Groupware Support for Requirements Management in New Product Development

By

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Outline

- The importance of Requirements Management and Requirements Management Systems (RMS) in multi-site product development
- Building an information systems design theory for RMS
  - Characteristics of design theories
  - Meta-requirements for RMS
  - Meta-design for RMS
  - Empirical validation of the meta-requirements and the meta-design of the design theory
- Conclusions and Future Research

Characteristics of software-intensive high technology businesses

- Pressure towards shorter time-to-markets
- Increasing complexity of product designs
- Globalization of markets
- Fierce competition
- Continuous price erosion

Business goals of software-intensive high technology businesses

- Companies need to
  - shorten the cycle time of new product development (NPD)
  - improve product quality
  - target the right markets with the right products and
  - maintain or reduce the amounts of total resources required
- in order to become
  - major players in the markets
  - highly profitable

Effective requirements management is key for achieving the goals

- Success depends on how extensively and effectively the companies collect, analyze, and utilize requirements in their product development
- Especially during the earliest phases of new product development (NPD) different stakeholders need to synthesize their expertise in order to develop a credible product definition

Requirements management (RM) and NPD

RM processes are concerned with

- systematic collection of information about customer needs, technical constraints, and other issues which need to be accounted for in product decisions
- refinement of such information into product concept representations suitable for systematic evaluations within the NPD organization
- preparation and recording of product decisions as part of the earliest milestone reviews in product development
Challenges in reaching an agreement about the product definition

- The development activities in global companies are typically scattered across multiple sites
- Face-to-face meetings are hard to set up
- Spontaneous socialization among people from different sites is hampered
- Differences in incentives and organizational culture
- Divergent perceptions about the marketplace and the product’s mission
- Different professional backgrounds and knowledge (e.g., marketing vs. engineering)

Why Requirements Management should be supported with RMS?

- The need to establish good communication and collaboration patterns between different functional groups is often highest during the creation and analysis of requirements
- This “fuzzy front end” of NPD offers the largest and cheapest opportunities to shorten the development cycle and improve product quality

Why Requirements Management should be supported with RMS?

- Many of the problems during the later phases of the product life-cycle, particularly in terms of additional effort, are caused by
  - fluctuating and conflicting requirements
  - communication and co-ordination breakdowns
- Systematic work flow and visibility of the process is needed to eliminate information gaps
  - Linking of requirements and features
  - The system level requirements need to be traced in a centralised place

Groupware technologies as the knowledge management platform of RMS

- The progress of enterprise-wide groupware technologies offers new possibilities for
  - the creation and sharing of requirements knowledge in geographically distributed environments
  - Communication, coordination, and collaboration, thus increasing the productivity of knowledge work
  - redesigning NPD processes (e.g., increasing customer orientation by making R&D designers aware of customers’ use contexts and needs)

(Re)Designing the requirements management process with RMS


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How can corporations design and use RMS for requirements management?

- Little theory-based guidance is available to help design groupware-based requirements management systems (RMS) for large geographically distributed organizations.
- This research draws on literature and experiences from large-scale distributed industrial development projects at Nokia to facilitate RMS-enabled process development in order to meet the business goals.

Research methods for building the RMS design theory in Phase I:

- Literature review: Meta-requirements and kernel theories
  - NPD & Requirements Engineering
  - Organizational Memory, that is, “the means by which knowledge from the past is brought to bear on present activities, thus resulting in higher or lower levels of organizational effectiveness” (Stein & Zwass, 1995, p. 89)
  - Computer-Supported Co-operative Work

Research methods for building the RMS design theory in Phase II:

- Phase II (1998-2000)
  - A follow-up study at five business units of Nokia was conducted to validate and refine RMS and to assess empirically the implications of RMS on the RM processes.
  - 30 people were interviewed including product and marketing managers, R&D engineers, and managers, and groupware and information management specialists.
  - This phase was conducted over a one-year period when RMS had been introduced in about 15 product lines at Nokia.
  - Grounded theory analysis of collected data.

Building a design theory for RMS:

- Design theories, unlike other theories, support the achievement of goals.
- An information system design theory (ISDT) is “a prescriptive theory based on theoretical underpinnings which says how a design process can be carried out in a way which is both effective and feasible” (Walls, Widmeyer, and El Sawy, p. 37)
Building a design theory for RMS

- This research serves as the first stage in building an ISDT for RMS in NPD organizations
- The design theory answers the following questions:
  - What are the necessary and sufficient properties of RMS?
  - How RMS should be designed and aligned with the RM processes of large high-technology companies to best achieve the business goals?

Contributions of this research

- The main contribution of this research is the building of the ISDT for RMS through:
  1. the creation of a generic set of meta-requirements for RMS
  2. the development of the RMS meta-design, and
  3. the empirical validation of the meta-design by analyzing instantiations of the design at various product-lines of Nokia

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Characteristics of Design Theories

- Design theories have several distinct characteristics that differentiate them from other theories:
  1. They must deal with goals as contingencies
  - For example, the ISDT for RMS states that if the business goals (shortening the cycle time of NPD while improving product quality, targeting the right markets, and maintaining or reducing the total resources required) are to be achieved, then RMS should be designed and used to redesign the RM processes
  2. They prescribe both the properties an artefact should have if it is to achieve certain goals and the method(s) of artefact construction
  3. A design theory can never involve pure prediction or explanation
  - For example, the ISDT for RMS explains what properties RMS should have and how RMS should be built and predicts that an RMS will achieve its goals (i.e., supporting the attainment of the business goals) to the extent that it possesses the properties and is built using the methods prescribed by the theory
  4. They are prescriptive, composite theories integrating explanatory, predictive, and normative kernel theories from natural and social sciences and mathematics into design paths that realize more effective design and use
  5. They involve both the application of scientific theory to design artefacts and the use of the scientific method to test design theories (usually by building and testing the artefacts empirically)
Characteristics of Design Theories

6. Design theories tell “how to (achieve the goal)/because” whereas explanatory theories tell “what is”, predictive theories tell “what will be”, and normative theories tell “what should be (the goal)”

Example of a traditional theory

- For example, a theory about the role of RMS champions might be devised stating that NPD organizations aim at improving communication, coordination, and collaboration by means of leveraging RMS and hypothesizing that NPD organizations with powerful RMS champions are more likely to achieve this goal.
- The purpose of the theory is not to achieve the goal but to predict that goal achievement is more likely when a certain condition (powerful RMS champion) is met.

The structure of an IS Design Theory: the design product

- An ISDT must have two aspects: the product and the process of design.
- The product aspect has four components:
  - Meta-requirements describe the class of goals to which the theory applies.
  - Meta-design describes a class of artefacts hypothesized to meet the meta-requirements.
  - Kernel theories are theories from natural or social sciences and mathematics governing design requirements.
  - Testable design product hypotheses are used to test whether the meta-design satisfies the meta-requirements.

The structure of an IS Design Theory: the design process

- The process aspect has three components:
  - Design method describes procedures for artefact construction.
  - Kernel theories of the design process aspect are theories from natural or social sciences governing design process itself.
  - Testable design process hypotheses are used to verify whether the design method results in an artefact which is consistent with the meta-design.

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Meta-requirements for RMS

- Most meta-requirements for RMS (e.g., supporting bi-directional traceability) are derived from the RM process and the NPD process as a whole.
- Some meta-requirements may be derived from (systems) product domains.
- Meta-requirements for RMS should thus integrate systems and software engineering help RMS designers understand RM in a holistic product development context help build a common language so the RMS designers can communicate with RM specialists and other stakeholders involved with RM (e.g., testing).
Meta-requirements for RMS: factors of RM enabling and enabled by RMS use

- Clarity of the product development process (Paturle & Stevens)
  - Functional integration (Burchill and Fine)
  - Clarity of decision making (Kataki and Saleh)
  - Process participation (Burchill and Fine)
- Contextual awareness (Burchill and Fine)
- Traceability (Burchill and Fine)
- Measurement for process improvement (Paturle & Stevens)

Meta-requirements for RMS: Integrating the views of stakeholders

Meta-requirements for RMS: Product and organizational domain models

An Overview of a New System Product Development Process

Meta-requirements for RMS: Stakeholders and the RM process

Meta-requirements for RMS: From “Voice of the market” to product specification
Meta-requirements for RMS: Supporting both product and system product businesses

- High level user requirement

Meta-requirements from the perspective of organizational memory

- Products are delivered as incremental releases
  => Organizations can maintain information in RMS about the features that have been supplied in earlier releases or are planned for implementation in future releases
- Features are shared within product lines and across product subsystems of large systems products
  => Organizational memory in RMS is crucial for storing and sharing this knowledge

Meta-requirements from the perspective of design objective credibility

A framework for analyzing the Meta-requirements for RMS

<table>
<thead>
<tr>
<th>Meta-requirements for RMS</th>
<th>Communication</th>
<th>Control</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact</td>
<td>Development and application of domain models to support information sharing, storage, and retrieval across the units involved</td>
<td>Use of domain models in the allocation of responsibilities for the further processing of requirement information</td>
<td>Definition of interfaces to other RMS instantiations</td>
</tr>
<tr>
<td>Process</td>
<td>Enforcement of jointly approved milestones for workflow support</td>
<td>Separation of knowledge acquisition and decision making, Clarification of decision criteria and rules for applying the criteria</td>
<td>Enforcement of controlled procedures for the revision of domain models</td>
</tr>
<tr>
<td>Content</td>
<td>Adoption of standard representational schemes in the description of requirements</td>
<td>Accumulation of a full revision history with each requirement</td>
<td>Controlled introduction of revised guidelines for describing requirements</td>
</tr>
</tbody>
</table>

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Meta-design for RMS

Three-level processing from ideas into product/release requirements:

1. Collection/categorization of ideas/suggestions/requirements candidates
2. Analysis/evaluation/prioritization of product/release specific "customer" reqts
3. Selection/review of product/release specific "functional" requirements

RMS support for the five phases of requirements management

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture</td>
<td>The process of collecting new product ideas and requirements from relevant sources with minimal control on representation or content.</td>
</tr>
<tr>
<td>Categorization</td>
<td>The association of submitted requirements with appropriate context.</td>
</tr>
</tbody>
</table>

RMS support for the five phases of requirements management

<table>
<thead>
<tr>
<th>Document</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product idea</td>
<td>An expression of a customer need or some other desired property that may call for the implementation of a new or enhanced product functionality.</td>
</tr>
<tr>
<td>Feature proposal</td>
<td>A description of a product functionality, expressed in a detailed and unambiguous format to permit the making of a go/no-go decision.</td>
</tr>
</tbody>
</table>

The two-layered document structure of RMS

The generic template for a requirement in RMS (1/2)

<table>
<thead>
<tr>
<th>Class</th>
<th>Question</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>What is the requirement about?</td>
<td>Description Rationale</td>
</tr>
<tr>
<td>Origin</td>
<td>Where does the requirement come from?</td>
<td>Author Source Date of creation</td>
</tr>
<tr>
<td>Categorization</td>
<td>What parts of the product and the development organization is the requirement related to?</td>
<td>Traceability links Position in product structure (i.e., architecture) and associated organizational responsibilities Interfaces to other product lines</td>
</tr>
</tbody>
</table>

The generic template for a requirement in RMS (2/2)

<table>
<thead>
<tr>
<th>Class</th>
<th>Question</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>What are the implications of the requirement?</td>
<td>Status Priority Customer need Required work effort Risks</td>
</tr>
<tr>
<td>Workflow</td>
<td>What should be done to this requirement next? By whom?</td>
<td>Task description Assignments to persons</td>
</tr>
<tr>
<td>History</td>
<td>What has been done to the requirement? When?</td>
<td>Information about all prior edits, editors, and changes</td>
</tr>
</tbody>
</table>
Role, content, and process dimensions of information navigation

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Basis of information organization (Examples in italics)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Role</strong></td>
<td>The role in which the user interacts with the requirements database. (e.g., Requirements sorted by their author)</td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>Content-related assessments which have been made about the requirement. (e.g., Requirements sorted by their priority)</td>
</tr>
<tr>
<td><strong>Process</strong></td>
<td>Phase in the document life-cycle. (e.g., Requirements sorted by their review status)</td>
</tr>
</tbody>
</table>

Examples of metrics provided by RMS for process monitoring and redesign

<table>
<thead>
<tr>
<th>Type</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs</strong></td>
<td>How many new product ideas are being submitted monthly? What percentage of submitted requirements come from customers? Which functions in the NPD organization create requirements?</td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td>How many new feature proposals are produced and approved monthly?</td>
</tr>
<tr>
<td><strong>Involve-ment</strong></td>
<td>Which persons and organizations are the most active ones in requirement processing? How many weekly read and write operations are there? Who are the key persons in the requirements process?</td>
</tr>
<tr>
<td><strong>ROI</strong></td>
<td>How long does it take - on the average - to develop and approve specifications for a new product functionality? What percentage of suggested functionalities is approved (i.e., what is the decision yield)?</td>
</tr>
</tbody>
</table>

Which assessment and decision support facilities should be afforded by RMS?

- Formal evaluation approaches (e.g., QFD) help stakeholders examine how the individual requirements contribute to the objectives of product development
- But in a distributed organization, “lightweight approaches” may be preferred because
  * the amount of new data limits possibilities for using complicated procedures
  * the possibilities for organising meetings are limited
- => The RMS design does not impose formal evaluation practices

Finding the right people for requirements assessment

- RMS was coupled with an organizational model and adjunct databases containing information about specialists in, say, specific market areas or technical standards
- The meta-design of RMS thus provides a way of modeling “know-who”, which contributes to the visibility of knowledge and the extensibility of RMS

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Validating the Meta-Design of RMS

- Validation of an ISDT in an industrial context is very challenging
- Many factors influence the success of RMS
- The alignment of RMS and the NPD process is critically important
  - Success can be perceived due to RM process related factors even if RMS did not meet all the meta-requirements
  - Failure can result (although it is unlikely) even if RMS met all the meta-requirements
Institutional factors affecting the redesign of RM but not the ISDT for RMS

• Internal champion (Putlock & Stevens)
• Convincing the management and engineers about RM (Putlock & Stevens)
• Small pilot projects (Putlock & Stevens)
• Learning and education (Marshall & Chevallier)
• A good working atmosphere (Putlock & Stevens)
• External certification (Putlock & Stevens)

Institutional factors that affect the evolution and institutionalization of the new RMS-supported RM process but are beyond the scope of the validation of the ISDT for RMS

An inductive system diagram of the interactions of RMS with critical RM and NPD factors

- Diminished Pressure for Rash Progress
- Traceability
- Global Awareness of RM Process
- Usage of RMS adapted into the RM Process
- Commitment to the RM Process
- Depth of Analysis
- Competence of Decision Making Concerning Product Features
- Validity of Requirements Specification
- Understanding Feasibility and Resources
- Understanding Customer Needs
- Shortening of Product Development Time and Reduction of Development Costs
- Functional Integration
- Improvement of Customer Satisfaction

Validating the Meta-Design of RMS: Implications of RMS on RM

• RMS increased global awareness of the RM process, thus increasing commitment to RM
• An R&D specialist stated: “Before the introduction of RMS we did not have the requirements management process at all. ... Requirements were in mailboxes and desk drawers before. It is more controlled now we have groupware - we have visibility of the issues that are on the table.”
• A product manager stated: “The first thing is that all the people are committed to the RM process and the tool. ... We here in R&D can see that marketing people are inputting requirements all the time, that is, we trust that everybody are doing this and are committed to use it [RMS].”

Validating the Meta-Design of RMS: Implications of RMS on RM

• RMS increased functional integration of the RM process
• A marketing specialist stated: “Marketing people are located all over the world and they do not often know very well the organization and who is responsible for what. I believe that, for example, a person from Hong Kong, who stays here [in Finland] for a month in the beginning [for training] and then returns to Hong Kong, will not understand very well where to send the requirements. RMS solves such problems because the person simply needs to input the requirements and select the related areas [in product structure] from a list. Immediately when somebody responsible for the area has started working on the requirement, one can see the name of that person and know that the matter is being dealt with.”

Validating the Meta-Design of RMS: Implications of RMS on RM

• Improved traceability and functional integration led to better understanding of the needs of customers
• A senior marketing director stated: “We usually have a small team of marketing and R&D people that develop a common understanding of the product concept or feature and convince our top management that it should be implemented, but the developers will be people who are not directly involved in that front-end process. The biggest challenge is in communicating the original need and idea to those people that eventually start defining the specification and implementing the solution so that they really understand holistically why this is done and what need it should fulfill. After all, this communication will influence to what extent the solution will fulfill the original need and ideas. ... [RMS] helps also the decision making – the better the need, business idea, and solution are understood and documented, the easier the decision making.”

Validating the Meta-Design of RMS: Implications of RMS on RM

• The improved competence for and quality of decision making concerning product features leads to more valid requirements specifications
• This, in turn, reduces not only the product development times but also the costs
• An R&D specialist stated: “We have been metering these things [cases in which change requests are received before milestones E1, E2, and E3]. The later the change request comes, the harder the change and the more effort it requires. If we make a single change to the user interface, it requires that all the features must be tested – you can not just test the single feature...”
### Why the benefits from RMS were not fully achieved? (1/2)

- RM processes in some business units were unclear
- RMS was introduced in some units without adequate preparation
- Lack of commitment to use RMS
  - Many long-term benefits from RMS were not seen in the beginning of adoption
  - Benefits are hard to measure
- Lack of resources for
  - the full-time owner of the process and RMS
  - analysis
- Need for rich face-to-face communications

### Why the benefits were not fully achieved: Lack of commitment

- While the early adoption of RMS was almost trivial whenever there was a strong RMS champion, it was often extremely challenging and time-consuming to reach the stage of institutionalized use and the associated benefits from RMS
- A marketing specialist stated: “I use RMS very seldom. I just recently checked whether something has happened there, but not a lot, it has been quiet there. But there has not been an e-mail note either stating that use [RMS artefact] again ... you start to assume ... that unless there is some command about using a system, nobody else is going to use it anyway.”

### Why the benefits were not fully achieved: Lack of commitment

- The most notable challenge was that often requirements were not entered in RMS artefacts in the first place
- A senior marketing director stated: “Requirements that are surfaced during business negotiations and the decisions related to them do not always end up in our RMS. Such a requirement may already exist [in the RMS artefact] but it may not exist as well and then the approval of management can be sought even through direct phone calls. It is a business issue that in that stage we can make a positive decision and commit to implementing this and then a separate exercise is needed to find out how to fit the implementation in the [product development] schedule and so on. This can be done without the artefact, which of course is not necessarily good from the view point of the [NPD organization as a whole but from the view point of our business it can be necessary.]”

### Why the benefits were not fully achieved: Inadequate resources

- R&D people typically had a backlog of requirements to work with and inadequate resources for dealing with process development and new requirements
- The business people needed feedback quickly and did not see the point in entering requirements if there did not seem to be fast response. A marketing and sales specialist stated: “I want some indication whenever something is happening to a requirement I have entered. There should be some defined processing time in the process and the tool so you would have some deadline by which you could expect an answer. What is particularly unmotivating in requirements management is that you do not get any feedback. If you put something there, it will then just stay there.”

### Why the benefits were not fully achieved: Narrow RM scope of RMS

- Marketing people could also be left in the dark because RMS supported product development work only until the product features for the next release were frozen
  - Designers, implementers, and testers used numerous production tools in the later stages of product development but not RMS because it did not benefit them directly
  - Most tools were not integrated with RMS, so automatic status updates of requirement documents were not possible
- Customers and marketing could not trace through RMS what happened to their accepted feature proposals in the later stages of product development
Why the benefits were not fully achieved: Narrow RM scope of RMS

- Product lines emphasized the role of requirements specifications as a primary input for the later stages
  - Designers, implementers, and testers felt that all the necessary information had to be available in the specifications and did not consider the browsing of RMS databases very important
- This specification-centred view of product concept-related organizational memory guaranteed high usability and accessibility of limited aspects of the memory but was simplistic and reductionistic
  - For example, all relevant traceability related information could not be incorporated in specifications

Why the benefits were not fully achieved: Unclear and poorly coordinated RM

- Collaboration between marketing and product development was also hampered because RMS and RMS requirements databases were not shared adequately across product lines and BUs
- An R&D specialist responsible for requirements management in a product line stated: “Customer requirements are collected much too redundantly. Projects often collect the same things from the same customers. Whenever projects start, they send questionnaires to the customer interface, that is, sales asking what customer requirements there might be for such and such a product. The customer interface will get so many inquiries that they either do not care about those or respond very infrequently or give answers that do not have much relevance.”

Why the benefits were not fully achieved: Unclear and inadequately resourced RM

- Challenges in reaching the institutionalized use of RMS could be attributed to organizational issues, not to flaws in the design of RMS
- An R&D specialist stated: “The RM process has not been thought of a lot. Organizational structures tend to be such that no people can be found working full time in the RM stage. They [organizational structures] have been built so there is a project organization that at some stage starts to work on the requirements. Even the projects are in practise established when the RM stage has been completed. We should have full time people to manage RMS databases and do RM work in the front end and then also to work during the projects to update the RMS databases so we would know for each requirement that now this project has completed design, implementation, and/or testing of the requirement, or the projects should be made responsible for updating the status information in the databases.”

Why the benefits were not fully achieved: Need for face-to-face discussions

- A senior marketing and sales specialist stated: “Understanding of the domain of use cannot be conveyed through the RMS artefact. It is a very difficult thing to communicate through any literary way. Maybe the best way to facilitate the understanding of the domain and experiences of users is to provide people with an opportunity to meet the users and hear direct comments from them concerning the products in use or have direct feedback from them concerning new projects and their specifications. For example, busloads of mechanical engineers have been sent to see in what kind of environments those devices will be used and which practical problems exist. It should probably be done more systematically but of course it will be away from product development time so there has to be some sort of a compromise.”

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Conclusions

- Groupware-based RMS help
  - Capture the voice of the customer
  - Leverage global collaboration for improved product quality
  - Disseminate market and product knowledge
- Key ingredients in successful RMS deployment
  - Commit key stakeholders and set clearly defined targets
  - Agree on responsibilities and allocate adequate resources
  - Strive for clarity and simplicity of NPD
  - Prepare for the learning process and maintain the ability to adapt
  - Integrate RMS with all the relevant components of the IT infrastructure to provide an end-to-end support for NPD

Conclusions

- This research started to build an information systems design theory for RMS
- The meta-requirements and the meta-design of the ISDT for RMS (describing the class of RMS artefacts meeting the meta-requirements) were created
- They were validated by empirically analyzing instantiations of RMS in the multi-site product-lines of Nokia

Conclusions: Limitations of the Research

- The meta-requirements and the meta-design have been shaped by the demands at Nokia
- Some aspects of RM processes may have been emphasized while downplaying others potentially relevant in other NPD settings
  - For example, groupware support for synchronous remote interactions may be helpful but has not been addressed because the groupware platform did not support such interactions
  - Future research is needed to refine, generalize, and validate RMS in the context of an integrated IT infrastructure for NPD

Conclusions: Future Research on Kernel Theories

- Most meta-requirements for RMS are derived from RM processes
- Some requirements may be derived from (systems) product domains
- Kernel theories for RMS should thus
  - Integrate systems and software engineering
  - Place RM in a holistic product development context
  - Help RMS designers understand this context, and
  - Build a common language so the RMS designers can communicate with RM specialists and other stakeholders involved with RM (e.g., testing)

Conclusions: Future Research on Kernel Theories

- Process assessment and improvement standards and frameworks such as CMM-I meet these requirements for kernel theories
  - They are abstractions from the real-life practices of numerous organizations => Relevance
  - They help build a common language by integrating various supporting theories or management methods such as benchmarking, organizational learning, and total quality management
  - Their wide scope is a weakness from the viewpoint of RMS
  - They need to be complemented with more focused analyses of the earliest phases of NPD

Conclusions: Future Research on Kernel Theories

- Organizational memory construct is useful for designing RMS
- Theories drawing on social sciences play the most important role in the context of RMS
- Future research must analyze these and other kernel theories in depth to find out whether they pose new meta-requirements that could lead to the improvement of the ISDT for RMS
Conclusions: Future Research on Testable Design Product Hypotheses

- For example, the following hypothesis can be stated to test whether the meta-design satisfies the meta-requirements:
  - RMS artefacts will increase the depth of analysis of requirements (quality item)
  - improve the traceability of requirements (quality item)
  - reduce the cycle-time of new product development (time-related item)
  - increase the number of requirements the RM specialists can analyze in a given time (resource-related item)

- Further empirical research should study these and similar hypotheses in many different types of NPD organizations to refine and validate the ISDT so that it meets the business goals set for the theory.

Conclusions: Future Research on Design Methods

- RMS pilots were kept simple and robust and delivered to RM domain experts in the product lines in rapid cycles for fast feedback.
- Participative design (PD) improved quality of RMS, built organizational commitment to using RMS, and enabled product lines to gradually (re)structure their RM processes around the rules and resources afforded by successive RMS releases.
- PD could be relied on because most RM domain experts were IT-skilled engineers and also the marketing people were competent in leveraging the corporate groupware infrastructure.

Conclusions: Future Research on Design Process-related Kernel Theories

- Many IS development methods such as prototyping do not have explicitly specified kernel theories.
- The separation between kernel theories of design product and process is somewhat artificial.
  - Structural properties of RMS cannot be separated from the design processes that constitute the properties and the use processes that are constituted by and reconstitute the properties.
  - The kernel theories of product and process aspects need not be the same but they must be overlapping so the ISDT can be used to discuss, understand, and improve design and use processes employing (to the extent possible) the same terms and concepts.
  - Future research is needed to identify and further develop such kernel theories for RMS.

Conclusions: Future Research on Testable Design Process Hypotheses

- Providing an exhaustive list of design process hypotheses to verify whether the design method results in an artefact which is consistent with the meta-design has been outside the scope of this research.
- An RMS artefact satisfying the meta-requirements and the meta-design can be implemented relatively easily and in many ways.
- Organizational implementation of RMS to achieve the business goals is more challenging.
- The most important aspect of the design method is its ability to ensure that RM processes and RMS artefacts are successfully aligned and integrated.

Conclusions: Future Research on Testable Design Process Hypotheses

- Our participative design method worked relatively well in integrating business processes with RMS.
- Future research can experiment with the following and many other design process hypotheses:
  - The design (and associated change management) of RMS artefacts must satisfy both:
    - local requirements of business units to the maximum extent so that the unit-level buy-in is facilitated and
    - the meta-requirements and meta-design so that a corporate-wide, productized RMS solution can be obtained.
Discussion