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DEVELOPMENT OF A FRONT-END PROJECT MANAGEMENT TOOL FOR THE PRODUCT INNOVATION PROCESS

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1 Introduction

1.1 Situation

The fuzzy front-end of the product innovation process is often cited as the weakest point in the product innovation process [1,2]. This fact represents a tremendous opportunity for businesses to improve the efficiency of this process through the development of a tool which can guide a cross-functional, perhaps geographically dispersed, team through a more structured, yet creative, front-end process. The front end includes the identification of opportunities, the translation of the opportunities into ideas via idea generation and collection, the development of the concepts, and finally the realization of the concepts as plans for new product development [3]. The objective of the performing front-end analysis rather than jumping straight into product development is to reduce technical, budget, market, and schedule risks associated with new product development [4] and requires the involvement of marketing, R&D and manufacturing. The weak points of front-end practices range from company to company but include poorly documented and fragmented processes to instances of companies bypassing the phase altogether, which is a missed opportunity and leads to an inefficient product development phase. [1].

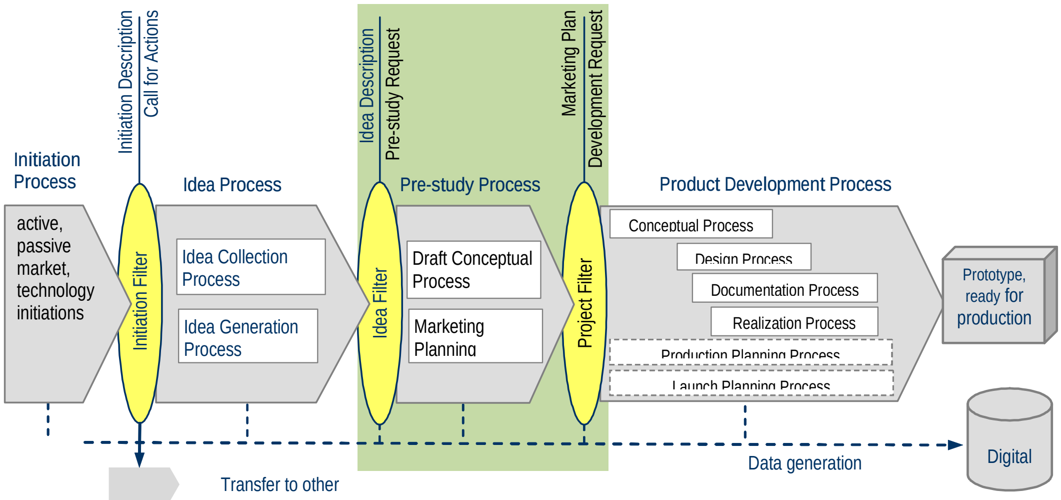

Figure 1. The Diagram of the processes that comprise the front end

1.2 Purpose of the Paper

The purpose of this paper is to represent a methodology for structuring of the front end to form a strong foundation for an efficient product development phase through front loading. To this end, a project management tool for the pre-study process of the front end was developed. The end product will be a customizable IT tool to guide companies through a front-loaded innovation development process.

1.3 Methods

First the tasks which comprise the front end were identified and categorized into sub groups. In this manner, a list of important tasks, as mutually exclusive and collectively exhaustive as possible was devised. Second, these tasks were clearly defined, in order to adjust for the lack of common terms of fuzzy front-end elements [3], and then structured with respect to the principal deliverables of the front end which serve as checkpoints. These deliverables include the product concept, product definition, and project plan documents [1]. Since inconsistent documentation is a common weakness of the front-end practices and documentation is essential for organizational learning and efficient communication across groups, these documents establish the basis for the structure of the tool. The identified tasks guide the conceptual development, from qualitative and speculative ideas into more quantified plans and resource requirement estimations, through the three checkpoints via iterations. A checklist tool was therefore created to better structure the tasks through these checkpoints. Subsequent to the task list creation, through the application of an activity-based design structure matrix (DSM), the chronology of the tasks was identified through the analysis of their inputs. The numerical based DSM identified the loops, where no clear sequence or concurrency of the tasks was apparent, due to the complexity of the dependencies which exist between them. Subsequently, decisions were made subjectively, framed by the scenario of a generic market driven new product, to grade the importance of the inputs in such a way to "tear" these loops of information dependency which identify a reasonable sequence. These decisions represent an opportunity for the customization of the sequencing according to company specific needs.

2 Results and Discussion

Currently, the task checklist is comprised of 65 tasks and has been divided, on an activity basis, into 9 sub processes. Figure 2 displays the 9 sub processes relative to the reference model of product innovation shown above. The sub processes were determined based on all the tasks that are typically part of the front end processes. The sub processes give a concise list of the general tasks involved and serve to group the specific tasks based on the similarities in the activities and functions required to satisfy them. The checkpoints of the front end are shown in the diagram as well indicating the general progression of the conceptual development into plans. Additionally, the 9 processes are more fully described by the tasks, which they contain as displayed by the checklist.

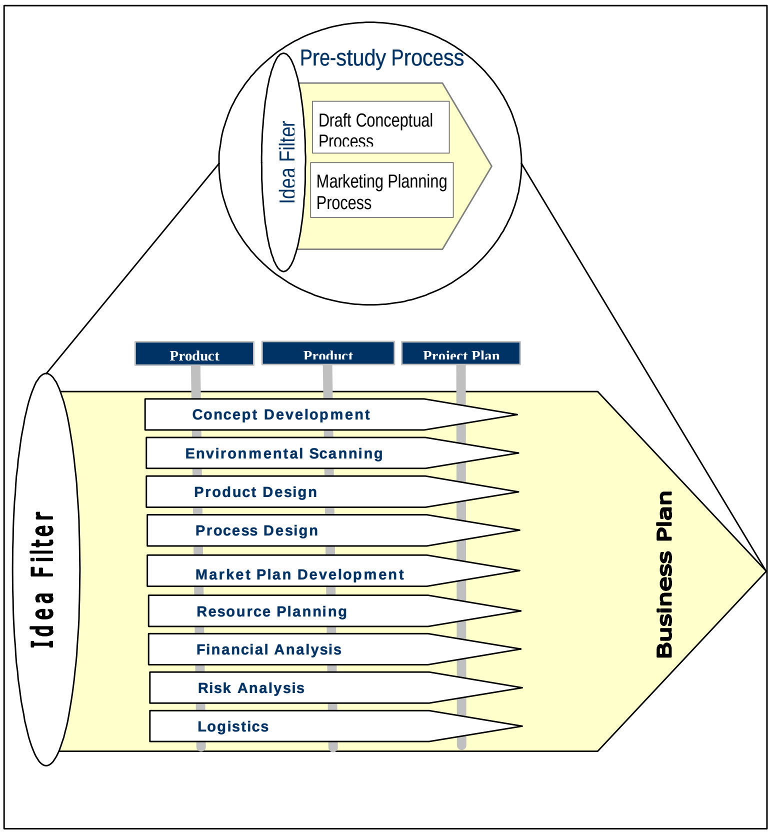

Figure 2. Pre-study Process divided into 9 activity based sub processes

The *Concept development* sub process includes the tasks, which set the foundation for the idea to develop into a product design. The concept must be fully understood prior to the establishment of the product requirements. In this sub process, the project vision is clarified, the project mission is defined, and the concept is assessed with respect to market factors, corporate objectives and strategies.

Environmental Scanning: This is a continuous process and essentially builds on and updates the market assessments performed prior to the pre-study phase. The updated information must be considered as the concept and product definition develop since changes in the environmental areas can create market shifts or barriers that affect the feasibility of the concept and create the need for iterations.

Product Design in the front end includes the design drafts which are an effort to translate the concept into a specified product. It includes feature definition and derivation, design considerations with respect to quality, capabilities, legal issues, and competing products, and preliminary performance and feasibility assessments.

Manufacturing Process Design: This includes the creation of a working draft of the manufacturing process relative to the developing concept and eventually the specified product. As the product concept becomes more developed, for example once the material is considered, the draft must be updated accordingly.

Market Plan Development: This involves of course the marketing activities that could either drive the innovation process or determine the placement of a technology driven product. The marketing plan must be considered in the front end and updated as the concept develops. Marketing is an essential part of the product development phase, thus the tasks under this sub process create the foundation for planning through the collection of relevant marketing tactics and strategies.

Resource Planning: This includes all the preliminary estimations of internal and external resources including personnel, equipment, technology, time, partnerships etc. It is the identification of the available resources and the needed resources for the concept at hand. These activities are the source of the information to compare the available to the required and thus determine the feasibility of a concept from this perspective.

Financial Analysis sub process employs data collected from marketing and cost estimations in order to estimate the projected return that a concept could realize in comparison to the costs that will be incurred for the complete product development.

Risk Analysis: Identification of potential internal and external risks associated with the product development process and the product itself (includes financial, manufacturing technical, liability, marketing risks, schedule, etc...). Additionally, the risks must be planned for through the development of contingency plans.

Logistical Planning: This sub process is primarily part of the project plan phase. The task listed under this should be considered for the establishment of the new product development plan.

Generally, the tasks within these sub processes proceed and iterate to guide the development of the output of the idea generation phase into a developed concept, then a defined product and finally, a project plan for the complete product development phase. The tasks that comprise the sub processes are listed in Table 1.

Table 1. The nine major sub processes of the pre-study and the corresponding tasks that comprise each sub process

Concept Development	**Product Design**	**Process Design**		**Marketing Plan Development**
• Create vision and mission Statements • Concept characterization • Identify and Characterize key users • Competitive assessment • Assess plan alignment • Priority assessment • Prestudy scheduling • Patent strategy • Concept selection • Concept feasibility Assessment	• Functional definition • Derivation of basic requirements • Competitive benchmarking • Quality considerations • Form design • Design for manufacturing • Consideration of legal issues • Consideration of product accessories • Packaging considerations •	• Consolidation to requirement list • Use-case scenario • Performance criteria • Assessment of user-need fulfillment • Theoretical research and evaluation • Modeling • Prototyping • Product Performance assessment • Design feasibility assessment	• Draft of Manufacturing process • Material Planning • Manufacturing process scheduling • Project plan feasibility assessment	• Product plan • Pricing plan • Promotions plan • Distribution plan

Resource Planning	**Financial Analysis**	**Risk Analysis**	**Logistical Planning**	**Environmental Scanning**
• Identify key personnel • Identify technologies required • Identify available resources and constraints • Identify relevant partnerships • Capital requirements estimations • Value chain considerations • Time-to-market estimation • Cost estimations (R&D, Manufacturing, Marketing)\	• Projected return estimation • Total cost estimation • Budget estimation	• Identify risks • Inventory and grade risks • Identify preventative measures and contingency plans	• Inventory management • Supply chain logistics • Lead time estimation	• Market • Segments • Competition • Customers • Technology • Regulatory • Socio-political trends • Macroeconomic trends

2.1 Checklist Tool

The tasks that comprise the nine sub processes detailed above are organized in the checklist according to their activities and the documents, which form the basis of structure for the checklist tool. A greatly abbreviated sample of the checklist is shown below as Table 2.

Table 2**:** An abbreviated sample of the checklist tool

Sub Process	Requirements	**Product Concept**		**Product Definition**		**Product Plan**
Concept Development						
	Concept Characterization	✓ Mk	Rd			
	Assess plan alignment	Mk	Rd	Mk	Rd	
	Assess user-need fulfillment	Mk	Rd	Mk	Rd	
	Priority Assessment	Mk	Rd			
	Patent Strategy	Rd		Rd		
Environmental Scanning						
…	…	…		…		…
Checkpoint Completion						

Checklist Features:

- The columns are headed by the checkpoints defined by the primary document deliverables of the front end.
- The rows labeled by the tasks are divided into activity based sub processes, and listed in an activity-based order, which is not necessarily sequential.
- In the active tool, currently created in excel, the definitions of each task and check point are imbedded in the file in order to create a common basis for the users of the tool.
- Links to document outlines, which can and should be customized, and perhaps eventually automatically output after the DSM partitioning is performed, are located relative to each checkpoint.
- The horizontal progression of the tasks indicate formal iterations, however, there could be sub iterations present between checkpoints. In order to determine whether a task has passed into the next checkpoint, the team must decide if the information is detailed enough to be included in the document based on company standards or pre set guidelines.
- Each task, per checkpoint, is also assigned to departments in order to indicate that information should be integrated cross functions before a task is completed. This feature serves to integrate departments, establish accountability, promote cross-functional communication, and indicate the information that must be established prior to moving on.
- Blackened boxes indicate that a task is not necessary in order to satisfy the corresponding checkpoint. The placement of the black boxes can and should be customized based on the type of innovation, the information needs, the company's documentation requirements, and the determined sequence.
- As the task is completed by the involved parties, to the desired level of completeness, it is checked off and integrated into the working document.
- As the column is filled, the document reaches its completion so that the end task is an approval check, which can serve as a go/n-go decision point by the key decision makers.
- It is possible for certain tasks to develop faster than others, so the checklist permits the horizontal progression without regard to the final completion of the vertical column. This feature thus permits the flexibility to promote a natural development of the concept as ideas occur, but also ensures that this flow is documented relative to the other tasks involved in the front end.

2.1.2 Checklist Discussion

The identification of the right tasks is typically an internal company process. However, the checklist discussed here essentially lists all the tasks that could potentially be required so that the company, or project team, can select which ones are relevant to the project at hand. In order to retain the flexibility of the front end, which fuels the necessary creativity of innovation; the list merely suggests guidelines in order to educate the users.

Different departments such as R&D, manufacturing and marketing should work in accord in order to figure out which tasks would add value and quality to the pre-study process and reduce risks of the product development phase. As mentioned before, different dimensions and varying levels of available information affect the pre-study process and the fundamental content of the task list. For example, the need to conduct research on the current and possible future state of the market might be less for an already market-driven idea than for a technology driven idea. In another case, a company that prefers target-costing method will require a different pre-study structure than one that uses traditional mark-up pricing. Such details can play major roles in determining the tasks that need to be performed and their sequences. The checklist combines the activity based structuring of the front end via the information based structuring by coupling the progression with the documented deliverables. Thus, the tool encourages the structuring via information needs rather than tasks. Generic information needs are displayed in the document outlines; however, customization of the outlines will serve to assist the customization of the list itself by indicating what tasks are necessary to bring that information. During the identification of tasks, dependencies between them can be fully ignored and all that is necessary is to fulfill the information need via certain tasks. After the list of necessary tasks is finalized, based on the documents required, a sequence can then be identified via the DSM.

2.1.3 DSM Results

The DSM was successfully employed to indicate which tasks should be sequential, coupled, and/or can be performed in parallel. The output from the matrix was a pseudo-sequential listing of tasks with their relative inputs, outputs and feedback points, which represent sites of iteration. The first column of the DSM, shown in Figure 3**,** lists the identified sequence of the tasks. This chronological organization did not match the initial sub process list. This was as expected since the sequenced list was based on the information flow and not just the similarity of the activities. The list is headed by the inputs that come from communication links such as corporate documents, ideas from the idea generation phase, and the continuous environmental scanning. Any tasks that together created a circular path of dependency were also identified by the DSM and represent the area of future customization capabilities on a per company or per project basis.

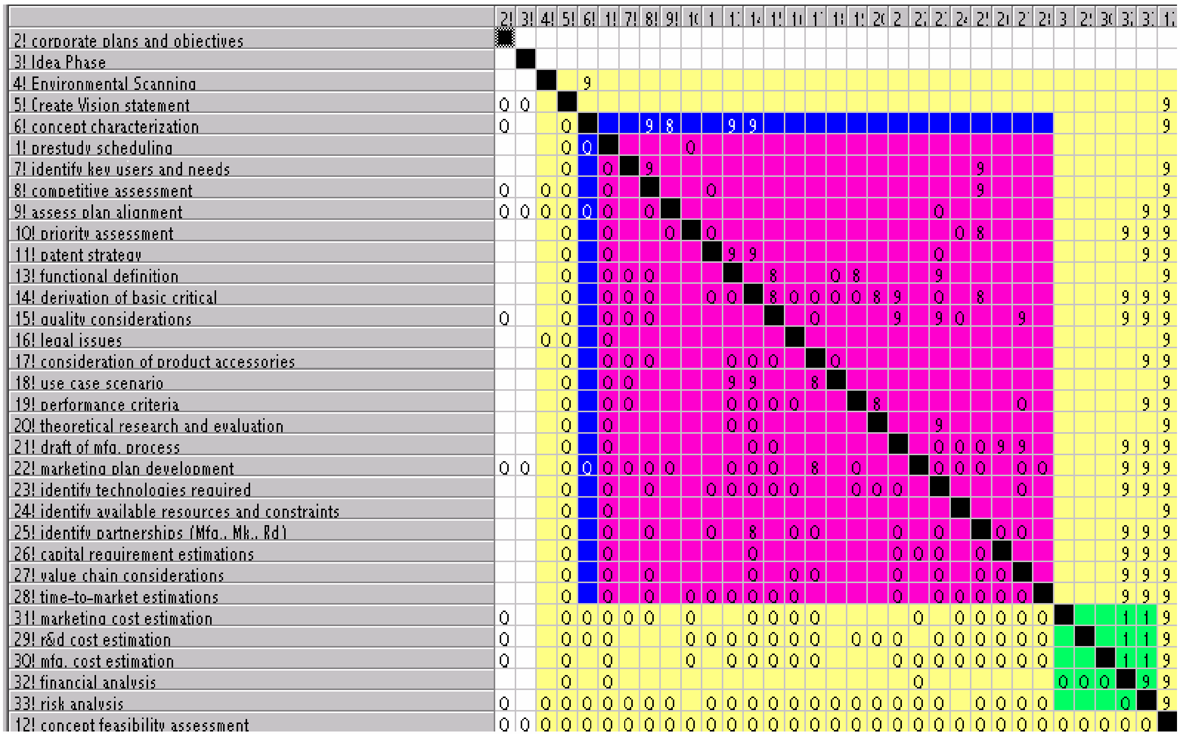

Figure 3: DSM matrix of the product concept tasks after partitioning and selective tearing

There are essentially four blocks of tasks apparent in the DSM in Figure 3. Different colors indicated in the DSM represent different levels of input relationships that create circular patterns. For instance, the yellow area is really the beginning of the tasks of the product concept checkpoint and takes its color from the first 9 on the right side of the diagonal. Similar is the case for the blue block, which takes its color from a stronger dependence that was assigned by the team as a degree of 8. The purple block that takes its color from the 0s, encompasses the tasks for the creative development of the concept with respect to planning, marketing, product and process design. The purple blocks are the circuits where a sequence can only be enforced by tearing the circuit through subjective decisions. The smaller separate green box contains tasks relating to the financial assessment of the developing concept. Tearing was selectively performed in this final block as indicated by the boxes marked with the number 1, which were initially 0s and a part of a purple block before tearing. The financial assessment box was torn in a logical progression to build towards a completed financial analysis. Thus, the purple box, which is the only block still containing strong and exactly the same degree of inputs on the right side of the diagonal (indicated by 0s), represents the customizable area for this market driven scenario. This box can be quickly sequenced in the future based on company specific, or project specific needs colleted via simple questionnaires and interviews that eventually lead to tearing the dependency circuits hidden inside that block. It was decided that it was not productive for the panel to continue with the tearing of the purple block without a specific case in mind. The results otherwise, would be quite subjective. Figure 4**,** shows the banded view of the tasks, which indicates which tasks can be performed in parallel to save time.

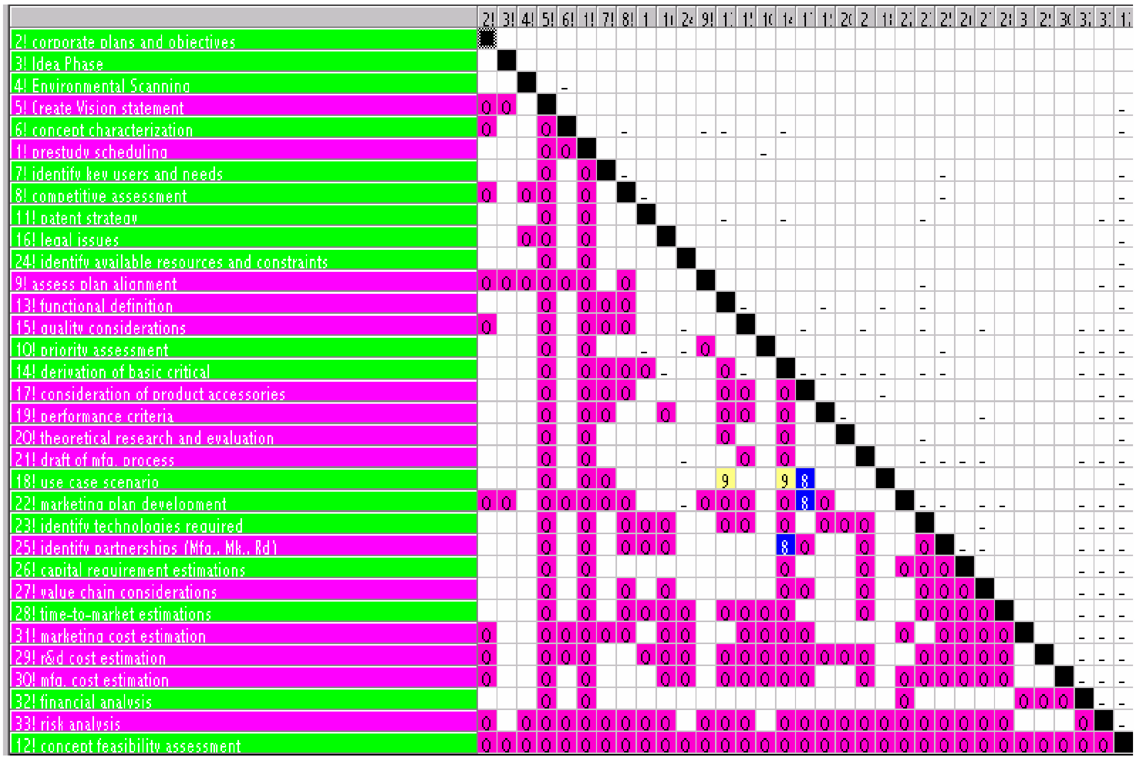

Figure 4: Banded view of the sequenced product concept phase as outputted from the PSM 32 software.

2.1.4 Discussion of DSM

Nobelius and Trygg ask the question of the applicability of a “general model” of the fuzzy front end [5]. This question arises undoubtedly from the fact that the front end is the creative side of innovation and must remain flexible, as well as the fact that different innovations and companies have varying information needs and practices. The idea of defining a structured front end, by nature of the subject, is contradictory. The front end is nebulous and the path to take can vary depending on the project at hand and company and even individual teams involved. However, companies repeatedly cite a need for help in this area and where there is demand, supply follows. There must, therefore, be a place for a tool that will help these companies in need to understand the front end and give them a jumping off point from which they can fully develop their own methods. Furthermore, through the integration of the DSM and the checklist, an opportunity for customization can be introduced to the carefully developed checklist. The tasks can be rearranged base on content, sequence, or deleted altogether, depending on the company needs.

The tool presented offers two alternative methods by which customization can be introduced into the sequenced checklist. The first alternative is enmeshed with the tearing decisions as discussed above. Once the tasks are compared to a set of corporate methods or an identified problem, the circuit tasks can be quickly sequenced through simple questionnaire-based feedback from representatives. Alternatively, default scenarios can be used to aid subjective decisions, which will result in a suggested sequencing of the tasks. For example, a market driven innovation requires a different sequence than a technology driven innovation. Additionally, the use of target costing creates different needs as well. Therefore, the future IT tool can have multiple scenarios preprogrammed which can simply be selected by the project head, or the company can customize their own through auxiliary service. Additionally, a cross-functional group workshop, as employed in the study to determine the task dependencies, could be realized in the industrial setting. This is not only important because it sets the standard about who will perform these tasks but also because the common agreement upon the dependencies is vital not to skip any dependency and opens the gates to communication.

3 Limitations of DSM

While the DSM method offers many benefits, it has some limitations. DSM is a tool that was developed by engineers for the purpose of design. It has many advantages over some other project management tools including the fact that is shows a tremendous amount of information flow on one sheet and is quite simple compared to some tools. However, for the application of the tool to cross-functional teams, including R&D, marketing, manufacturing, and perhaps finance representatives, the DSM output itself may not be very well accepted. Additionally, the DSM can recognize circuits in a complex process; however the series of dependencies involving multiple tasks is not always readily apparent to the user [16]. Thus, an IT tool, that will integrate the checklist and the reasoning of the DSM, is under development to create a user-friendly application for front-end planning. Prior to this development it will be essential to verify the usage of the DSM matrix. The current method employed a ready-made software package based on just one type of partitioning algorithm. The results should be verified through the exploration and trial of different types of partitioning algorithms.

4 Conclusions

The described checklist tool, sequenced via the DSM method may subsist alone as an important tool for structuring the front-end and provide a detailed model of the early phase of the product innovation process. The interactive checklist tool will serve to relay guidelines regarding what should be done, who needs to be involved, and what information must be presented. However, to fully develop the usability of this ides, the manipulation and output of the DSM will be the basis in the development of a software tool to manage the project based on the identified information flow. Consequently, it will retain the basic checklist structure that has already been developed. The results, thus far, warrant continued development of this tool through the refinement of the task lists and their definitions via industrial workshops, the development of the user interface, further study in customization of the tool, and usability scenario testing. Specifically, the future tasks include. The long term goal is the creation of an IT system, comprised of the interactive checklist powered by DSM decision making, through the translation of the model into a useable, customizable tool for the teaching of organized product innovation processes to young companies who do not currently have guidelines or the refreshing and refining of more mature company practices.

5 References

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