to the selected pre-defined alterative is not feasible NORM helps decision makers to find a consensus by means of considering alternative solutions. Alternative solutions may be to 1) limit the requirements volume by only considering part of requirements 2) lower demands on appropriate level of detail and accuracy 3) find a way to acquire the same information with less effort 4) increase Maximum allowed effort that can be spent on pre-project activities or 5) make changes in the process in order to lower the number of decision points pre-project, since a large number of decision points might create an overhead. For example if for the decision point "Initial screening" the selected pre-defined alternative for the cost estimation (alternative 2) turns out not to be feasible, then the Decision Makers and Decision Material Providers can discuss of it is possible to use alternative 1 from Table 1.

4. Initiation and usage of NORM framework

This section elaborates on how to initiate NORM and discusses the possible usage scenarios of NORM framework.

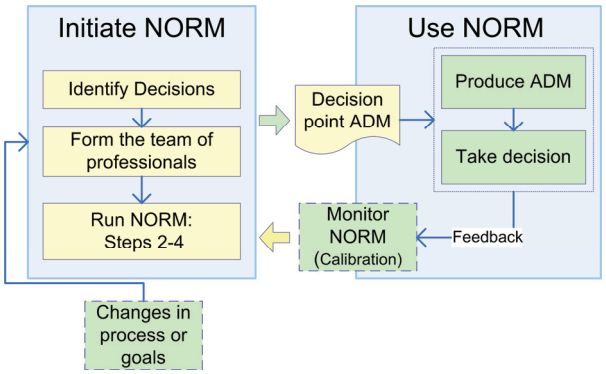

Figure 8: Initiation and usage of NORM framework

4.1. Initiating and executing NORM steps

Initiation and execution of the NORM steps requires some initial preparation, such as identifying which decision points should be studied and assembling the team of professionals consisting of Decision Makers and Decision Material Providers. The steps of specifying the characteristics of identified pre-project decisions (Section 3.2) and formulation of decision ADM (see Section 3.3 and Section 3.4) should be conducted in a workshop allowing discussion and exchange of ideas between the Decision Makers and Decision Material Providers.

As mentioned previously the main goal of NORM is defining ADM of pre-project decisions, however initiation and execution of NORM steps may generate positive side effects. For example the structure for describing characteristics of decision points used in NORM enables comparison of decision goals and applied criteria, thus verifying that the applied criteria

matches the goal of a decision. NORM is also expected to facilitate finding consensus and improved ways to meet the goals and needs of different pre-project decisions. As shown in Figure 7 NORM helps to identify any misalignment between the needed ADM production effort and the effort that is allowable based on constraints of the process applied at the company and then facilitates finding consensus by providing different alternatives.

4.2. Using and improving NORM results

The obtained results from execution of NORM steps have a twofold usage. Firstly NORM via ADM provides a clear guideline on appropriate detail and accuracy of the information that should be provided for the decision makers as well as provides recommendation on how much effort is appropriate to spend on production of the specified ADM. Secondly NORM provides a possibility to monitor and compare how well the prescribed levels of information detail and accuracy as well as allowed effort are kept in reality. This type of comparison may help in identifying bottlenecks in the process caused by misinterpretation of decision needs or existing constraints and allows tuning of process performance as well calibration of the information in the NORM model. For example, if after running NORM steps for the first time, ADM of a decision "Initial Screening" prescribes to spend not more than "x" hours on analysis of a requirement and in reality analysis of requirements in average takes more than "x" hours this will indicate that the initial estimation of ADM production effort was too optimistic and needs to be calibrated. Calibration of the variables in estimation models based on experience is a known technique and is aimed at improving estimations over time [24]. The comparison of ADM production effort with effort that is spent on developing ADM in reality will also help to pinpoint requirements types that require higher than usual analysis effort and will thereby identify the complex parts or possible bottle-necks in the decision making process. Once the complex parts are identified the companies can start working on ways to decrease the complexity or in cases where this proves impossible, offer more support and resources for the process and decision point.

Figure 8 provides an example of how NORM is intended to be used over time starting from its initiation. As shown in the figure, updating information in NORM is necessary over time and is usually triggered by changes in the applied process (for example changes in the characteristics of decisions) and a need to calibrate NORM recommendations based on the feedback and experience of using these recommendations in practice. Updating and calibrating information in NORM requires re-running of NORM steps in order to produce better ADM recommendations. How often NORM needs to be executed depends among other things on the stability of the process and development environment of a company. The recommendation though is to run NORM every half year to make sure that ADM recommendations are up-to-date.

5. Discussion and Conclusions

The development of the NORM framework was triggered by the need for correct and timely RE decisions pre-project, identified both through the collaboration with our industrial partner (Ericsson AB) and studies of the characteristics and challenges of companies practicing market-driven RE reported by other researchers [1, 3, 12, 25]. NORM contributes by means of identifying and studying the characteristics of RE decisions, thus increasing the understanding of the area, and providing a framework for defining appropriate decision material (ADM) for RE decisions in a market - driven environment. NORM also provides a possibility for defining and monitoring ADM production effort.

The concept of ADM is central in NORM as it is connected to scalability of the RE decision-making process. Producing "perfect" decision material for all requirements early would overload a company receiving large quantities of requirements; on the other hand a bare minimum might not be appropriate either. In NORM the balance of good-enough is represented by ADM and is maintained through the identification and careful study of the characteristics of RE decision points. In order to achieve maximal alignment between ADM and the specifics of the applied RE process both the information needs of a specific decision point, and constraints of the surrounding process are considered.

To the best of our knowledge, NORM is unique in focusing on the appropriate decision material (ADM) for RE decisions and ADM production effort. There exist several RE models that in one way or another provide support for the market-driven decision making process by suggesting solutions for some of the market-driven RE challenges and/or increasing the knowledge of market-driven RE and associated decision making processes [4, 5, 18, 21]. However, none of these models focuses on definition of appropriate effort for producing ADM of pre-project decisions.

The development and evaluation of NORM and the concepts presented in this paper is an ongoing activity

and both static and dynamic validation is planned and under execution in collaboration with industry. The intention of the validation is to assure usability and usefulness, but also scalability and industry relevance.

The initial evaluation of NORM concepts has been conducted via informal interviews with practitioners at Ericsson AB (see step 4 in Figure 2). The purpose of these interviews was to present NORM and receive initial feedback without actually executing the NORM steps. In total 4 interviews were conducted where people from product management and quality assurance organizations were interviewed. The feedback on NORM model was positive and most of the interviewees felt that the provided structure of describing decisions and steps of identifying ADM was useful.

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