กรอบการทำงานส่วนหน้าแบบฟัซซี่สำหรับแผนกพัฒนาผลิตภัณฑ์อิเลคทรอนิคส์

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FUZZY FRONT END FRAMEWORK

FOR AN ELECTRONIC PRODUCT DEVELOPMENT DEPARTMENT

Mr.Suttisak Suriyachanhom

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Engineering Program in Engineering Management

The Regional Centre for Manufacturing System Engineering

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วิทยานิพนธ์นี้นำเสนอกรอบการทำงานส่วนหน้าแบบฟัซซี่หรือวิธีการอย่างง่ายสำหรับการดำเนินงานในขั้นตอนก่อนการพัฒนาผลิตภัณฑ์ ผลของการจัดทำกรอบการทำงานนี้ประกอบไปด้วย การกำหนดสิ่งที่ต้องมีพื้นฐาน การแบ่งการดำเนินที่จำเป็นเป็นส่วนย่อย คำอธิบายวิธีการที่แนะนำ และ การนำเสนอเครื่องมือสนับสนุนต่างๆ

วิทยานิพนธ์นี้เริ่มต้นจากการพิจารณาการทำงานส่วนหน้าแบบฟัซซี่จากเอกสารวิชาการต่างๆ หลังจากนั้นจึงดำเนินการตรวจสอบการทำงานส่วนหน้าที่บริษัทที่กำลังศึกษากำลังใช้อยู่เพื่อหาจุดบกพร่อง จากข้อมูลการตรวจสอบนี้จึงได้พัฒนากรอบการทำงานส่วนหน้าแบบฟัซซี่ขึ้นมา ท้ายสุดจึงได้นำกรอบการทำงานใหม่นี้ไปประยุกต์ใช้กับการพัฒนาผลิตภัณฑ์ใหม่โครงการหนึ่งเพื่อสาธิตว่าสามารถใช้งานได้

กรอบการทำงานส่วนหน้าแบบฟัซซี่ที่นำเสนอนี้สามารถแบ่งออกได้เป็นสามส่วนคือ ส่วนของการสร้างความคิด (Ideation) ส่วนกำหนดมโนภาพของผลิตภัณฑ์ (Concept) และ ส่วนการวางแผนการพัฒนา (Planning) สำหรับส่วนแรกนั้นจะใช้เพื่อเลือกสรรความคิดที่เหมาะสม ส่วนที่สองจะใช้เพื่อกำหนดมโนภาพของผลิตภัณฑ์ซึ่งรวมไปถึง ข้อกำหนดหลัก รูปแบบ และหน้าที่การทำงานพื้นฐาน สำหรับส่วนสุดท้ายนั้นจะใช้สำหรับการวางแผนอย่างเหมาะสม และได้แนะนำวิธีการ และเครื่องมือในทางปฏิบัติ เพื่อช่วยในการดำเนินงานในขั้นตอนก่อนการพัฒนาผลิตภัณฑ์ต่างๆนี้

ประโยชน์จากการใช้กรอบการทำงานส่วนหน้าแบบฟัซซี่นี้คือ งานต่างๆที่อยู่ในช่วงการวางแผนผลิตภัณฑ์สามารถทำได้รวดเร็วขึ้น แล้วก็ยังมีประสิทธิผลมากขึ้น โดยที่การทำงานที่รวดเร็วขึ้นนี้เกิดจากการที่ทีมงานสามารถทราบว่าควรจะดำเนินการอะไร มีวิธีการอย่างไร และ จะใช้เครื่องมืออะไร นอกจากนั้นการใช้กรอบการทำงานที่ได้แนะนำนี้ก็ยังช่วยให้ผู้ทำงานไม่หลงลืมการดำเนินงานที่สำคัญๆ ซึ่งก็จะเป็นผลให้การดำเนินงานในขั้นตอนก่อนการพัฒนาผลิตภัณฑ์ต่างๆนี้ มีประสิทธิผลมากขึ้น

ภาควิชาศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต ลายมือชื่อนิสิต..............................
สาขาวิชาการจัดการทางวิศวกรรม ลายมือชื่ออาจารย์ที่ปรึกษา..............................
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KEY WORD: FUZZY FRONT END / FFE / FRONT END OF NPD / NPD / PRE-DEVELOPMENT

SUTTISAK SURIYACHANHOM: FUZZY FRONT END FRAMEWORK FOR AN ELECTRONIC PRODUCT DEVELOPMENT DEPARTMENT. THESIS ADVISOR : DR. REIN BOONDISKULCHOCK, THESIS CO-ADVISOR : MR. KEISHU KONDO, 111 PP. ISBN 974-14-2660-7.

This thesis proposes an easy-step approach, the fuzzy front end (FFE) framework, in accomplishing pre-development activities of the new meter platform projects. The outcomes of this customized framework contain identification of prerequisites, sub-divisions of essential tasks, description of recommended methods, and offerings of supporting tools.

The thesis process began with extensive review of FFE literature. Then the case company's current process was investigated to reveal deficiencies. After that, an articulated FFE model was developed through employing the same analogy as in general design processes. Finally, to demonstrate how the proposed model is applicable, the FFE framework was implemented into a new product platform project.

The proposed FFE model can be divided into three elements: Ideation, Concept, and Planning. The first element is used to select an appropriate product idea. The second one is used to define the product concept including major specification, features, and functions. The last one is used to create a suitable project plan. Through looking at specific elements in this outlined model, the practical methods and tools are suggested to aid execution of such early phase activities.

As a result, a benefit from using this FFE framework is that product planning activities can be performed quickly and effectively. Through following the articulated FFE model, the FFE team knows what activities should be done, what methods should be followed, and what tools can be referred. Thus, the team is able to start quickly and complete their jobs faster than ever. In addition, since the use of framework helps FFE member to ensure that vital information and critical analysis are not overlooked in the early development phase, the FFE team is able to execute such up front activities effectively.

The Regional Centre for Manufacturing Systems Engineering	Student's Signature..............................
Field of Study Engineering Management	Advisor's Signature..............................
Academic Year: 2006	Co-advisor's Signature..............................

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CHAPTER 1
Introduction

This thesis presents a customized framework for an electronic product development department (EPDD) in dealing with ambiguous, chaotic, and unstructured activities during the early phase of product development. The data gathering, the implementation, and the validation will be carried out in the case company, a manufacturer of electricity meter products namely as “XYZ”.

1.1. BACKGROUND OF THE STUDY

New product development (NPD) is a creative and interdisciplinary activity that transforms a market opportunity and technological innovation into successful products. It begins with a foreseen window of opportunity and ends in production, sale, and delivery of the products (Ulrich, 2004). NPD plays a dominant role in the formation and execution of corporate strategy. Especially in a product-oriented enterprise, NPD is not only a major activity during day-to-day execution, but also essential to the economic success. Hence, well-managed product development activities are hallmarks of successful product-creation firms.

According to Koen (2005), a product innovation process can be divided into three portions: the fuzzy front end (FFE), the new product development (NPD), and the commercialization (Figure 1.1). Each portion requires specific methods and techniques to deal with difficulties involved.

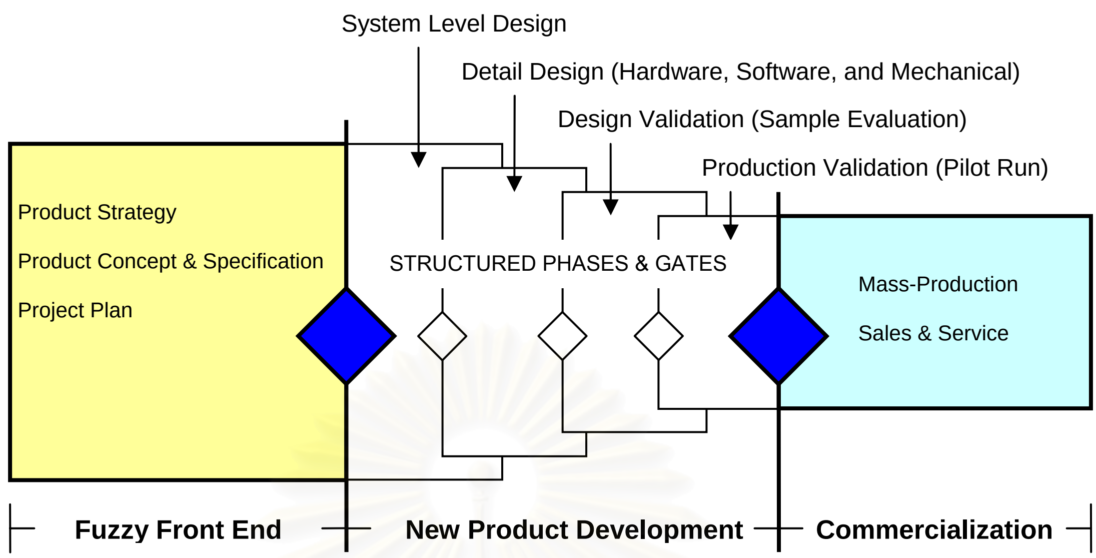

Figure 1.1 Product Innovation Process

The FFE or pre-development phase (conceptualization and project definition) begins when an opportunity is first considered worthy of further ideation, exploration, and assessment. Then the management brings together a core team to identify customer needs, market segments, and competitive situations as well as to investigate company's capabilities and available technologies aligned with the existing business and technology plans. During this period, the formed team probably came up with a lot of product ideas that fulfill those requirements. However, the FFE phase ends when the company decides to invest in the idea and commits significant resources to such development project. Therefore, it can be said that the main focus in this stage is about creativity and business success.

After receiving an approval for significant investment and resources, the project is brought into the NPD phase (design, development, and validation). The primary task is to realize the product from the concept, which is drawn and written in documents, to physical and visible things. Compared with the FFE phase, creativity is less of an issue in the NPD stage. But rather, as project schedule and the product specification are set, the emphasis is shifted to project success regarding allowed cost, acceptable quality, and planed schedule. Thus, in order to meet those objectives, the suitable methods and techniques should rely on target costing, structured phases and gates, and project management.

Finally, when the well-developed product comes out, it is time to manufacture, launch, and commercialize it successfully. Therefore during the commercialization stage (mass-production, sales, and service), primary focus is on operational efficiency, mass-production quality, sales and marketing effectiveness, and proper services.

1.2. CURRENT SITUATION OF THE CASE COMPANY

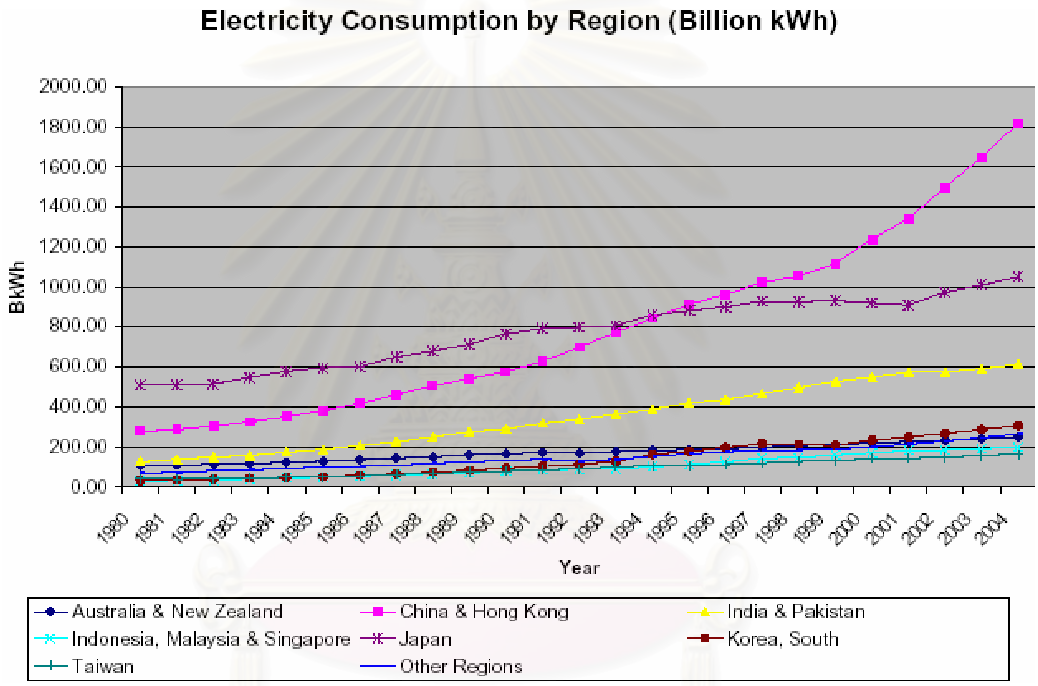

Figure 1.2 Increasing demand for electrical energy

Competitive environment in Asian electricity meter industry has changed significantly in the last five years. Deregulation of the utilities has produced a tougher competitive environment for the suppliers of electricity. At the same time, increasing demand for electrical energy (Figure 1.2) has required better management of distribution. These changes considerably affected to utility companies in Asian countries who are XYZ's mainstream customers. Apart from that, technologies, particularly in electronics and materials, are changing faster than ever. Recently, as a result of electronic meter emergence, they are demanding new kinds of electricity meters continuously. Thus, in order to cope with such competitive situation, the case company decided to pursue new product development strategy through frequently lunching new meter products.

XYZ is a joint venture between Thai shared holders and a famous Japanese firm. The business process and the working system are all transferred from the well-managed Japanese firm. For the case company, as mapped into Koen' innovation process (Figure 1.1), the current product development process can be divided into three stages: Product Planning stage (or FFE), Development stage (or NPD), and Mass-Production stage (or commercialization).

Although the case company employs an established NPD practice, unfortunately, it doesn't have any clear method for the FFE activities. But rather it employs experience residing in each particular person in the Product Planning people. This is because the pre-development phase is ambiguous and is seen as a very small portion when compared with total time and effort required by the other phases.

1.3. RATIONAL OF THE STUDY

"Any firm that hopes to compete on the basis of innovation clearly must be proficient in all phases of the new-product development (NPD) process (Khurana and Rosenthal 1998)."

1.3.1. A little attention paid to pre-development study and practice

Whereas, the phases of formal development and mass-production have been studied extensively, the early phase of the product innovation process is insufficiently treaded in the literature. For decades, many companies have dramatically improved cycle time and efficiency by implementing formal product development processes such as GE's Tollgate Process (Wheelwright and Clark, 1992), Stage-GateTM (Cooper, 1993), and PACE® (McGrath and Akiyama, 1996). However for the pre-development activities, as they are unstructured, dynamic, and ambiguous, some of researchers and practitioners viewed them as not manageable to an organization. Moreover, some of them had attempted to adopt the formal stage-gate processes to manage their front-end activities. Interestingly, many studies reveal that formal NPD practices do not apply for the FFE and there is much difference between them (Koen, Ajamian, Boyce, Clamen, Fisher, Fountoulakis, et al, 2002).

Despite recently researchers in the field of innovation management have been paying more attention to pre-development activities (Herstatt, Verworn, and Nagahira, 2004), several theoretical FFE models which have been developed do not mean to be universal to all manufacturing companies. It is essential to customize for each organization. Thus, this thesis presents one of the opportunities to contribute FFE study, especially practical knowledge.

1.3.2. Less vagueness from utilization of the framework

As the front-end phase consists of opportunity identification, idea generation, concept definition, product strategy formulation, and project evaluation, the activities included are often chaotic, unpredictable and unstructured. Moreover, the features of information during this FFE stage tend to be more qualitative, informal, and approximate. Thus, it makes much difficulty to the case company people in dealing with those kinds of product planning activities.

In such situations the framework is much more appropriate to provide the participants with a comprehensive view of what have to be done and how the internal and external elements are liked together. When a new product initiative comes up, the organization or a team just follows the corporate model and refines the basic framework or makes only a few minor modifications. Through utilization of the FFE framework, it does not only reduce the variations and uncertainty, but also valuable time and resources can be focused into the needs of the development program As a result, the case company can perform its up front activities more effectively and quickly than ever.

1.4. OBJECTIVE OF THE STUDY

The objective of this study is to develop a Fuzzy Front End framework for an electronic product development department in the case company. This is through refining and customizing existing FFE models from previous research. The FFE framework should facilitate for product planning people to carry out pre-development tasks.

1.5. SCOPE OF THE STUDY

In this thesis a framework is defined as a simplified description of a complex entity, or process, a structure composed of components framed together.

The study project covers the pre-development activities of solid-state electricity meter development in the case industrial company. No other industries, companies or products are discussed. Focus is upon finding necessary and applicable activities that correspond to a particular type of such organization – a medium joint-venture firm that develops, manufactures, and markets electricity meters for Asian utility customers.

The FFE model shall be formulated, but this framework shall not been fully implemented and tested because there are time limitation and company restriction. Instead a preliminary validation shall be used through comparing previous project data and a single project implementation.

1.6. EXPECTED OUTCOMES

The major expected outcome is the customized FFE framework for an electronic product development department in the case company including basic set of pre-development activities, methods, and their relationship. Thus, the result of this study shall include:

(1) Identification of necessary pre-development activities, shown as components

(2) Descriptions and internal flowcharts for each component

(3) Relationship diagram of components, so called FFE Framework

In addition, the author expects that the developed framework does not only aid the practitioners in dealing with pre-development difficulties but simplifies tasks and shortens product planning cycles.

1.7. EXPECTED BENEFITS

Benefits to the author and academic literature are about:

(1) Exploration of uniqueness and difficulties of pre-development activities

(2) How theoretical FFE models are adopted to the real world application, especially medium electronic manufacturing firms

Benefits to the case company include:

(1) A useful FFE framework for developing new products

(2) The product planning activities can be performed quickly and effectively.

1.8. METHODOLOGY

The study is divided into five steps as follow:

Step 1: *Literature Study*

- Study the relevance literature including FFE characteristics, tools, methods, and techniques

Step 2: *Data Collection*

- Gather necessary information for developing the framework from both internal and external sources
- Interview the company's practitioners who involve in concept development and program definition

Step 3: *Develop the basic FFE framework*

- Identify the basic FFE elements through referring theoretical FFE models
- Clarify methods and techniques for each FFE element

Step 4: *Validate the FFE framework*

- Collect previous product development project data
- Gather input data for the framework
- Examine the developed FFE framework with pre-development activities
- Compare difference between a previous project and the implemented project.
- Refine the framework as necessary

<u>Step 5</u>: *Conclusion and Thesis Write up*

- Summarize the study
- Suggest for further study
- Write up thesis paper

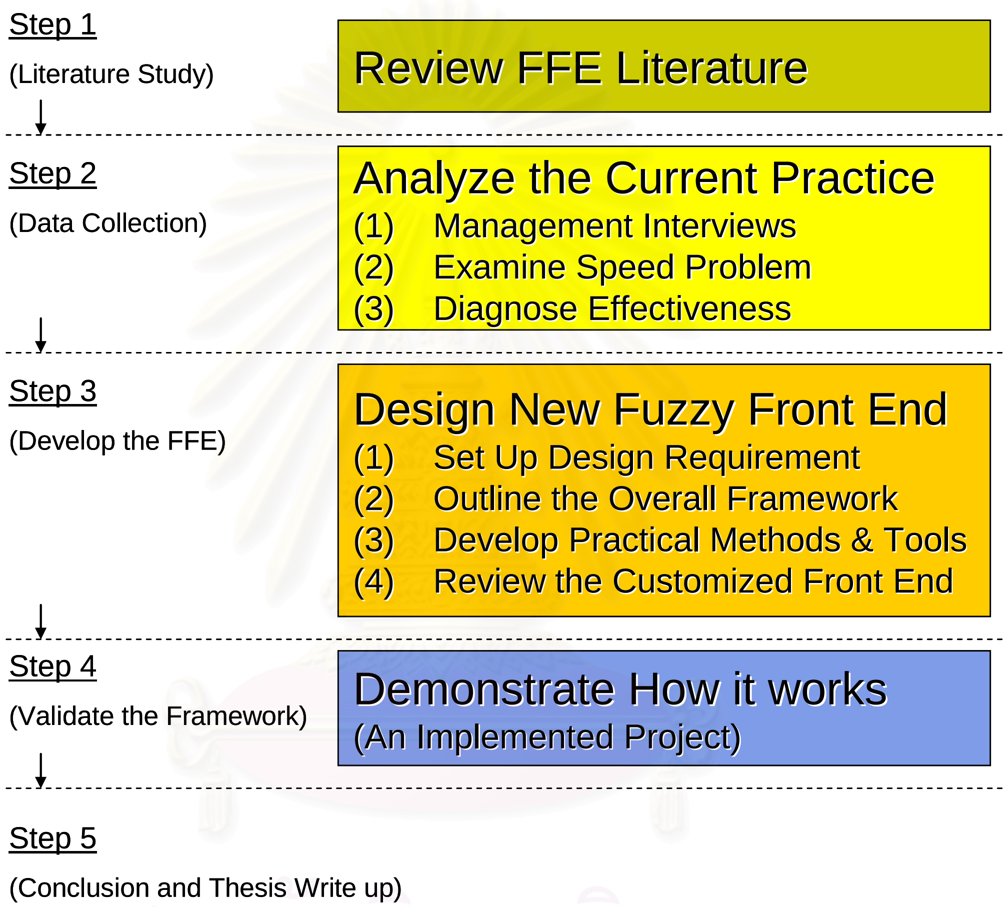

Figure 1.3 Thesis Methodology

CHAPTER 2
Literature Review

Throughout this chapter the author will extensively explore FFE literatures including both theoretical foundations and best practice models. This is to provide the author an in-dept understanding of FFE characteristics as well as a cognitive set of FFE process choices. In the theoretical section, the nature of FFE actives are firstly explained, and the five process categories are then presented. Finally, a variety of FFE models and process descriptions for managing such pre-development activities and tackling uncertainties are reviewed and further discussed.

2.1. THEORITICAL FOUNDATIONS BEHIND FFE

The term FFE refers to activities that take place prior to the start of the formal and well-structured product development. The FFE begins when an opportunity is first considered worthy of further exploration, and ranges from the generation of an idea until to either its approval for full-development or its termination. According to Murphy and Kumar (1997), such pre-development work consists of idea generation, product definition, and project evaluation. Additionally, as noted by Khurana and Rosenthal (1998), the FFE includes product strategy formulation and communication, opportunity identification and assessment, idea generation, product definition, project planning, and early executive reviews. Even though the pre-development activities cannot be clearly scoped, in short, the FFE can be defined as period between when an opportunity is first considered and when an idea is judged ready for development.

As this thesis is aimed at developing a suitable FFE framework for the case company, it is essential to understand the nature and the outcomes of FFE in order to achieve high FFE performance (Kim and Wilemon, 2002)

2.1.1. Nature of FFE Activities

Followed by the NPD process, the FFE is often chaotic and unpredictable. The pre-development characteristics fundamentally differ from formal development stage in a number of ways. According to Koen et al. (2002), as shown in Table 2.1, while the FFE is more experimental and ad hoc with uncertain time of completion, the NPD activities are likely to be disciplined and goal-oriented with a project plan. In addition, the front-end process employs merely individuals or small amount of resources rather than multi-functional and huge development team.

Table 2.1 Difference between FFE and NPD process

	Fuzzy Front End (FFE)	**New Product Development (NPD)**
Nature of Work	Experimental, often chaotic. "Eureka" moments. Can schedule work—but not invention.	Disciplined and goal-oriented with a project plan.
Commercialization Date	Unpredictable or uncertain.	High degree of certainty.
Funding	Variable—in the beginning phases many projects may be "bootlegged," while others will need funding to proceed.	Budgeted.
Revenue Expectations	Often uncertain, with a great deal of speculation.	Predictable, with increasing certainty, analysis, and documentation as the product release date gets closer.
Activity	Individuals and team conducting research to minimize risk and optimize potential.	Multifunction product and/or process development team.
Measures of Progress	Strengthened concepts.	Milestone achievement.

(Adapted from Koen et al., 2002)

The FFE stage is primarily characterized by experimental nature, high tolerance for ambiguity and uncertainty, and chaotic phenomena regarding technological and market related factors. For instant, fuzziness in the pre-development activities can come from unclear customer requirements, unproven and changing technologies, and unpredictable competition environment (Poskela et al., 2005). Apart from such external factors, the FFE process itself, such idea generation, causes vague conditions. Most companies reply on unwritten rules for generating and developing product concepts to heighten amount of new product ideas. Thus, the ideation activities are greatly influenced by people creativity.

2.1.2. FFE Outcomes

The FFE effort results in a well defined product concept, clear NPD project scope and targets, and a business plan aligned with the corporate strategy. A conceptual design document normally demonstrates designers' familiarity with the customer requirements and a clear product strategy for NPD effort to follow (Rosenthal, 1992). An output of the FFE must also be a project brief that can guide the work in the NPD. It should produce a formal project plan including resource needs, schedule, and budget estimates. The last FFE outcome, probably the most important to company executives, is a detailed business plan. This should be an analysis of financial and business figures that prove viability of the proposed new product. At the completion of FFE stage, the project proposal must convince the company to perform further development of the right product, which makes sense from market, technical, financial and business perspectives.

From the previous explanation, although a relatively small amount of resources is needed in the fuzzy front end, decisions are made that have a major effect on future resource spending and on probability of success. It is because the important project objectives: quality, costs, and timings, are mostly defined during the FFE phase. Moreover, the FFE outcome determines which products/concepts will be further developed with a significant investment. Therefore at this early stage, the resource spending is low, but the effect on the organization future is very high.

2.1.3. Categorization of FFE Processes

Since there are a variety of models for managing FFE presented in the literatures, in order to facilitate the author to understand the key principles, it might be appropriate to refer to a typology of FFE process categorization. According to Perttula (2005), the FFE process models can be categorized into five process models: waterfall model, spiral model, design to schedule, informal delivery process, and other process variants.

(1.) Waterfall Model

The waterfall model is a kind of linear sequential models which employ several individual processes cascaded together with a formal review at each transition stage. In particular, the Stage-Gate model developed by Cooper (2001) consists of three stages: discover, scoping, and business case development. With the pre-work in the first stage, the opportunities are uncovered and brought into a formal review, which preliminarily intends to kill the loser ideas. Upon this upstream work are resolved, the FFE work continues into the scoping stage and passes into the next review gate through to the last ones.

(2.) Spiral Model

The spiral model, such as NCD-model by Koen et. al (2002) is a concurrent process driven by the leadership and culture of organization. The process elements or activities include: opportunity identification and analysis, idea genesis and selection, and concept and technology development. These activities run into non-sequential steps and iterations between elements are allowed.

(3.) Design to Schedule Model

The design to schedule model, such as twin-track model presented by Reinertsen [28], is a process is developed to speed up FFE activities. The process description begins with the classification of an opportunity, which recognizes the cost of delay as a key driver for entering either of the tracks. The model is composed of the normal track and the fast track. The first one is sequential, using resources sparingly. The second one is concurrent, making decisions quickly with the expense of being costly.

(4.) Informal Delivery Process

The informal delivery process is an un-formulated model that doesn't have any formal or cognitive approaches to create and evaluate new product concepts. In such cases, new product proposals may occur from champions or entrepreneurs of the company. Practically the processes include: discovering commercial values, manifesting discovery as product, communicating potential through business case, acquiring resources to prove potential and reduce risk, and seeking approval to enter formal development.

(5.) Other Process Variants

Apart from those defined models, the processes can be modified to fit into applications if they are considered too rigid. In some cases, the variant model may also attain certain features from all or some of the process types, and therefore be a combination of different generic process.

As described, each type has its own specific and similar features. While the waterfall and design to schedule processes can be characterized as linear and sequential phases, the spiral and informal delivery processes represents as non-sequential and concurrent models. Thus, to be concise the review of FFE models will be grouped as sequential and non-sequential types

2.2. REVIEW OF FFE PROCESSES

2.2.1. Sequential Types

(1.) Anil Khurana and Stephen R. Rosenthal (1997)

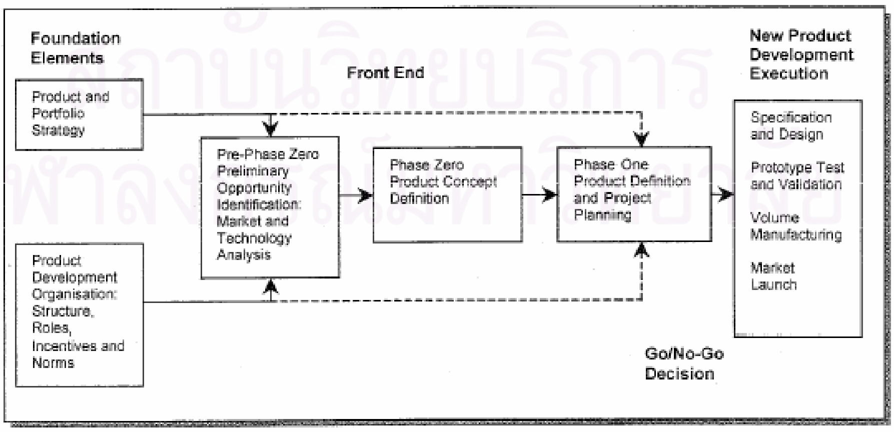

Figure 2.1 Foundation and project-specific elements of FFE

Khurana and Rosenthal studied front-end processes in eleven companies ranging from consumer packaged goods to electronics to industrial products. They modeled the new product development front end as pre-phase-zero, phase zero, and phase one sequences and classified the seven critical activities into foundation and project-specific elements (Figure 2.1).

(1.1.) The foundation elements

The foundation elements include product strategy, product portfolio planning, and product development organizational structure. The strategy formulation and communication provides direction to decision making. The portfolio plans map all new product initiatives across the business to balance risk and potential return. The organizational structure supports product development capabilities and competencies.

(1.2.) The project-specific elements

The project-specific elements consist of product concept, product definition, value chain considerations, and project definition and planning. In general, the process begins with exploring opportunities in "pre-phase zero" underpinned by the foundation elements. Upon a worthy product arises, the company assigns a small group of people to work on the project-specific activities. Firstly, during phase zero the product concepts are preliminary explored with identification of customer needs, market segments, competitive situations, business prospects, and technologies. Then, the chosen concept is elaborately developed into the product definition which leads to a choice of product features and functions, target market segments, and design priorities. Additionally, the value chain is extensively considered as a product package including the product itself, the company, the brand image, the sales interaction, the delivery process, the after-sales service, and the follow-up relationship. Finally, in phase one the company assesses the business and technical feasibility of new product, confirms the product definition, and plans the NPD project.

(2.) Charles J. Nuese (1995)

Nuese divided an entire product innovation process into five phases: advance planning, definition, design, demonstration, and customer support (Figure 2.2). The process begins with front end activities which are combination of the advance planning and the definition. Then the development is performed through design and demonstration. Finally, commercialization is supported by ongoing manufacturing and sales organizations.

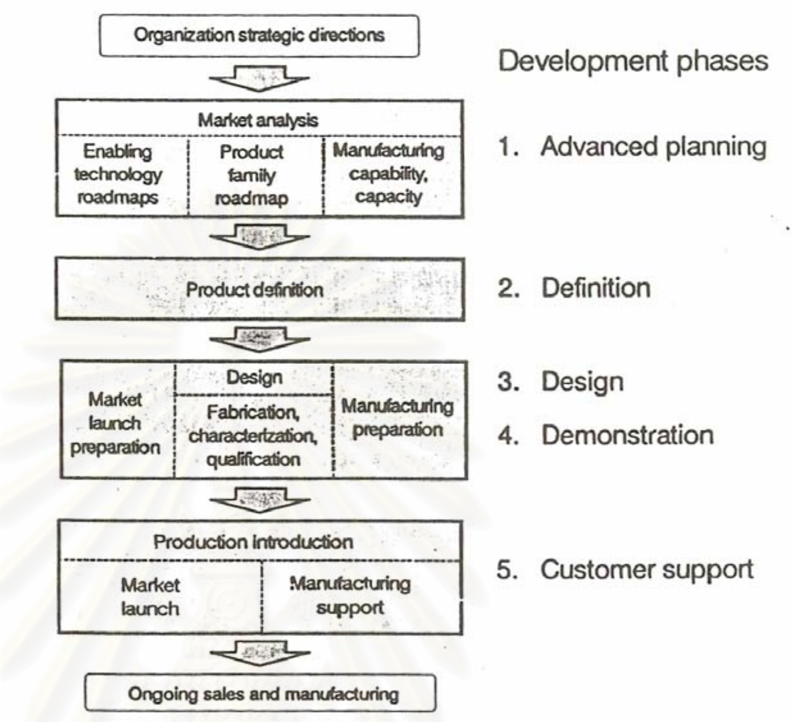

Figure 2.2 An entire product innovation process

(2.1.) Advance Planning

The advance planning is the consideration of market directions over a long range period. Generally the focus is on a product family and its expected impact to company's technological and manufacturing capabilities. The outcomes in this step are a product family roadmap synchronized with technology and manufacturing roadmaps and a top-level market and competitive analysis.

(2.2.) Definition

Once a product family is chosen, the development process shifts to individual product candidates. During this definition phase, the activities proceed in three sequences: initial concept screening, product definition, and business plan.

(3.) Steven A. Murphy and Vinod Kumar (1997)

Murphy and Kumar studied front-end activities in fifteen high technology firms by adopting Cooper's Predevelopment model (1988). The result revealed that firms undertake predevelopment activities in order to create clearly defined product prior to development.

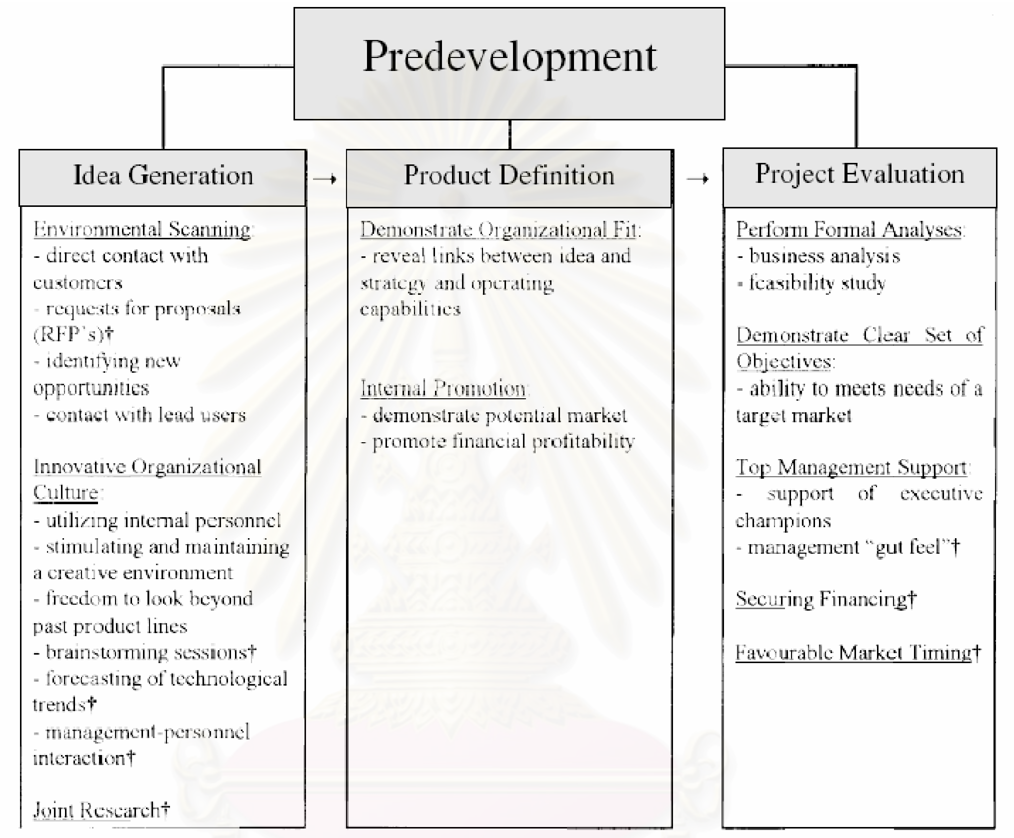

Figure 2.3 A models of pre-development activities

As shown in Figure 2.3, this model consists of idea generation, product definition, and project evaluation stages.

(3.1.) Idea Generation

Idea generation is a dynamic stage where ideas come from direct contact with customer, through identifying new opportunities in the marketplace and utilizing the creativity of the firm's employees.

(3.2.) Product Definition

Product definition transforms the idea into a new product possibility. It involves gaining organizational support through demonstrating a like between the idea and the firm's strategy and operating capabilities.

(3.3.) Project Evaluation

Project evaluation involves assessing the development and market potential of a proposed new product venture.

(4.) Karl T. Ulrich and Steven D. Eppinger (2003)

Ulrich and Eppinger described the front end process as a concept development phase. The model is sequential and consists of identifying customer needs, establishing target specifications, generating concepts, selecting concepts, testing concepts, setting final specifications, and planning the project (see Figure 2.4). In practice the entire front end activities rarely proceed in purely sequential fashion, but rather some activities may be overlapped and iterative.

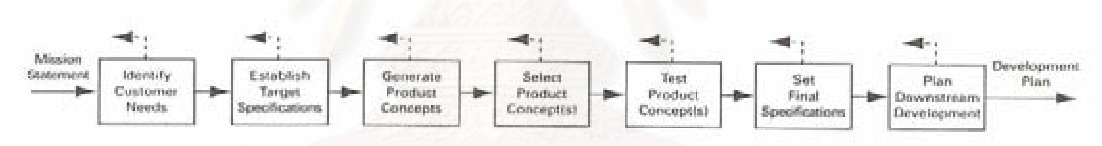

Figure 2.4 Front-end activities

(5.) David L. Rainey (2005)

Rainey studied the previous front end models, then identified the essential elements and arranged them into an explicit framework (Figure 2.5). The model consists of idea generation, concept development and selection, and NPD program definition.

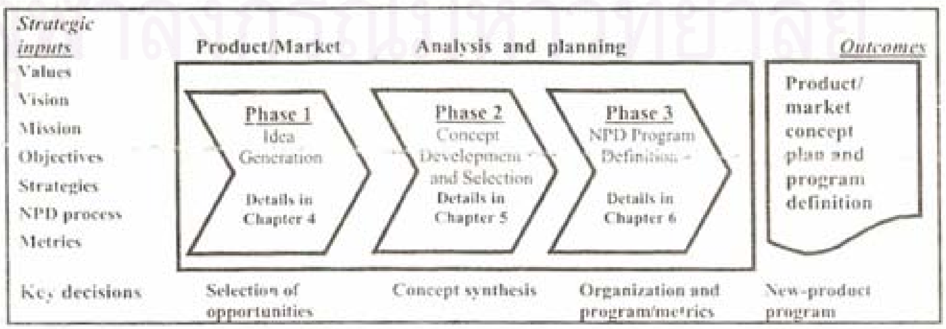

Figure 2.5 The front-end phases of NPD process

(5.1.) Idea Generation

The Idea Generation phase is aimed to provide an expeditious means of identifying, describing, analyzing, and evaluating the external dimensions and the strategic, market, technical, organizational, managerial, informational, legal, and systems requirements of the new-product ideas. Figure 2.6 provides a general flow chart of idea generation identifying the most important elements of this portion.

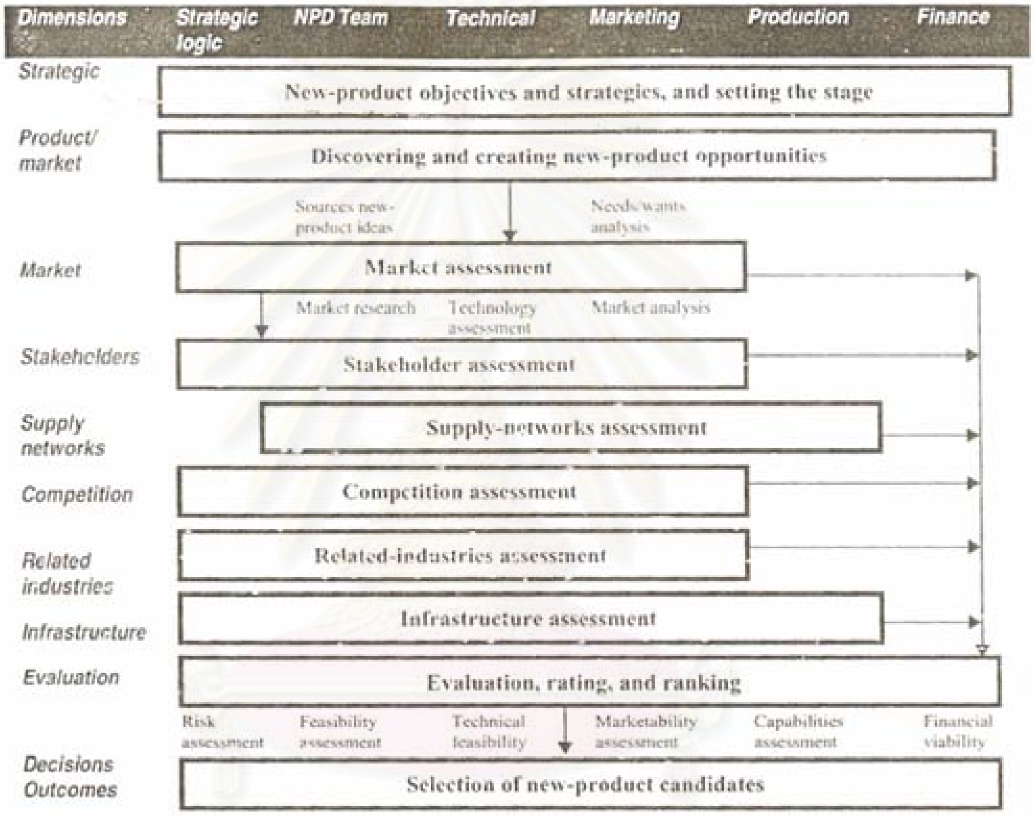

Figure 2.6 Idea Generation flow chart

(5.2.) Concept Development and Selection

The Concept Development and Selection phase expands the basic perspectives of the previous activities into comprehensive new-product candidates. Based on sufficient analyses, the product/market, marketing, production, and financial dimensions can be defined and articulated. This portion begins with the concept development which includes selecting product/market segments, identifying customer wants and needs, establishing product specifications, defining a preliminary view of the marketing program for supporting commercialization, characterizing the general scheme for producing the product, and illustrating the financial implication of the new product and the NPD program. Then the elaborated concepts are brought into assessment, testing, and screening. Finally based on selected criteria, the best candidate is chosen to proceed to the subsequence phase. Figure 2.7 provides a simplified flow chart of concept development and selection.

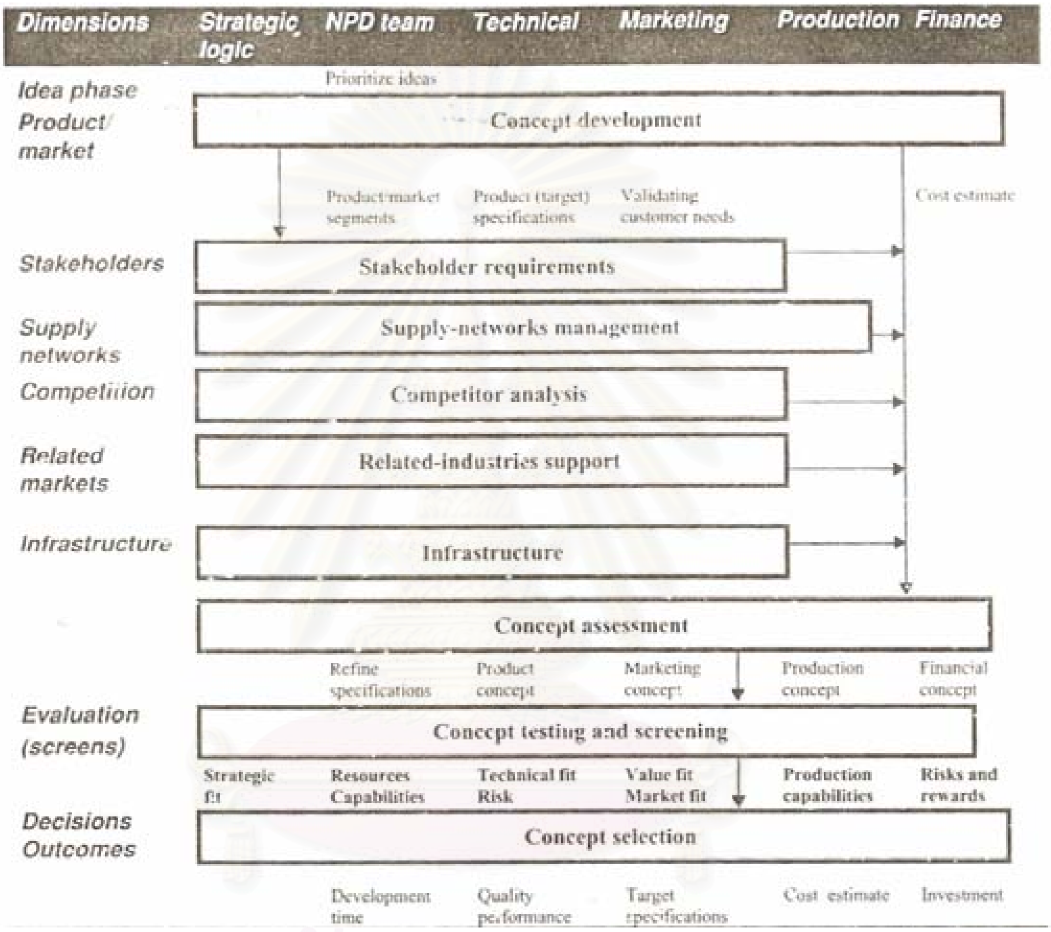

Figure 2.7 Concept Development and Selection flow chart

(5.3.) NPD Program Definition

The Program Definition phase translates the selected concept into actionable plans. The definition includes statements or overviews pertaining to the product/market perspective, the mission of the program, objectives and strategies, insights about external factors, and the investment commitment. Therefore, it provides the plans, practices, and performance measures for managing the NPD process and the related program aspects from conceptualization to commercialization.

According to the model, the internal dimensions are considered in term of process, program definition and plan, people management, and performance measures. On the other hand, the external dimensions are considered in term of product/market perspectives, explicit and tacit stakeholders, supply networks, competition, related industries, and infrastructure. Figure 2.8 depicts the essential elements of the program definition activities.

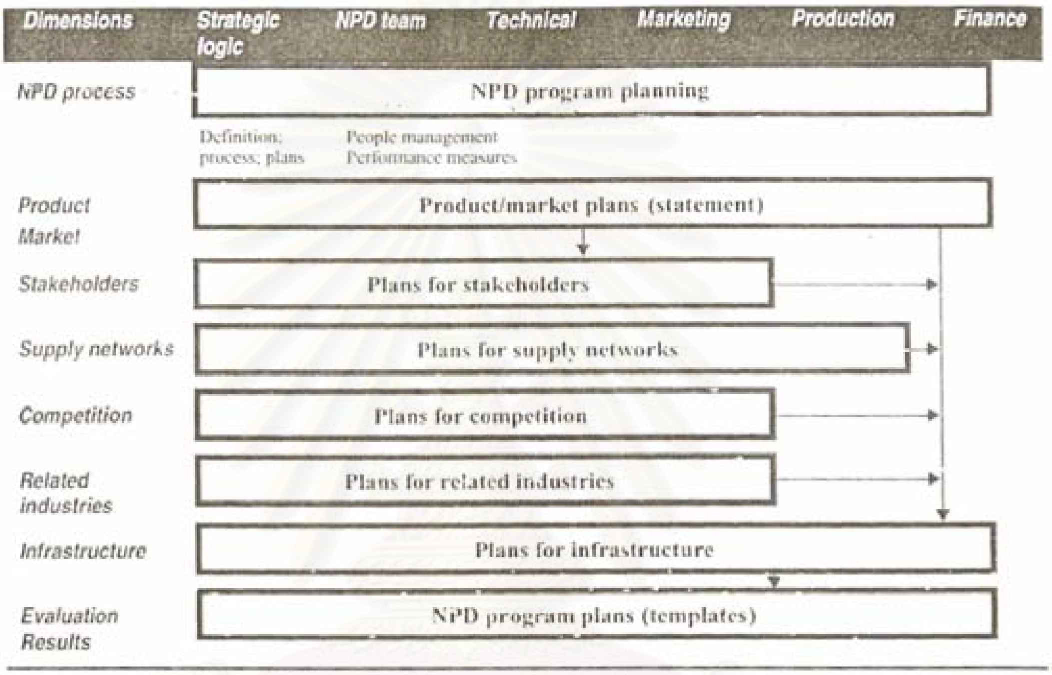

Figure 2.8 NPD Program Definition flow chart

Therefore, based on his model, the front-end activities can be carried out through the exploration and the maturation of new-product ideas, the selection of appropriate opportunities for further development, and the determination of overall game plan for the NPD program.

2.2.2. Concurrent Type

Peter Koen, Greg Ajamian, Robert Burkart, Allen Clamen, Jeffrey Davidson, Robb D'Amore, Claudia Elkins, Kathy Herald, Michael Incorvia, Albert Johnson, Robin Karol, Rebecca Seibert, Aleksandar Slavejkov, and Klaus Wagner (2001)

Koen et al. developed a theoretical construct, defined as the New Concept Development (NCD) model. This developed model is based on a study of the current approach to the front end in large multinational companies and is aimed at providing a common language and insights on the front and activities. According to the NCD model, there are mainly three portions: the inner spoke area, the engine, and the influencing factors. As shown Figure 2.9, the inner elements are surrounded by the influencing factors and are driven by the engine

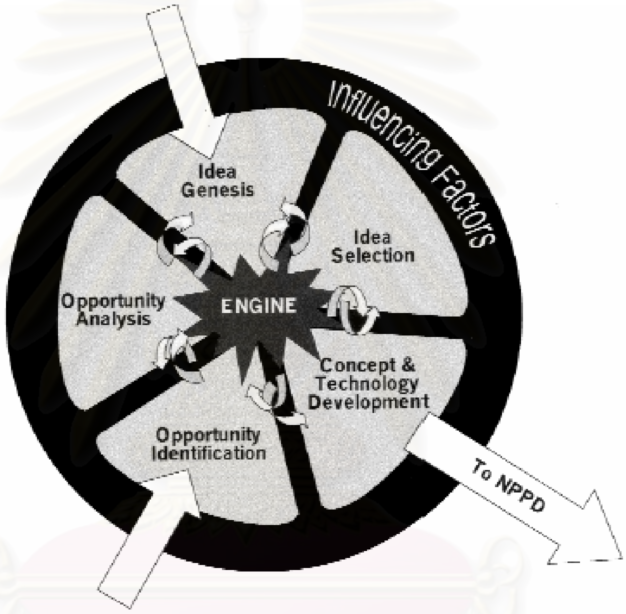

Figure 2.9 New Concept Development (NCD) model

(1.1.) Inner Spoke Area

The inner spoke area includes the five controllable activity elements: opportunity identification, idea generation, idea enrichment, idea selection, and concept definition. Notably the authors use the term “elements” rather than processes and the circle shape instead of sequential portion. This is because the information in the front end phase flows among all the five elements iteratively and unstructured, as opposed to structured gates in the new product development phase.

(1.2.) Engine

The engine represents the leadership, culture, and business strategy of the organization which set the environment for innovation. The core engine doesn't only drive the front activities move on, but is also a key part and distinguishes highly innovative companies from less successful ones.

(1.3.) Influencing Factors

The influencing factors are organizational capabilities, the outside business factors (distribution channels, law, government policy, customers, competitors, and political and economic climate), and the enabling sciences. All of the factors are unlikely to be controllable and affect to foreseeing new product opportunities as well as creating product ideas and concepts.

2.2.3. Summary of the FFE Processes

In short, much knowledge and particular issues can be learned from exploring the FFE literature. While the presented models don't graphically appear in similar ways, there is consensus on the processes within the FFE. Even though stated differently by various authors, it comes down into the following common findings:

- Idea Generation and Selection
- Concept Development
- Project Planning

In addition, business strategy and technology strategy can be seen as important supporting elements that guide the activities and decisions in the FFE. Although they don't belong to individual project level, they must essentially be provided as foundation elements.

CHAPTER 3
Analysis of the Company's Current Practices

The purpose of this chapter is to analyze the current FFE practices in the case company. Firstly, the author will explain the overview of the product design and development program, which includes planning activities as well as design and development processes. Secondly, the author will extensively look at the company's current practices during the FFE stage. Thirdly, in-depth interviews with key management personnel will be referred as a clue. This is to explore current deficiencies in terms of speed and effectiveness. Finally, regarding such management opinions, the checklist for diagnosing the front end capability and the model for accelerating the front-end activities will be used to examine effectiveness and efficiency of the current practices respectively.

3.1. COMPANY'S PRODUCT DESIGN AND DEVELOPMENT PROGRAM

3.1.1. Top-down Planning Perspective

The case company business, its suppliers, and customers all operate in a macroenvironment of forces, which generally arise from six major changes: demographic, economic, natural, technological, political-legal, and social-culture. Upcoming of these environmental changes can shape opportunities as well as pose threats. For instant, emerging of new electronics and software technologies creates new customer requirements as well as new competitive entrances. Without continuously monitoring these factors and properly responding such changes, the company would go into considerable loss in the market shares and sale revenues. Thus, uncontrollable factors must be monitored and responded in order to stay competitive in marketplaces. This brings to the needs for strategic planning activities.

At the high level, the case company regularly formulates corporate strategies and business unit plans (see Figure 3.1). By monitoring changes in business environment such as rising of material cost, increasing number of the competitors, etc., the corporate strategies are created and aligned with the mother company policies. While this highest planning activity is aimed at providing overall responses to the external influential factors, the lower level – business unit – is formed for specific areas. Basically with the use of the top level plan, each business unit considers strategic reaction for its own area. For instant, after the business unit B, which is responsible for electricity meter products, foresees upcoming of Chinese competitors, it considers to improve its existing product as well as operational efficiency in order to achieve a cost reduction model. Emergence of new electronic devices also forces the case company to develop a new meter platform that is aimed for enhancing new functions and features.

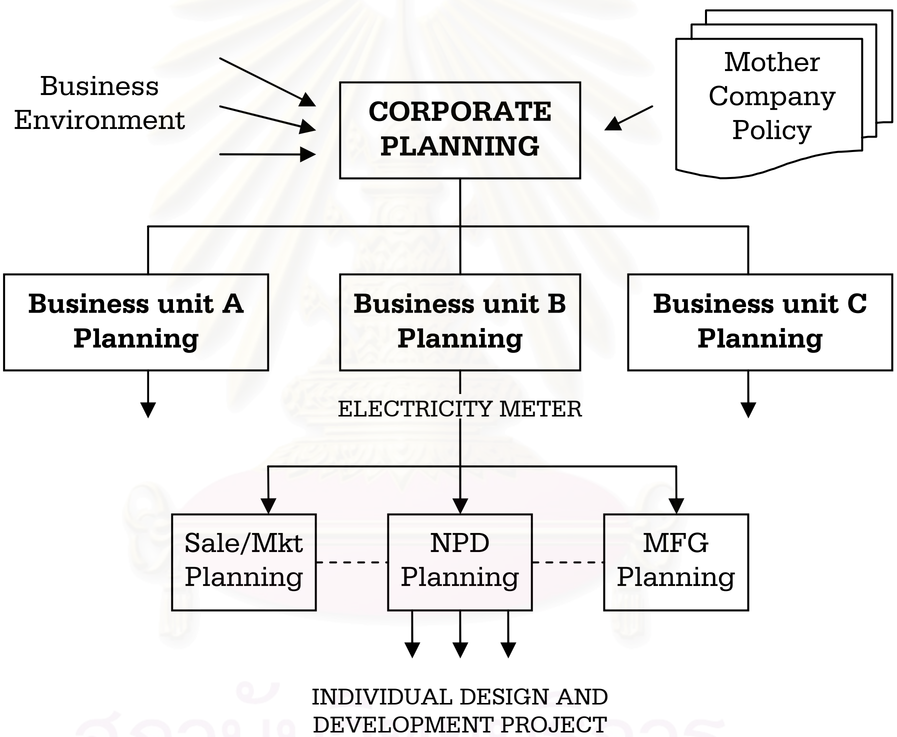

Figure 3.1 Company's planning system

In conclusion, these business unit plans initiate each functional department to create its action plans that tie together with relevant activities. These initiatives make the EPDD plans for a new electronic meter platform, the manufacturing department (MFD) plans for new process and technology, and the sales/marketing department (SMD) plans for developing new markets.

3.1.2. The Design and Development Process

For the case company, the entire product design and development process can be subdivided into three stages: planning, development, and mass-production.

Figure 3.2 The case company's design and development process

(1.) Planning Stage

Once the EPDD receives a request to develop a new product platform, design and development activities begin. By using market information derived from SMD, the EPDD manager starts pre-development work in the planning stage, which is aimed at providing clear product concept, well-planed project schedule, budget and resource allocation, and worthwhile five-year business plan. Then these information, analysis, and plan are documented and proposed to a review committee consisting of an engineering director, a SMD manager, and a MFD manager.

Prior to an approval for significant investment and resources, it is essential to ensure that the new platform development is proposed with minimal uncertainty. Thus, the committee reviews these planning documents by focusing on definition of customer and market, feasibility of the product concept, detail of the project plan, and forecast of business figures. Finally the review board accepts the full-development of the new product platform, rejects the development proposal, or entitles further investigation and bounces the product development plan back to the earlier steps.

(2.) Development Stage

After receiving an approval for such significant development effort, the full development begins in order to realize the product from concept, which is drawn and written in documents, to physical and visible things. The development activities include defining system specification, performing detail design (e.g. software, hardware, mechanical designs), evaluating design level samples, improving design for mass-production, and validating mass-production level samples.

Before moving to the mass-production stage, the results of development evaluations are brought into review with a gate committee consisting of an engineering director, a SMD manager, a MFD manager, and a quality control department (QCD) manager. The purpose of this gate review is to receive an approval for manufacturing ramp-up and market release of the new product.

(3.) Mass-Production Stage

At this final stage, the new product is now ready to be introduced. The main activities include a considerable amount of sale effort and a certain level of production and quality control. It is the transition of primary duty from the product development team to the manufacturing people and sales force responsible for ongoing business.

3.1.3 Current Pre-Development Practices

From the case company planning stage, it can be extensively explained into the details as in Figure 3.3.

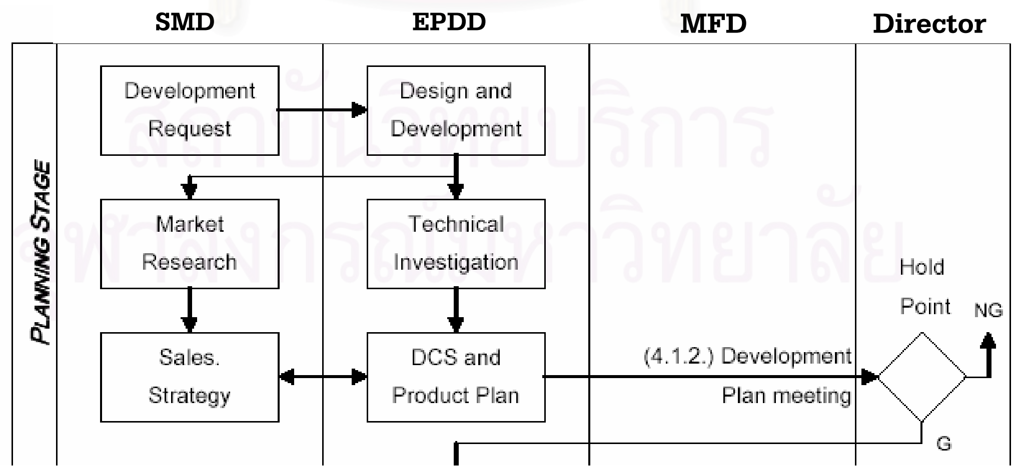

Figure 3.3 Current Pre-Development Process

According to the company's ISO manual, pre-development activities are only documented in the design and development procedure as:

Once SMD requests to develop a new product, the market research shall be performed by SMD and technical feasibility shall be investigated by EPDD department. Upon completion of market research and technical investigation, the planning stage shall be performed as follows:

(1) EPDD manager shall prepare DEVELOPMENT CONTROL SHEET and PRODUCT PLAN document including product strategy, design specification and standards, manufacturing flow model, cost analysis, and project schedule. DEVELOPMENT CONTROL SHEET shall be used as a record throughout the design and development processes and PRODUCT PLAN shall be used as "Design and Development Inputs" in the further stage.

(2) EPDD shall have the Development Plan meeting for reviewing PRODUCT PLAN document with SMD, MFD, and Engineering director in order to ensure that "Design and Development Inputs" corresponds to all customer requirements and manufacturing capabilities. The results shall be recorded in MEETING REPORT. Finally, Engineering director shall decide whether to go (G) the further step or not. In case of no go (NG) to the further step, engineering director shall decide to stop or repeat (1) to (2) again. In case of go, DEVELOPMENT CONTROL SHEET shall be approved and it is the starting point of a development project.

The current FFE process is likely to be the formal delivery process as described in the literature review (Chapter 2). Since there is no specific method to be followed, the process relies much on people insight and experience.

Depending on business situation and company strategy in each year, the development of new product platforms in the case company may be triggered by a new customer requirement, a new business opportunity, a formal planning exercise, or even an initiative of a management executive. Whatever activates a new product platform, the ideas have to be brought into an agreement with the SMD. From the need for a new product platform, the SMD then requests the EPDD to perform pre-development activities together. At the time, the primary charge is shifted to the EPDD and it is the starting point of the FFE activities.

The EPDD manager plays a central role in the front-end stage. Throughout this stage he collaborates with the SMD to obtain market information, customer requirements, and sales strategy. In parallel with those activities, the EPDD manager considers preliminary technical issues and assigns engineers to work on developing product concepts, making concept prototypes, and testing those ideas. Finally the potential concept is then chosen and is brought into preparing a product development plan (PRODUCT PLAN and DEVELOPMENT CONTROL SHEET), which includes product strategy, design specification and standards, manufacturing chain, cost analysis, project resource and schedule, and business case.

3.2. MANAGEMENT OPINION ON THE CURRENT PRACTICES

The expected benefit to the case company is not only a useful FFE framework for developing new products, but improvement in product planning activities in terms of speed and effectiveness. Thus, prior to designing an appropriate framework, in-depth understanding of the actual issues is necessary.

In order to capture practical opinions about deficiencies of the current front-end practices, interview with key personnel was conducted; one person who has more than fifteen years experience in Japanese product design and development practices and another one who has involved for more than eight years in industrial electronics development projects. The roles of the people that were interviewed within the case company are mostly in the product planning and development management level. Although the sample was not enough to produce statistical data, there can still be useful as qualitative information.

The following two open-end questions were prepared as foundations to assess the performance of the current FFE practice.

(1) *Compared with projects in your previous experience, is the case company's speed for FFE activities too slow? Can its cycle time be more shortened? In case of answering "No", please give me more explanation.*

(2) *Is the current FFE process effective for development of new product platforms? Are its deliverable outcomes sufficient and useful for performing full-development activities in the further stage? Is it needed to put more groundwork? In case of answering "No", please give me more explanation.*

From interviews of FFE practitioners, it has been found that:

3.2.1. Speed

The key personnel were asked to give their opinions about the front-end cycle time of the case company. The assessment methods are based on previous experience in similar projects, which primarily refer to one-year new product platforms.

One finding from the management interviews is that while the Japanese companies spend about one month for formal planning activities, the case company spend four months or more (See Appendix 2). As indicated in a recent project, it took five months to complete a product planning document. Key personnel interviews say that even putting more people, its cycle time will not be improved much but rather it may take longer. Thus, compared with normal front-end practices, the case's company speed is too slow.

As explored in details, the activities for obtaining market information, investigating feasibility, and defining the concept are included in the pre-development process. Can some of them be reduced or eliminated in order to shorten the cycle time? Obviously fewer activities can result in faster speed. However, only simply cutting activities is likely to create an incomplete product planning outcome and finally this groundwork is insufficient to pass an approval level at the review gate. Can the front-end speed be faster? In fact, Japanese companies also do the same activities in the FFE period. Nevertheless, the Japanese performs those tasks within a single month. **The case** company is probably lacking of suitable methods and tools for its front-end process. Thus, after embodying those practices, its process can be shortened.

3.2.2. Effectiveness

"Effectively managing the 'upfront or fuzzy front-end' (FFE) of the product development process is one of the most important, difficult challenges facing innovation managers" (Kim and Wilemon, 2002). For instant, if the project team enters into the development phase without sufficient preparation, risk such project delays, budget escalation problems, and various performance problems can be encountered.

The interviews also pointed out another aspect - effectiveness of the FFE process for new platform development. Even the case company spend more time on pre-development activities, are the current process effective to the further development stage? This more effort seems to be beneficial to the front-end groundwork. **However, it may not give an effective result. Since the FFE activities were performed without any formal method, its inadequate groundwork sometimes resulted into difficulties in the other phases; full-development and commercialization.**

The product planning experts also suggested that sufficient groundwork during the FFE phase is vital to success of the new product development. Unfortunately the FFE team doesn't have explicit guideline for dealing with those ambiguous pre-development works. This caused the product planning people overlooked some of crucial information and analysis. For instant, from the previous development project, the analysis of competitive products and competitor strength had not been taken place with much effort. Finally upon arising of new competitors, the previous project was nearly running into trouble. This is because the new comers released new features that the case company hasn't ever realized before. **It can be said that occasionally the current FFE practices employing each member experience didn't deliver sufficient and useful outcomes.**

The FFE activities are often chaotic, unpredictable and unstructured. In addition, the features of information during this FFE stage tend to be more qualitative, informal, and approximate. As recognized in a recent project, gathering clear market information and company capabilities was very difficult. By primarily depending on expertise residing in each FFE team, missing information is possible. **Therefore, the case company should put more front-end groundwork and necessitate the important items in an explicit form.**

3.3. DETAIL INVESTIGATION

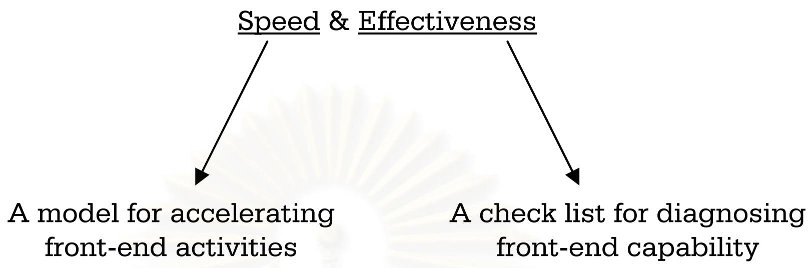

Figure 3.4 Structure Method for Analysis

The results of management opinions have indicated that the current front-end practices must be improved in terms of speed and effectiveness. However, to redesign the FFE process, it is necessary to deeply understand what the current process is lacking of. Thus, a structure method (see Figure 3.4) was developed in order to facilitate such detail investigation. The speed issues will be referred to a model for accelerating front-end activities and the effectiveness ones will be assessed by a checklist for diagnosing front-end capability.

3.3.1. Investigate FFE Speed by using an Acceleration Model

One finding from the management opinion suggested that the current FFE speed can be faster like Japanese development projects. How the case company can improve in this area? The cycle time reduction program might be put into an improving aspect of the front-end process. However, time saved from accelerating this phase can be meaningful only if it doesn't degrade the quality of pre-development outcomes.

In this section, the acceleration model developed by Kim and Wilemon (2001) will be used to understand the relationship between fuzziness level and FFE speed. Then the uncertainty reduction practices researched by Herstatt and Verworn (2004) will be used as basis for identifying possible areas to be improved.

(1.) Model for accelerating the FFE

The fuzzy level is characterized by opportunities, market needs, and available technologies, and by the activities performed in the FFE. While the beginning period is often determined by the opportunity considered, the subsequent period is determined by activities performed on the idea in the FFE as well as from external development, e.g., technological developments, competitor moves, etc.

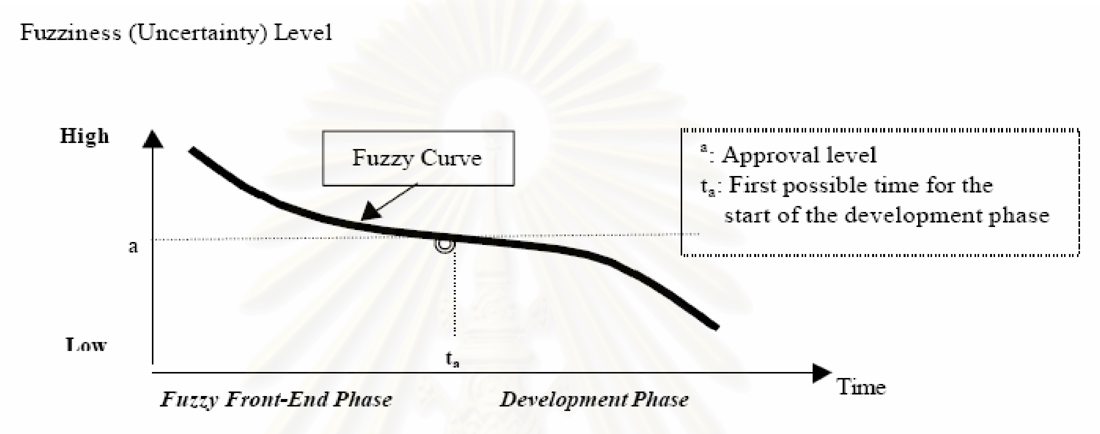

Figure 3.5 Pattern of the Fuzziness Level through Product Development Cycle

As shown in Figure 3.5, it is the pattern of the fuzziness level through a product development cycle. Initially the degree of uncertainty is very high because very little is known about market and technical information, especially if the product is very new to the company. As work on FFE progresses, the FFE team's knowledge increases. Then the fuzziness level gradually decreases and this reduction will continue throughout the development phase. Upon the degree of fuzziness descends to a certain level – an approval point (t_a), the FFE team will propose the new product development to the review committee.

Therefore, based on the acceleration model, there are two major ways to accelerate the FFE activities. One approach is to reduce the approval criteria (increasing acceptable fuzziness level, see Figure 3.6) and the other is to change the slope of fuzziness curve (see Figure 3.7).

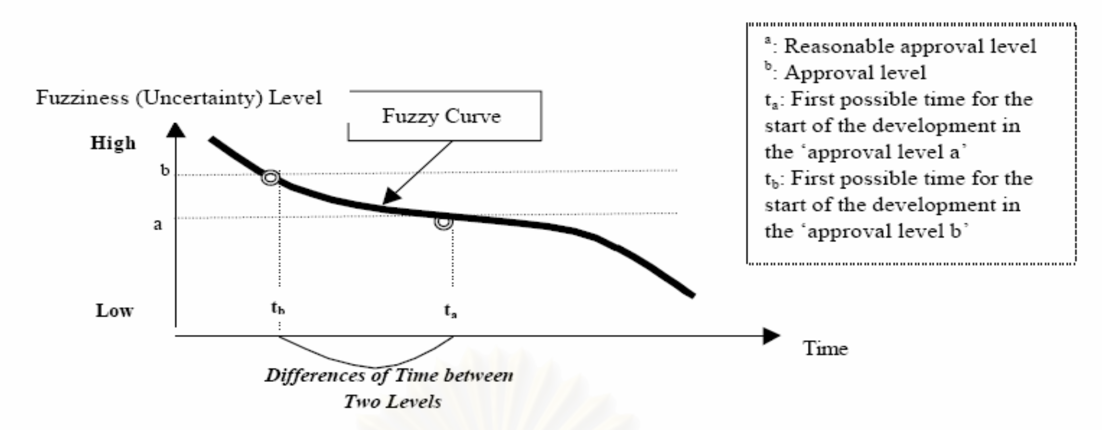

Figure 3.6 Moving up Fuzziness Level

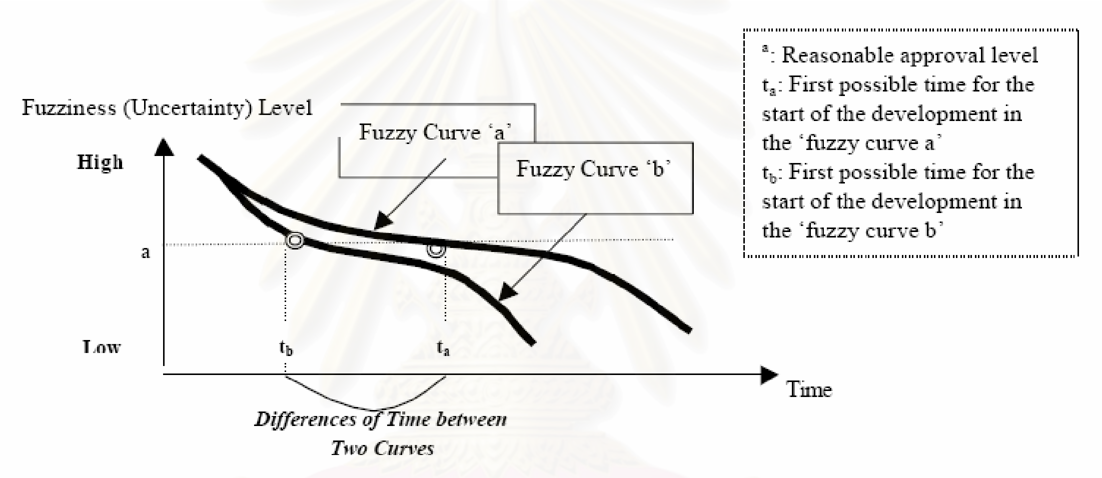

Figure 3.7 Changing the Slope of Fuzzy Curve

Although both approaches can facilitate the development phase beginning earlier, accelerating the FFE by simply shifting up the approval level is likely to create undesirable outcomes. Thus, shortening the front-end cycle time by effectively reducing uncertainty can be a desirable way to accelerate the FFE. Using this approach doesn't only speed the FFE, but also minimizes the difficulties encountered in the later phase.

(2.) Ways to Reduce Fuzziness

Fuzziness or uncertainty is defined as *"the difference between the amount of information required to perform a particular tasks, and the amount of information already possessed by the organization"* Herstatt and Verworn (2004). It often comes from markets, customers, and competitors as well as available technologies, required resources, and company-fit. In a new product platform project, relevant information has to be gathered in order to reduce risks and uncertainty. How the case company can improve its uncertainty reduction practices will be classified into two categories: market and technical uncertainties.

(2.1.) Examine Market Uncertainty Reduction

Herstatt and Verworn (2004) suggested that the target market has to be defined and customer requirements has to be integrated into the product concept. In the Company's ISO procedure, it indicates only EPDD manager collaborates with SMD to obtain market and customer information for developing the product concepts. **However, there is no specific requirement to clarify target market and no suggested methods and tools to bring together the customer requirements and the defined concept.**

Derived from the study of fuzzy front end practices in Japanese firms (Herstatt et al., 2004), the sources to clarify market and customer information are direct contact to customers, customer complaints, customer surveys, market research or study by externals, and analysis of competitors and their products. Although some of the methods and tools have been adopted in the case company, they have never been customized or developed for the practical applications in EPDD.

(2.2.) Examine Technical Uncertainty Reduction

Besides reducing market uncertainty, Herstatt and Verworn (2004) suggested that reduction of technical uncertainty is a further key. They emphasize the feasibility analysis and the definition of product specification.

Derived from the study of fuzzy front end practices in Japanese firms (Herstatt et al, 2004[40]), the methods or tools applied to reduce technical uncertainty include simulation, virtual reality techniques, rapid prototyping, and early physical prototyping. Although the current FFE process requires performing technical investigation of product concept and then concluding it into design specification, the requirement and the methods provided are too broad.

3.3.2. Diagnose the front-end effectiveness with the checklist

Based on Khurana and Rosenthal (1997) study findings, a checklist (see Figure 3.8) for evaluating the FFE on degree of formality and integration was proposed. By assessing FFE practices and calculating the score, the case company can map out how well it is performing FFE activities.

Formality of Front-End Process

1. Customer and market information is used early on to set scope for product (target markets, customer segments, features, price). ☐
2. Core team jointly reviews product concept and senior management formally approves. ☐
3. Early concept and other feasibility prototypes are planned, tested, and completed at front end so that there are no surprises later. ☐
4. Product definition is explicitly developed and documented. ☐
5. Major supplier and tooling considerations are explicit at front end. ☐
6. Manufacturing, distribution, and logistics requirements are planned; product concept is modified to reflect process and logistics constraints. ☐
7. Need for new technology for products is clearly stated. ☐
8. Project targets (time, cost, quality) and relative priorities are clear. ☐
9. Resource requirements are formally defined. ☐
10. Roles and responsibilities for tasks and communications for core team are clear and well executed. ☐
11. Roles for executive review team are clear and well executed (review criteria, decision responsibility, ongoing interaction with core team). ☐

Integration of Activities

1. There is a clear vision of product lines and platforms for specific markets. ☐
2. R&D and NPD have matching agendas and plans. ☐
3. Balance is sought and achieved among multiple NPD projects belonging to different platforms/product lines (e.g., risks, novelty). ☐
4. Project priorities are consistent with product strategy, portfolio plans, and resource availability. ☐
5. Resource allocations consider multiple project requirements and their relative priorities and pre-existing project commitments. ☐
6. Early identification of technical and organizational interfaces is done for systems products so that development can proceed smoothly. ☐
7. Core front-end team includes representatives from manufacturing, logistics, and after-sales service, apart from engineering and marketing. ☐
8. Staffing policies and project-specific staffing are consistent with the product strategy. ☐
9. Need for new innovations is anticipated so that extensive innovation is not required during the product development process. ☐
10. If there is uncertainty on any dimensions — e.g., technology or markets — organization has carefully planned alternative approach. ☐

Figure 3.8 Checklist for evaluating the FFE

(1.) Assess Formality of the Front End Process

(1.1.) Customer and market information is used early on to set scope for product (target markets, customer segment, features, and price)

☒ Yes ☐ No

As required in the company's ISO manual, during the front-end phase the SMD has to research market information and works together with the EPDD in order to support setting up product concepts and preparing development plans. However, there is no any specific method to obtain such market data. Therefore, this would be a portion to be improved into the FFE framework.

(1.2.) Core team jointly reviews product concept and senior management formally approves

☐ Yes ☒ No

Although engineers are assigned to work on product concepts, their works seem to be independent and this is no formal review during developing those concepts.

(1.3.) Early concept and other feasibility prototypes are planed, tested, and completed at the front end so that there are no surprises later

☒ Yes ☐ No

In order to reduce technical risks, several concepts are made into prototypes, which are finally tested and chosen at the early stage.

(1.4.) Product definition is explicitly deployed and documented

☐ Yes ☒ No

Product definition is not completely deployed. Only product specification is set and documented in the development plan, but this does not include operating principles and product architecture.

(1.5.) Major supplier and tooling considerations are explicit at the front end

☐ Yes ☒ No

Although FFE team sometimes considered strategic suppliers and tooling needs, these activities are never set as planning requirements.

(1.6.) Manufacturing, distribution, and logistics requirements are planned; product concept is modified to reflect process and logistics constraints

☐ Yes ☒ No

Form the current practices, only manufacturing and supply chain is considered in the development plan. However, matching between product concept and manufacturing, distribution, and logistics is not explicitly required.

(1.7.) Need for new technology for products is clearly stated

☐ Yes ☒ No

Since key operating principles, major components, and manufacturing techniques are not taken into account obviously at the pre-development stage, the need for new technology is quite hard to be identified.

(1.8.) Project targets (time, cost, quality) and relative priorities are clear

☐ Yes ☒ No

The project targets are set tentatively, but they are not prioritized. Additionally, target priorities are switched among each others.

(1.9.) Resource requirements are formally defined

☒ Yes ☐ No

According to the project plan, the schedule is set and the resource is set for each task broken down form the work package.

(1.10.) Roles and responsibilities for tasks and communications for core team are clear and well executed

☐ Yes ☒ No

There is no formal setting about roles and responsibility for tasks. In fact, engineers are assigned with the concept works and the EPDD manger directly takes control all of executions.

(1.11) Roles for executive review team are clear and well executed (review criteria, decision responsibility, ongoing interaction with the core team)

☒ Yes ☐ No

In order to review the product development plan, at the end of the FFE stage the plan is brought into a review committee which consists of relevant functional managers. The review factors depend on several criteria such as customer requirement, technical feasibility, and manufacturing capability.

(2.) Assess Integration of the Activities

(2.1.) There is a clear vision of product lines and platforms for specific markets

☐ Yes ☒ No

During the initial stage, several product offerings from a common platform are not clearly articulated. There is only the individual product plan that is set out for only primary and secondary markets.

(2.2.) R&D and NPD have matching agendas and plans

☐ Yes ☒ No

Since the case company is only a medium joint-venture organization, it doesn't include a dedicated R&D unit. Instead the company does obtain core technologies from the mother company located in Japan. However, the case company doesn't involve with the mother company in planning research and development of new technology. Thereby the matching agendas and plans would be difficult.

(2.3.) Balance is sought and achieved among multiple NPD projects belonging to different platforms/product lines (e.g. risks, novelty)

☐ Yes ☒ No

The case company realizes that launching multiple new platform projects in the same time can result into a nightmare. Because of the limited resources reason, especially software engineers, the company chooses running only a single platform project. Apart form that, occasionally running several incremental improvement projects occurs in parallel with an individual platform project, but there is no formal requirement to taking into account the balance of resource and risks.

(2.4.) Project priorities are consistent with product strategy, portfolio plans, and resource availability

☒ Yes ☐ No

The first priority is given for the new platform project because most new product initiatives arose from a strategic reason. It doesn't only include response to changing in customer requirements, but also development of company's capability and acquisition of new technical knowledge and skills. It can be said that the project priorities are clearly set out during the front-end phase.

(2.5.) Resource allocations consider multiple project requirements and their relative priorities and pre-existing project commitments

☒ Yes ☐ No

The primary engineer resource is allocated for a new platform project and the remained ones are assigned for incremental improvement and minor change projects.

(2.6) Early identification of technical and organizational interfaces is done for systems products so that development can proceed smoothly

☐ Yes ☒ No

Preliminary identification of technical and organizational interfaces is not explicitly performed during the pre-development period, but rather the formal consideration for technical interfaces is done after moving into the full-development phase.

(2.7.) Core front-end team includes representatives from manufacturing, logistics, and after-sales service, apart from engineering and marketing

☐ Yes ☒ No

Regarding company's current practice, the core team is not formally set. Only the EPDD manager and his engineers work together to create a product development plan, which refers to the data derived from the SMD.

(2.8.) Staffing policies and project-specific staffing are consistent with the product strategy

☐ Yes ☒ No

There is no formal matching between staffing policy and product strategy.

(2.9.) Need for new innovations is anticipated so that extensive innovation is not required during the product development process

☐ Yes ☒ No

There is no formal identification of new innovation, rather occasionally it arises from management insight.

(2.10.) If there is uncertainty on any dimensions – e.g., technology or markets – organization has carefully planned alternative approach.

☐ Yes ☒ No

The countermeasure plan or alternative approach for reducing uncertainty issues is not formally required.

(3.) The Front-End Capability Map

By using the checklist, the degree of formality was scored as four points and the degree of integration was scored as two points. The scores are then plotted on the front-end capability map (Figure 3.9).

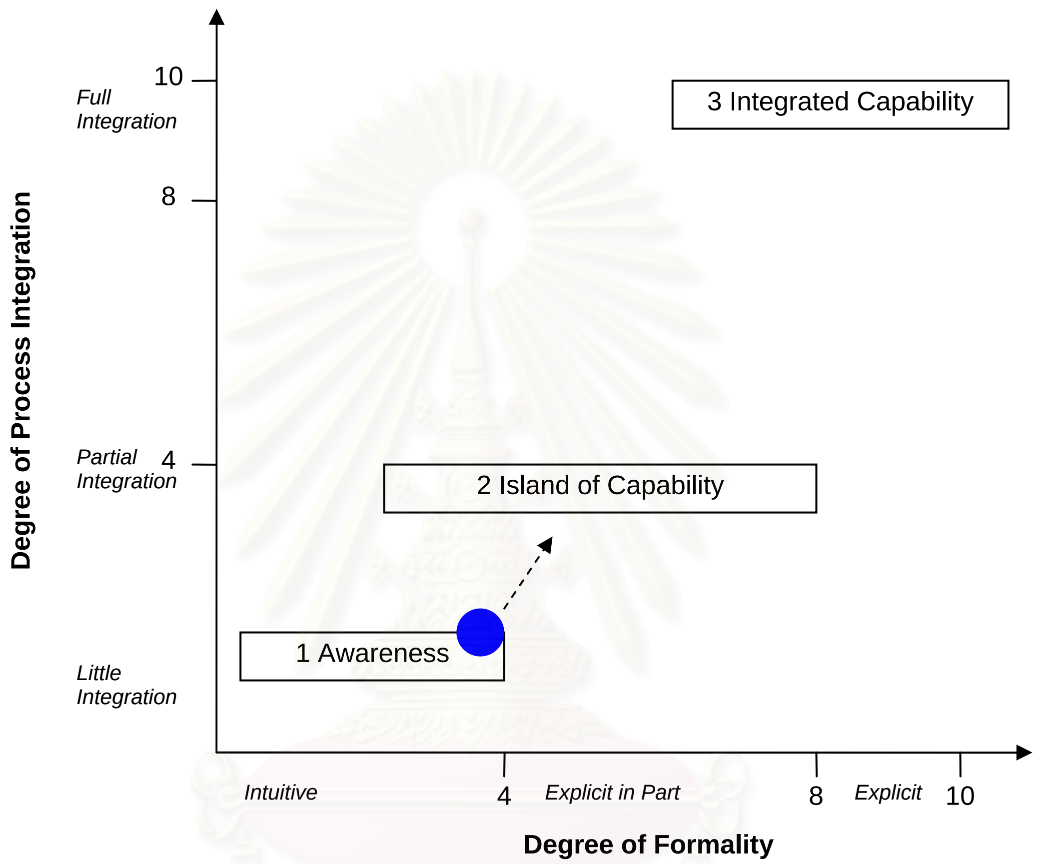

Figure 3.9 The Front-End Capability Map

This mapping indicates that the current front-end practice is at **the awareness level**. Khurana and Rosenthal (1997) suggested the companies that score three or less on either dimensions have deficient front-end and are likely to have major problems with their product development efforts.

CHAPTER 4
Designing the FFE Framework

This chapter is to customize FFE elements, and to develop a practical methods and tools for the EPDD. Based on the review of literature and the analysis of current practices, a FFE framework is proposed. First a set of design requirements will be presented that serve as inputs and constrains for designing the FFE process. Then the basic elements will be established in which outline the FFE framework. After that the practical methods and tools will be adopted to facilitate the use of such customized framework. Finally, the customized FFE framework will be verified against the design criteria.

4.1. ESTABLISH THE DESIGN REQUIREMENTS

According to the analysis of the company's current practices in the Chapter 3, the design requirements were summarized. They represent inputs and constrains that the suitable front-end model must meet all criteria.

4.1.1. The FFE must fit within the case company structure and process

At the moment, the stakeholders who involve in the design and development program consist of SMD, EPDD, MFD, and the engineering director. They all collaborate among each other to come out a worthy new-product plan. Changing in the organizational structure might affect to other department performance. In addition, it might require very large efforts to implement the new FEE method. Therefore, to avoid these difficulties, the new FFE process shall not require new departments or additional resources.

Apart form that, it should not involve any radical change to the other part of design and development practices. Since this thesis project is aimed to improve only the FFE portion, the customized process shall affect only activities within the planning stage. In short, the proposed framework must fit into the first stage of existing design and development process.

4.1.2. The FFE must deliver desirable outcomes required by the ISO procedure

Whatever the new process additionally suggests, the desirable documents - PRODUCT PLAN and DEVELOPMENT CONTROL SHEET – must be delivered at the end of the FFE stage. At least, these deliverable outcomes include product strategy, design specification and standards, manufacturing chain, cost analysis, project resource and schedule, and business case.

At the end of FFE activities, these outcomes will be brought into a major review with executives and relevant managers. The focus is on how well the product concept has been considered and developed, and how valuable the case company should invest for such large development efforts. Thus, without the desirable outputs such significant EPDD efforts might be considered as meaningless.

4.1.3. The methods for reducing uncertainty should be additionally adopted

In order to improve FFE speed, the method for reducing market and technical uncertainty should be adopted as appropriate.

Reduction of market uncertainty is a significant factor to speed up FFE activities. This can be performed through understanding target market and customer needs, and integrating them into product definition. Derived from the study of FFE practices in Japanese firms (Herstatt et al, 2004), the sources to clarify market and customer information include direct contact to customers, customer complaints, customer surveys, market research or study by externals, and analysis of competitors and their products

Apart from that, reduction of technical uncertainty prior to development is another factor to accelerate the FFE, which can be enhanced through verifying technical feasibility and clarifying technical requirements. Herstatt et al (2004) suggested the methods or tools that can be applied to reduce technical uncertainty. This includes simulation, virtual reality techniques, rapid prototyping, and early physical prototyping.

Therefore, trying to put more uncertainty reduction methods into the new FFE framework, the FFE speed can be further improved.

4.1.4. The FFE must be improved in terms of formality and integration

From the diagnostic result shown in the front-end capability map (Chapter 3), the process must be improved in term of formality and integration in order to achieve the Islands of Capability level.

As indicated in the diagnostic checklist, the degree of formality is four of eleven points. Thus, there is still a room for improvement. The new customized FFE should retain what has been formalized in current practices and should additionally clarify and document necessary activities. The possible methods include:

- Core team jointly reviews product concept and senior management formally approves
- Product definition is explicitly deployed and documented
- Major supplier and tooling considerations are explicit at the front end
- Manufacturing, distribution, and logistics requirements are planned; product concept is modified to reflect process and logistics constraints
- Need for new technology for products is clearly stated
- Project targets (time, cost, quality) and relative priorities are clear
- Roles and responsibilities for tasks and communications for core team are clear and well executed

Apart from formality, the integration indicates a very low level. Although improvement on this factor seems to be quite difficult, as stated by Khurana and Rosenthal (1997), there is a small gap to reach the Islands of Capability level. Therefore, if it is applicable without any conflict to the other design constrains, the new FFE should also include following methods:

- There is a clear vision of product lines and platforms for specific markets
- R&D and NPD have matching agendas and plans
- Balance is sought and achieved among multiple NPD projects belonging to different platforms/product lines (e.g. risks, novelty)
- Early identification of technical and organizational interfaces is done for systems products so that development can proceed smoothly
- Core front-end team includes representatives from manufacturing, logistics, and after-sales service, apart from engineering and marketing
- Staffing policies and project-specific staffing are consistent with the product strategy
- Need for new innovations is anticipated so that extensive innovation is not required during the product development process
- If there is uncertainty on any dimensions – e.g., technology or markets – organization has carefully planned alternative approach.

4.2. OUTLINE THE BASIC FRAMEWORK

Before looking at particular FFE elements, it is necessary to outline the basic framework covering all activities in the planning stage. Since all development activities of the EPDD can be categorized into the new product platform type, what kind of FFE produces is suitable for such development projects?

Generally the incremental development requires only little modification in product and process, but the breakthroughs involve very radical change. While the sequential FFE like the Stage-Gate fits for the incremental products, the concurrent ones seem to be better for the breakthroughs (Koen, 2005). For the new product platform type like the

EPDD projects, the characteristic locates between those two extremes. Thus, a proper model for the EPDD activities would be a mix between sequential and non-sequential process choices.

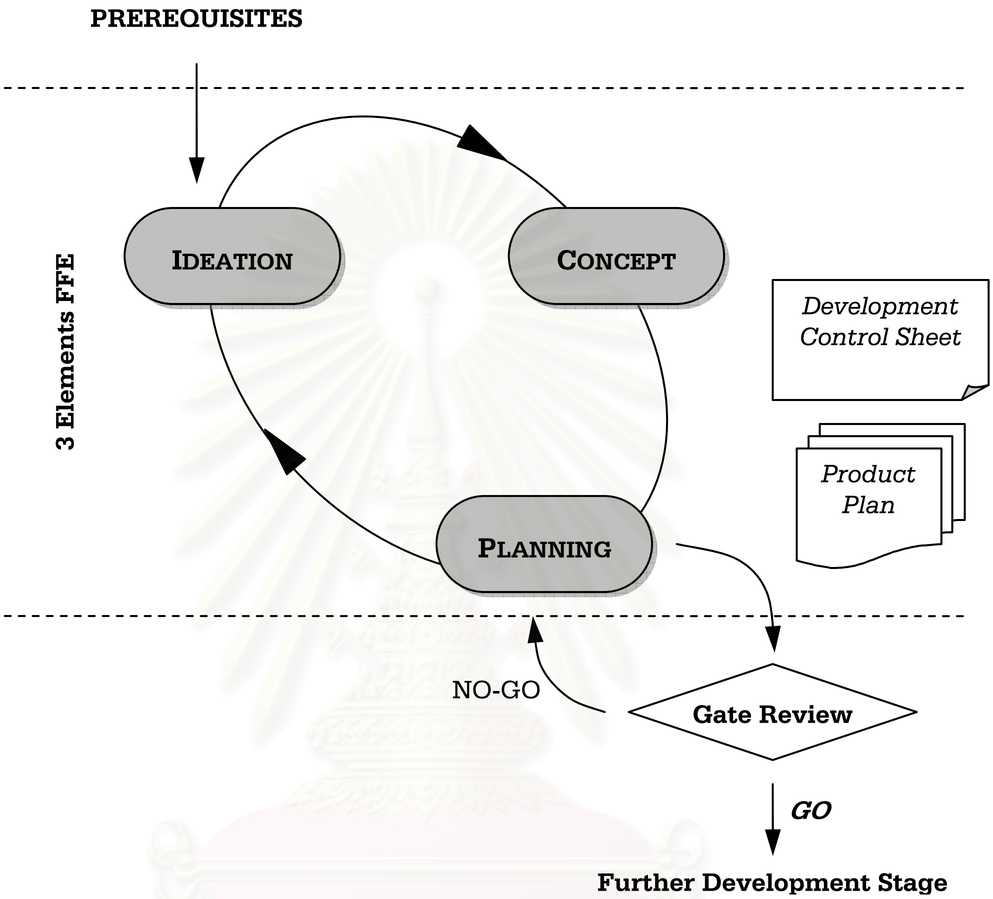

Figure 4.1 FFE Framework

As shown in Figure 4.1, upcoming of new product triggers, the FFE process starts with prerequisites. At the time, the FFE team enters to the 3-elements FFE. First the activities will focus on ideation, then move to concept, and finally run into planning. While the input from the upstream step becomes the foundation for the downstream step, the output of an upstream phase is seamlessly embodied within the body of the next phase and the process continues without interruption. The result of the FFE elements is PRODUCT PLAN and DEVELOPMENT CONTROL SHEET documents. Although drawn as a sequential process, it is possible for those activities to turn into a cycle iteratively until achieve a sufficient level for the approval committee at the gate review. Finally the review committee will evaluate whether such proposed product development project is worthy to go further or not.

4.2.1. Prerequisites

"Without a clear product strategy, a well-panned portfolio of new products, and organization structure that facilitates product development via ongoing communications and cross-functional sharing of responsibilities, front-end decisions become ineffective" (Khurana and Rosenthal, 1997).

The perquisites or supporting elements are essential precursors located in the upstream level of fuzzy front end elements. While the front-end focuses on an individual project level, the perquisites provide a basis across several product developments. They serve as precursor directing, scoping, and facilitating all activities in the fuzzy front end phase. Thus, before beginning any of the FFE processes, it is vital to have the foundational elements in place.

For the EPDD case, the supporting elements include a clear new product strategy, a well-planed product family roadmap, and an organizational structure.

(1.) New Product Strategy

While corporate strategy and business unit plan describes a company's overall direction, the product strategy defines product areas of interest, and establishes the strategies, objectives, goals, and direction for specific efforts. As indicated in his book (Cooper, 2001), the new product strategy should include the following:

- The goals for company's business's total product development efforts/ new product objectives
- The role of product development: how new products tie into company business's overall goals
- Arenas of strategic focus: markets, technologies, product categories, including priorities

- Deployment: spending allocations across the arenas.

- How to enter and how to attack in each arena in order to win

According to Moore and Pressemier (1993), decisions about which markets to serve and which products to develop and introduce are very important that they must be influenced by corporate or business unit top management. However, such executive people cannot carry out the search for new product ideas and the development of product concepts. How can the top management influence those critical decisions? With the use of new product strategy tying together corporate strategy, business unit plans, and product design and development program, the strategic level people can take control all focuses of FFE activities without interference to operational level.

(2.) Product Family Roadmap

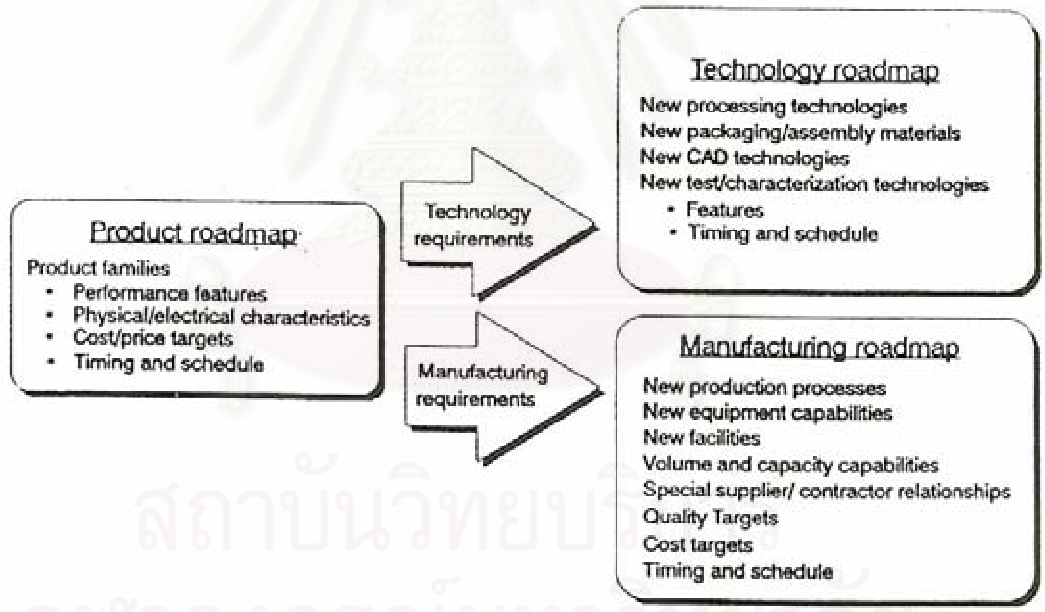

Figure 4.2 Product, Technology, and Manufacturing Roadmap

The product family roadmap provides a long-range plan for the performance features and characteristics of several product offerings as well as cost price options for each (Nuese, 1995). Within the focused arenas, existing products and new product initiatives should be mapped across the business to balance risk and potential return, short and long time horizons, or mature and emerging markets. In addition, this product roadmap should ensure consistency with company's technology and manufacturing roadmaps.

As shown in Figure 4.2, the product families are mapped out in an alignment with technology and manufacturing plans. Through considering technology requirements, such as new material technologies, and manufacturing requirements, such as new product equipments, the new product development can be planed with maximum benefits.

(3.) Organizational Structure

One of necessary preconditions is establishing the organizational structure for new product development efforts (Khurana and Rosenthal, 1997). The essential FFE structure consists of the project leader, the core team, and gate review committee.

The project leader is responsible for controlling all FFE activities right from the start and promoting the interests of the core team, which also includes lobbying for support and resources and coordinating technical issues. The core team, which is normally assembled with representatives from marketing and technical fields, performs searching new product ideas, conducting analytic work of concept definition, and preparing the product planning proposals. At the end, the complete product proposals are brought into review with the gate review committee consisting of executives from relevant areas. This is to evaluate how well it fit with the new-product objectives, company's capability and resources.

4.2.1. Three-Element FFE Model

From the literature review discussed in the chapter 2 and the company's current FFE practice, key activities were grouped together and divided into three elements: ideation, concept, and planning.

(1.) Ideation

Idea is the most initial form of a new product, which often consists of a high-level view of the solution envisioned for the problem or the need. The ideation is the formal starting point of the FFE stage where the market opportunities are identified, the new-product solutions are generated, and the potential candidates are chosen.

(2.) Concept

The concept element transforms the idea into initial concept design. A concept includes the product specifications from a customer's perspective, a preliminary view of marketing program for supporting commercialization, the general scheme for producing the product, the financial implications of the new product. In short, at this step the ideas are made more concrete as commercial specifications.

(3.) Planning

The planning is the preparation of a development project plan, which basically includes estimates of resource needs, development cost, and project schedule. In addition, it should contain forecasting sales and profitability and analyzing business case with potential revenues and firm growth opportunities.

4.3. PRACTICAL METHODS AND TOOLS FOR THE FFE

4.3.1. Element 1 - Ideation

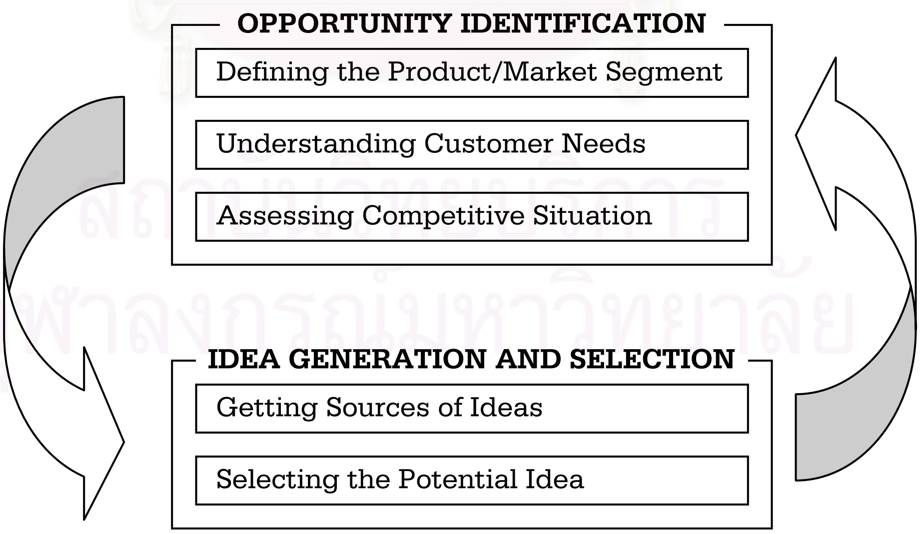

Figure 4.3 Overview of Ideation element

The challenge in this element is to seek for new-product ideas that have the potential for filling in the opportunity gaps, and to quickly convert them into a worthy idea for the further consideration - concept definition. Idea generation is open-end with less structure and definition, in which creativity and out-of-the box thinking are often needed. Nevertheless, ideation might take too much time or it is not able to identify the right opportunities if the approach is not structured properly, In order to structure the ideation approach, the activities are grouped together into (1) opportunity identification and (2) idea generation and selection (see Figure 4.3).

Once the strategic need for a new product has been in place, the FFE stage is trigged and then begins with the identification of new-product opportunities. By trying to understand market situations, both at the present and in the future, as well as to know company capabilities and available technologies, the opportunity gaps can be revealed. The core team then seeks for suitable ideas and chooses the right one to fit into those emerged gaps.

(1.) Opportunity Identification

Exploring new-product opportunities in the marketplace requires in-depth understanding of market environments and extensive investigation of technical capabilities. In order to uncover a business or technology gap existing between current situation and envisioned future, the core team needs to clearly understand how market is segmented, what are fulfilled and unmet customer needs in each segment, and what are strength and weakness of the competitors within each area.

(1.1.) Defining the Product/Market Segment

Customers in a market are never homogeneous (Doyle, 2002). They differ in the benefits wanted, the amount they are able or willing to pay, and the quantities they buy. This causes that only a single product rarely satisfies those customers completely. Therefore, dividing a market into segments and prioritizing them allows the company to truly understand the market needs, effectively create the specific product concepts, and certainly target one or more of these segments with the tailored offerings.

Segmentation is fundamentally about de-averaging the customer base. It is the process of dividing a market into distinct groups of buyers that are similar in the way that they perceive, value, use, and/or buy the products being developed (Boike, Bonifant, and Siesfeld, 2005). Generally the market segment is defined in terms of demographic aspects, geographic location, and buyer behavior characteristics (Rainey, 2005). As XYZ's customers are mainly in industrial and government organizations, the market can be segmented by applications and purchasing protocols.

According to Kidd (1998), defining the product/market segment can be facilitated with the use of the market segmentation grid (see Figure 4.4). In the market segmentation grid, major customers arrayed horizontally. The vertical axis reflects the different tiers of product application, performance, or price. By looking at the company's existing products, competitor's products, and available products in the market, the core team maps out them into each market segment.

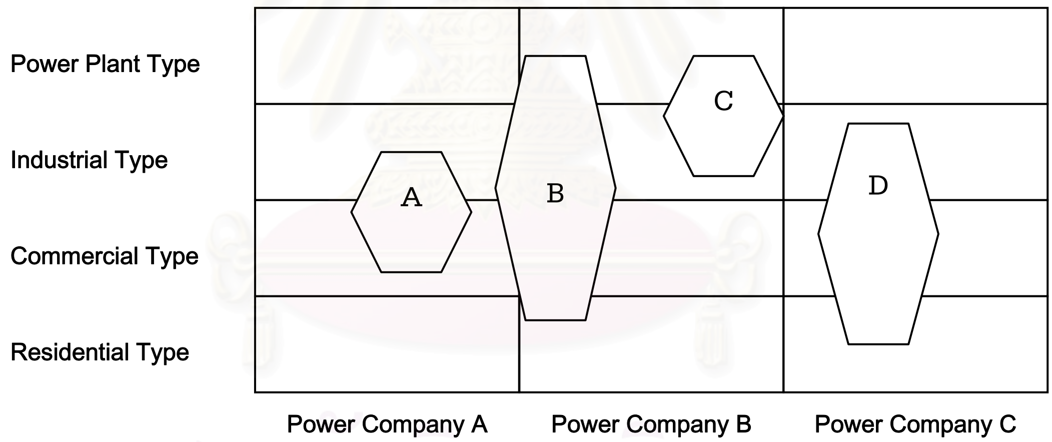

Figure 4.4 An example of Market Segmentation Grid

(1.2.) Understanding Customer Needs

"Customers desire/expect products that provide much better solutions in satisfying their underlying expectations" (Rainey, 2005).

The primary needs and wants are often expressed directly and are clearly defined and understood. The case company customers, electricity utilities, generally write down their major requirements into tender specifications, which show what kinds of functions and features are necessary. Nevertheless, there are some needs that are hard to be articulated because of functional complexity and preferable features. In such cases, latent needs are much more difficult to determine and often require the new solution before the need can be fully expressed. Thus, the following techniques are proposed to support capturing such hidden requirements.

(i.) Using Voice-of-Customer research to uncover new opportunities

Voice-of-customer (VOC) describes the “whats” (attributes) that customers are seeking and provides a sense of their relative importance (prioritized) (Rainey, 2005). In many cases, new-product ideas originate from customers who have difficulties with available products or markets that have needs not being fulfilled.

The customer voice has many roles in the development of new products. It can be a key link to understanding how a product is meeting the needs of its customers. It can express an idea for a new product or an improvement for an existing product. Therefore, by trying to identify their problems, unmet needs, or even unarticulated needs, many new product opportunities can be revealed.

The methods for obtaining the voice of the customer can be accomplished through many different techniques: focus group, survey, one-on-one interview, etc. The voice of the customer and the method used to gain their insight is dependent upon the objective and type of information needed from the customers. For the XYZ Company, the customer visit program is chosen because it directly sells the products to two or three major customers on basis.

(ii.) Customer Visit Programs

A customer visit program is a systematic approach of visiting customers with a cross-functional team to understand customer needs. The approach offers a variety of benefits: face-to-face communication, field research, firsthand knowledge, Interactive conversation, and inclusion of multiple decision makers.

Good customer visit programs can reveal new pieces of information that may have a direct impact on products offered to customers. How should customer visits be structured to maximize the benefits? To conduct an effective customer visit program, Mohr, Sengupta, and Slater (2005) suggested the following keys:

- *Get engineers in the front of customers.*

For high-technology products like advance-function electricity meters, relying solely on marketing personal to conduct customer visits may lack credibility on technical issues. The people who participate should include, at a minimum, an engineer, a product-marketing representative, and a key account manager. Thus, the key is that good teamwork must exist between engineering and marketing.

- *Visit different kinds of customers*

The common tendency in customer visit program is to visit only national/major accounts or buying-decision makers. Although visiting those kinds of customers may result in increasing satisfaction with these accounts, market share may shrink if the firm falls into the trap of developing products that exactly suit an ever-smaller number of customers. The firm should also listen to the freshest perspectives and greatest surprises from atypical sources such as competitors' customers, lead users, distribution channel members, or "internal customers of the firm.

- *Get out of the conference room*

Since the customers often don't realize and cannot vocalize specific needs, it is important to listen and observe what they do. Only inviting customers to discuss in the firm's premises might be not enough to articulate their latent needs. Therefore, rather than putting s the customers in a passive role, the case company should get into the customer premises and see how they act in an active role.

- *Take every opportunity to ask questions*

The visit programs are useful not only for getting new-product ideas but also for studying customer satisfaction in available or existing products, identifying new market segments, and exploring a myriad of other issues. Thus, the visiting people should take every opportunity for questionings.

- *Conduct programmatic visits*

It is important to coordinate the visits so that customers are not confused and irritated by a series of haphazard visits from different departments, divisions, and levels in the case company. Promptly logging and reviewing customer visits in a central database allows the firm to spot trends, define segments, identify problems, and pick up opportunities.

(1.3.) Assessing Competitive Situation

A competitive analysis is essential to determine the primary adversaries and their responses related to the new-product idea (Rainey, 2005). The intent of this analysis is to ascertain detailed information and data about selected competitors who are the most likely to present a threat to the success of the new product. The strengths and weaknesses of the principal competitors offer challenges and opportunities. The firm wants to find a gap in the existing products or to exploit the weakness of the competitors. Effective competitor analysis includes:

- Identifying their current position and strategies
- Assessing current capabilities and advantage features of their products
- Anticipating their future strategies and product improvements

By using the competitive analysis table (Table 4.1), the core team is able to comparatively understand competitor's strengths and weakness.

Table 4.1 Competitive Analysis Table

COMPETITORS	STRENGTHS	WEAKNESSES	REMARK
A1			
B2			
C			
D			
E5			

Information to be filled in the competitive table is usually available in the form of advertising, product literature, patents granted, articles in trade journals, etc. In addition, other rich sources of information include exhibitions at trade show, company's website, corporate annual report, and etc.

(2.) Idea Generation and Selection

The activities in idea generation and selection concern birth, development, and maturation of a concrete idea. The idea generation is evolutionary and requires enrichment in the ways of building up, tearing down, combination, reshape, modification, or upgrade. An idea may go through many iterations and changes as it is assessed with further study, critical discussion, or evaluation. Finally, the most promising idea is chosen for elaborating the product concept.

(2.1.) Getting Sources of Ideas

Once the core team captures a new-product opportunity, it is time to seek ideas or solutions to fill in the opportunity gap. There are numerous ways to search for new product ideas. In general, these include both formal and informal marketing research, sales force contact with customers, direct customer feedback, brainstorming, analysis of competitive products, technological forecasting, and R&D work (Moore and Pressemier, 1993). However without the appropriate sources of ideas, the idea generation might take too much time or is not able to get the right solution. In order to get start sourcing quickly, the following items are recommended for the case company.

(i.) Seek ideas from an internal perspective

New-product ideas may come from top management, R&D, product development, engineering, marketing, sales, service support, manufacturing, etc. Based on their knowledge and experience, they often have suggestions that lead to improved portions or new features.

(ii.) Get a rich source of ideas from customers

Customers probably have the next new-product ideas. They may find problems associated with the current products, identify new uses of existing products, describe the functions and benefits they expect, and provide other ideas for additional improvement (Rainey, 2005)

(iii.) Analyze competitor products

Although the purpose of this way is not to copy the competitors, it represents a valuable source of new product ideas. An analysis of competitor's product lines may provide insights into product attributes and the unique benefits that they provide. Another way that provides competitor's insights is to tear their products down to its basic components and use the concept of "reverse engineering" to determine how it was designed and built.

(iv.) Pay attention on trade shows, conferences, and publications

Trade shows, conferences, and publications present the perfect opportunity to uncover dozens of ideas from local and oversea sources at relatively little expense. They provide current information about competitors, their capabilities, and their products. They can report new product introductions from around the word, which new products may be years or month ahead of local markets in certain foreign countries. Thus, this information also gives us atmosphere of current technologies, features, and performance, and future trend of them.

(v.) Make contacts with suppliers to know new materials and applications

Suppliers are often a good source of new product ideas and help. They normally offer new materials or devices that provide solutions to existing problems or offer new features and benefits. Suppliers are also looking for new applications for their products and often come up with ideas for their customers (Cooper, 2001). By making contacts with suppliers, the several valuable ideas can be brought up.

(2.2.) Selecting the Potential Idea

Once a number of ideas have been generated, the inappropriate ones need to be thrown away and the proper ones need to be improved and pushed forward. By evaluating and ranking with criteria (see Table 4.2), the most promising idea can be selected. Generally, the criteria should be chosen by the company to reflect the factors that are considered to be more important. Although these can be varied case by case according to types of new product development projects, the criteria should include items from four areas: product factors, market factors, company factors, and financial factors.

Table 4.2 Idea Selection Table

SELECTION CRITERIA		**IDEA 1**		**IDEA 2**	
	Weight (%)	Rate (1-5)	Weighted Score	Rate (1-5)	Weighted Score
Product Factors					
1. Fills an unmet need					
2. Higher Performance/Function					
…					
Market Factors					
1. Strength to competition					
…					
Company Factors					
1. Fit with manufacturing system					
…					
Financial Factors					
1. Less investment for facilities / tools					
…					
TOTAL SCORE					

4.3.2. Element 2 – CONCEPT

At this element, the ideas are made more concrete as commercial specifications. Since defining electricity meter specifications and concepts are quite complex, it might be appropriate to establish basic specification first. By comparing customer requirements and competitor offerings, the case company is able to set up the right characteristics. After that, the concept development can be looked further into each detail: key performance and aesthetic attributes of the product and its price. Finally, in order to ensure that product benefits and features are optimally matched with technological capabilities and market requirements, feasibility assessment will be used.

In short, developing a product concept includes setting up target specification, performing conceptual design, and assessing technical and market feasibility (see Figure 4.5).

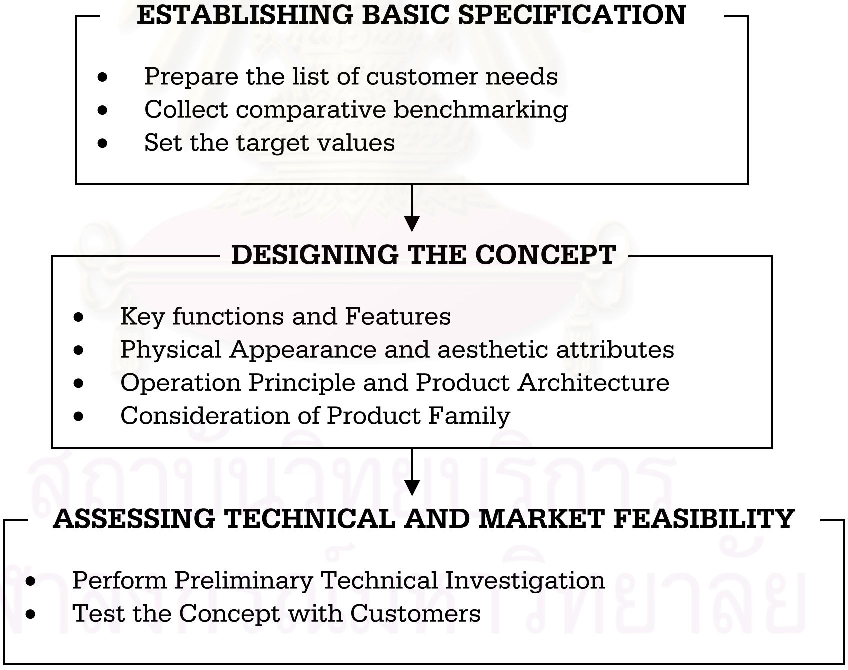

Figure 4.5 Overview of Concept element

(1.) Establishing Basic Specification

The product specification describes what the product has to provide and defines the product characteristics, which is based on what customer needs/wants and how the producer can meet the expectations. This initial specification combines the hopes and wishes of customers with the desires and practical aspects of technical capabilities and recourses of the organization, along with the marketing and financial implications (Rainey, 2005). Thereby, the product specification is the translation of the customer voice into technical terms.

Basically the product specification can be set out through a simple relationship matrix (Table 4.3) matching between needs and product characteristics. In addition, the method also includes a comparative analysis between the new product and its potential competitors. Ulrich and Eppinger (2003) suggested the following steps to establish the target specification.

(1.1.) Prepare the list of customer needs

The first step is to organize the needs obtained from the understanding customer needs and put into the rows of the matrix. Then the core team considers what characteristics, both tangible and intangible aspects, correspond to the needs. Finally, these product attributes are filled into the columns of the matrix.

(1.2.) Collect comparative benchmarking

By using the data obtained from the assessing competitive situation in the ideation element, the core team tries to put competitor values into the matrix.

(1.3.) Set the target values

By looking at what the customers need and how the competitors provide, the core team tries to set the target values for each specification item. The objective of setting these values is to satisfy customer requirements and compete with the other producers both at the present and in the future situations.

Table 4.3 A Simple Relationship Matrix

Customer Needs	Customer Requirements		Our Targets	Competitors	
	1	2		A	B
Primary Needs					
Basic Specification					
Voltage					
Current					
Frequency					
Operation Temperature					
.....					

O : Yes, X :No, n/a : not available

(2.) Designing the Concept

Once the major specification is set out, the core team begins to design the product concept. The objective is to produce design principles for the new product, which include key functions and features, physical appearance and aesthetic attributes, and operating principle and product architecture. In addition, if the product platform strategy is pursued, the concept has to be considered for the other models and the expansion options in the product family.

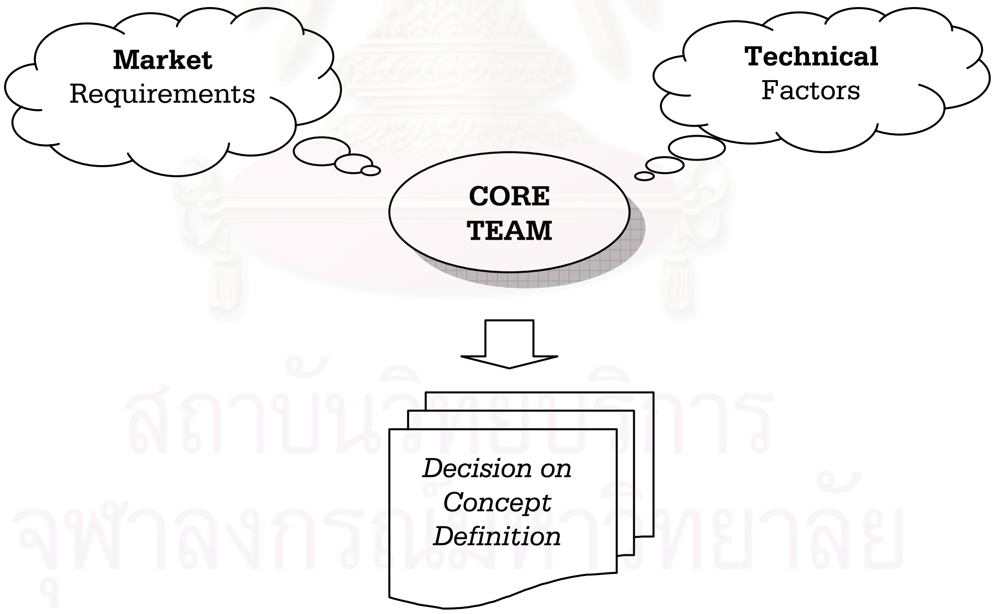

Figure 4.6 Concept Definition Process

Since the concept definition is quite complicated and very difficult to be set by using only a simple relationship matrix, the core team has to conduct in-depth discussion for such design principles. As shown in Figure 4.6, each concept item is brought into discussion meetings through evaluation based on market requirements and technical factors, and is finally concluded into concept definition.

(2.1.) Key functions and features

In the target specification, the product attributes are roughly defined because it aims to compare with customer requirements and competitor's products through looking at the overall picture of the product. For the concept development, the key function and featured are considered further in the detail.

(2.2.) Physical appearance and aesthetic attributes

One of the issues has to be considered during the conceptual design is to define how the product is looked like and where the important features is located. Early considering these physical appearance and aesthetic attributes is very important to both technical and market issues. For the case company products – electricity meters, the outline dimensions and the detail of user interfaces should be included in the concept design.

(2.3.) Operating principle and product architecture

In fact, there are several ways that the developed product can meet the target specification. In order to reduce ambiguity during the full development phase, the key operating principle and the product architecture have to be defined during the FFE phase. Additionally the major decisions in this early stage linking with key materials, components, and technologies can lead to involvement of key suppliers and partners.

(2.4.) Consideration for the product family

Once the basic concept is determined, the other models and the expansion options have to be further considered. For instant, one combination of an ordinary model and communication units can result into an advance electricity meter with Internet communication capability. In addition, derivative models can be in the forms of different voltage and current rating. This platform family planning enables the case company to offer two or more derivative products that share a substantial fraction of main parts and components.

(3.) Assessing Product/Market Feasibility

Before the concept is brought into the planning element, it is essential to ensure that technical development and commercialization are possible. The fist thing is to perform preliminary technical investigation. After that, the proven concept should be evaluated by the customers in order to know how well it corresponds to their needs/wants. Thus, by assessing product/market feasibility, technical and market uncertainties can be significantly reduced during the FFE stage.

(3.1.) Perform preliminary technical investigation

Depending on each situation, especially when using emerging technologies or new techniques, the case company might choose performing preliminary technical investigation before concluding the concept. For the case company, the following methods are suggested.

(i.) Rapid Prototype and Computer Visualization

"The possibility to get early feedback from a wide range of audiences (internal and external) has a further benefit: it allows to weed out mistakes early" (Stamm, 2003).

The use of prototype models enables the defined concepts to be early evaluated by technical people as well as customers. It is also useful for resolving crucial questions quickly and unambiguously. Thus, the case company can assess tangible or visible concept through rapid prototyping or computer visualization.

Rapid prototyping is the means of testing the designed concepts, especially mechanical constructions of an electricity meter. It allows physical prototypes of solid parts to be made in minimum lead time, without expensive molds and dies. Yet there is another inexpensive approach – the computer visualization. This doesn't only provide the core team with a near-perfect representation of the product and its components, but also leads to demonstration of production assembly.

(ii.) Product Cost Modeling

Evaluating the product concept in terms of cost requires an estimation model.In general, product cost mainly consists of material, manufacturing, and overhead costs. Although this seems to be complicated and requires detailed information and data about the product specifications, engineering details, and production requirements, the conceptual cost can be modeled by using the information from concept design, such as major components. Through using product cost modeling (Table 4.4), the core team can assess whether the concept is possible to be commercialized or not.

Table 4.4 Product Cost Modeling

ITEM			TARGET COST (THB)	NOTE
	Material Cost	Electronic parts		
		Mechanical parts		
	Subcontractor Manufacturing Cost	Component Assembly		
	In-house Manufacturing Cost	Product Assembly		
		Part Fabrication		
Shop Cost (SC)				
Total Cost (TC)				
Profit (Profit rate in %)				
Sale Price				

(3.2.) Test the concept with the customers

Once the product concept is created, it is time to get it in front of customer to see their reaction. Defined in the basic specification, the functions/features, and physical appearance, the concept is brought into discussion with the major customers. The purpose is to make sure that customers will buy such new product when it releases into the market. As a result, early testing the concept with customer is not only an assessment of market feasibility, but also a way to get suggestion or even complain for further improvement.

4.3.3. Element 3 - PLANNING

Once the product concept is set out, the core team has to go further into the planning element, which includes determination of development activities and schedule, identification of resource, investment, and facility needs, and strategic decisions on sales/marketing, manufacturing, and business/finance.

(1.) Development Schedule and Resource Allocation

Scheduling development tasks and allocating resources are prime steps for the planning element. The purpose is to determine the formal development efforts in terms of sequence, timing, man power, and necessary skills. From the project management practices, there are many available methods and tools to facilitate these kinds of planning activities. To be appropriate for early development tasks of the EPDD, the following approaches are suggested; Work Breakdown Structure and Gantt Charts.

(i.) Work Breakdown Structure

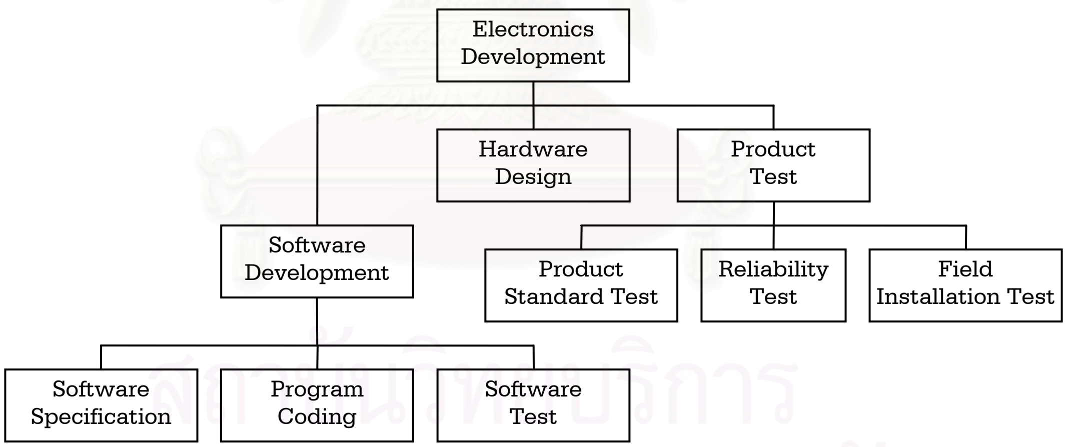

Figure 4.7 Work Breakdown Structure (WBS)

The first step is to break the product development project down into a manageable level (see Figure 4.7). The main task is hierarchically broken down into partial activities until to the smallest tasks, called work packages. For instant, a software development can be subdivided into specification, coding, and testing tasks. This is the same as in hardware jobs in which product testing work can be broken down into standard test, reliability test, and field installation test. Finally, with use of this work breakdown structure (WBS), timings and resources can be simply estimated and allocated to each work package.

(ii.) Gantt Charts

Once the full development phase is broken down into sub-processes based on the WBS technique, the relationships of tasks have to be mapped out to determine which ones are dependent on each others. Some tasks might be sequentially tied to the predecessors if inputs from the upstream steps are necessary. For instant, coding tasks can not be started earlier than completion of writing software specification. By using the bar charts or Gantt charts (Figure 4.8), all project tasks, both dependent and independent, can be properly scheduled.

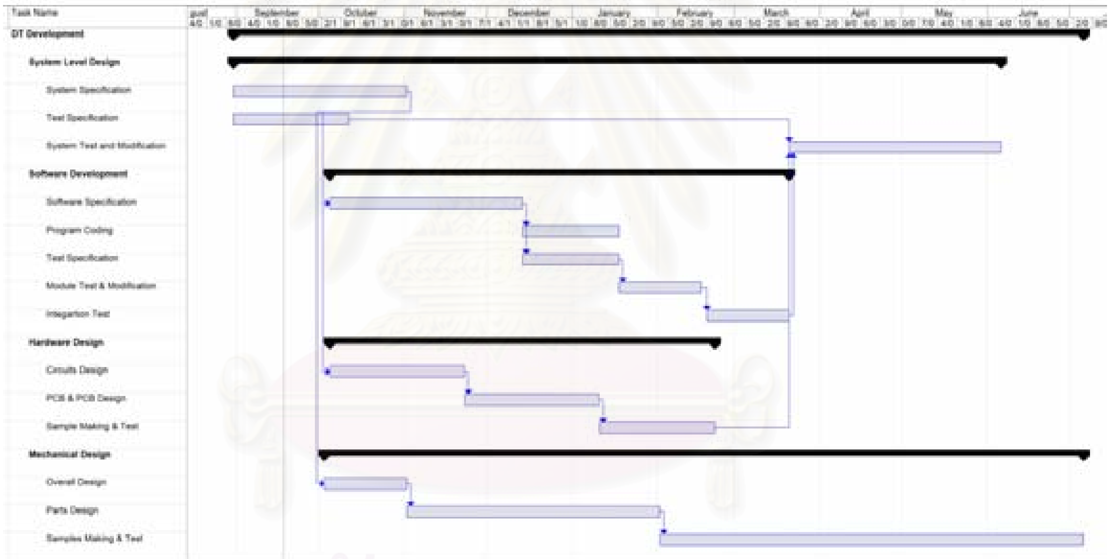

Figure 4.8 Gantt Charts

(2.) Development Expense and Tools/Facility Investments

Founding development expense and tools/facility investment is the most critical step of planning activities. Expense for development execution is the money that shall be spent out without retainable assets. Generally this includes cost for making prototypes/samples as well as charge from third-party testing laboratories. On the other hand, tools/facility investment is the money that shall be used for buying manufacturing assets, such as new testing equipments.

To be compromise with the case company accounting system, the estimates of development expense and manufacturing investment shall be categorized into:

- Mold/Die/Tool Estimates
- Development Facilities
- Manufacturing Facilities
- Development Expense

(3.) Sales Plan and Marketing Strategy

Once the core team ends up with a product concept including technical specification as well as target costs, the SMD considers possibilities to gain market shares from introduction of this new product. Based on the competitor assessment and market research information, five-year sale targets are then forecasted. The figures of sale revenues are quite related to the marketing strategy. Thus, the plan should include not only how many units will be sold out, but also what kind of strategic intents will be deployed for such new product.

(4.) Manufacturing and Supply Chain

Manufacturing and supply networks are vital to success of any product development project (Rainey, 2005). The planning for contributions of suppliers and distributors should begin as soon as the initial concept is constructed. Early identification of strategic suppliers and partners will facilitate the case company to improve efficiencies, effectiveness, linkages, and waste reduction. In addition, this also provides the stakeholders in the further stage to consider how to maximize manufacturing benefits from product functions/features. For instant, if the hardware engineers recognize where the electronic boards will be produced, the supporting features for quality checks can be provided in order to reduce defective rate. Thus, the tentative manufacturing, operations, or supply plan should be set out at the early phase.

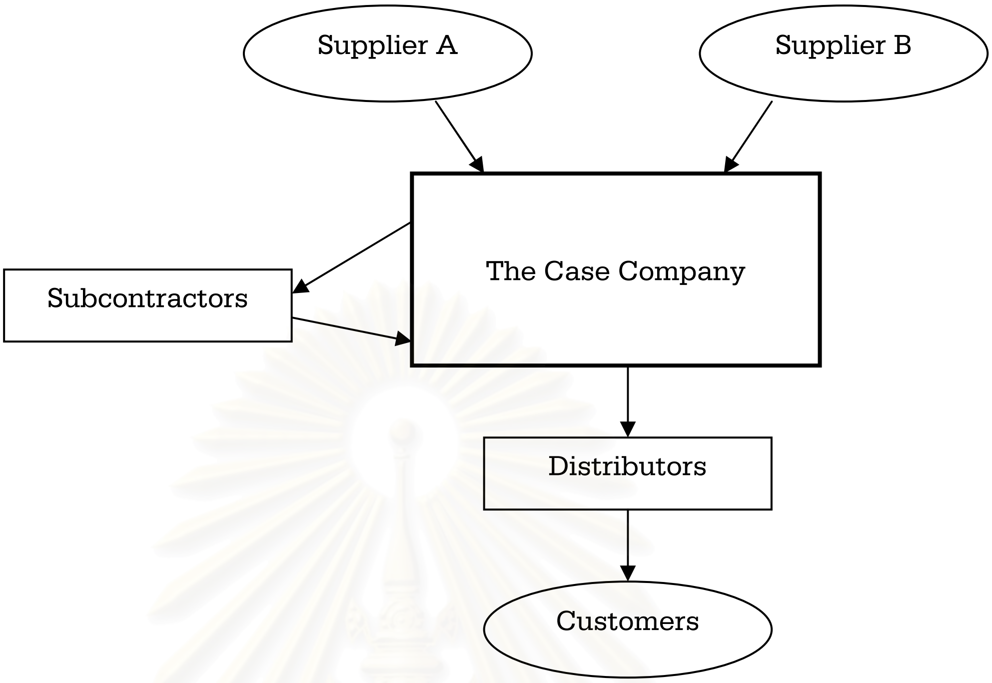

Figure 4.9 Manufacturing and Supply Chain Plan

(5.) Financial/ Business Case Analysis

The final activity during the planning step is the analysis of financial/ business case. Obviously, before going to propose the executive committee, this crucial step has to demonstrate how profitable the new product is. To provide a quick step, the financial/business case analysis table is developed for the case company. See table 4.5. By using the previous data such as product cost, sale targets, and development expense/manufacturing investment, the core team tries to adjust each figure to maximize the profits.

Table 4.5 Financial/Business Case Analysis

	FISCAL YEAR	Year 1	Year 2	Year 3	Year 4	Year5
BUSINESS CASE ANALYSIS	[1] Sales Volume (Unit)					
	[2] Sales Revenue (KB)					
	[3] Unit Cost (B)					
	[4] Unit Price (B)					
	[5] Profit Ratio (%)					
	[6] Profit (exc. of ROY.)					
	[7] Cost Reduction (KB/Yr)					
	[8] Development Cost (KB)					
	[9] Cum. Dev. Cost (KB)					
	[10] Machine Investment (KB)					
	[11] Cum. Mac. Invest. (KB)					
	[12] Tool Investment (KB)					
	[13] Cum. Tool Invest. (KB)					
	[14] Mold & Dies Invest. (KB)					
	[15] Cum. M&D. Invest. (KB)					
	[16] Jig Investment (KB)					
	[17] Cum. Jig Invest. (KB)					
	[18] Initial Payment (KB)					
	[19] Cum. Init Pay. (KB)					

4.4. VERIFICATION OF THE PROPOSED FFE FRAMEWORK

Prior to an implementation into the demonstration project, the customized FFE framework should be reviewed against the four design inputs and constrains. This is to ensure that the developed FFE fulfilled the design objectives.

4.4.1. Company Structure and Process Fit

As stated in the framework, the stakeholders still include SMD, EPDD, MFD, and the engineering director, and the major resources are from EPDD. See Figure 4.10. This new framework does not require any new department, and additional resources.

In addition, the FFE process does not affect to any radical change. The three-element FFE model with suggested methods and tools was put instead of the technical investigation activity. It works by conveying market data from SMD into the Ideation element, and ends up with the planning element integrating the Sales strategy together. Thus, the primary responsibilities of SMD are still the same.

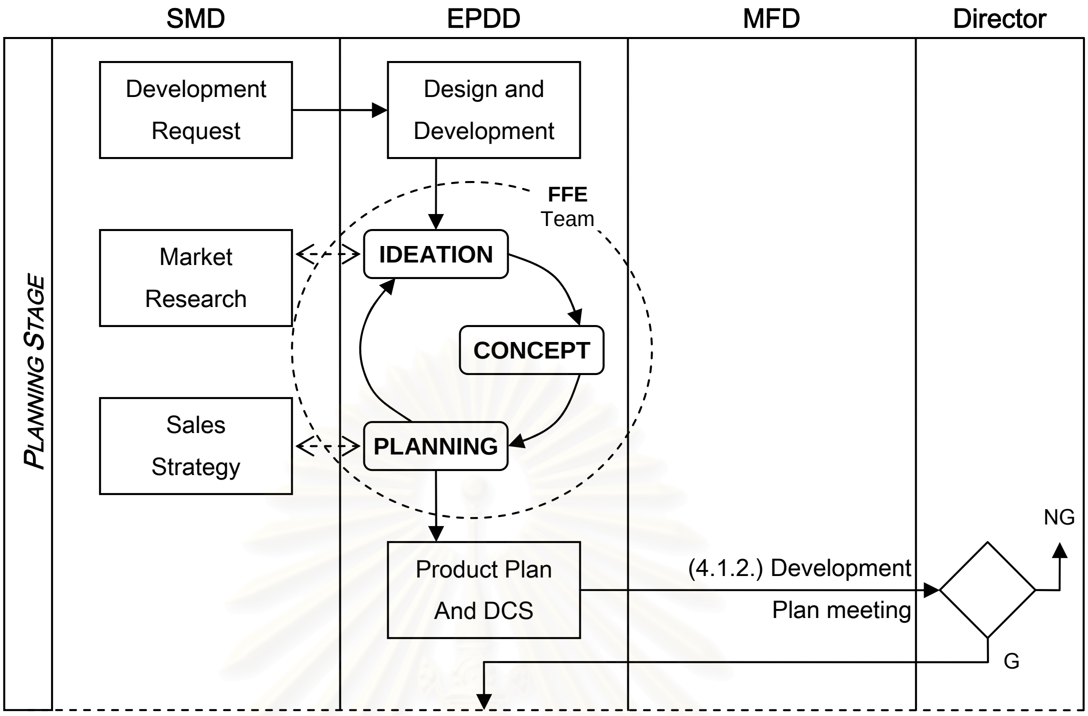

Figure 4.10 New Pre-Development Process

4.4.2. Desirable Outcomes

By using the practical methods and tools, the desirable outcomes can be delivered as in the Table 4.6.

Table 4.6 Outcomes VS Practical Methods and Tools

REQUIRED OUTCOMES	PRACTICAL METHODS AND TOOLS
Product Strategy	Prerequisites • New Product Strategy
Design Specification and Standards	Establishing Basic Specification
Manufacturing Chain	Manufacturing and Supply Chain
Cost Analysis	• Product Cost Modeling • Development Expense and Tools/Facility Investments
Project Resource and Schedule	Development Schedule and Resource Allocation with: • WBS • Gantt Charts
Business Case	Financial/ Business Case Analysis

As summarized, it obviously indicates that the use of the customized FFE leads to deliver the company's required outcomes.

4.4.3. Further Uncertainty Reduction

To improve the FFE speed, the customized framework additionally includes several methods to reduce uncertainty. See Table 4.7 and 4.8.

Table 4.7 Additional Market Uncertainty Reduction

MARKET APPROACHES	BEFORE	AFTER
Understanding target market and customer needs, and integrating them into product definition	n/a	Product specification can be set out through the simple relationship matrix
Direct contact to customers	Information from Sales	Customer Visit Programs
Customer complaints	n/a	Using Voice-of-Customer research to uncover new opportunities
Customer surveys	n/a	n/a
Market research or study by externals	n/a	n/a
Analysis of competitors and their products	n/a	Assessing Competitive Situation

n/a : not available

Table 4.8 Additional Technical Uncertainty Reduction

MARKET APPROACHES	BEFORE	AFTER
Verifying technical feasibility and clarifying technical requirements	n/a	Perform preliminary technical investigation
Simulation	n/a	n/a
Virtual reality techniques	n/a	Rapid Prototype and Computer Visualization
Rapid prototyping	n/a	
Early physical prototyping.	n/a	

n/a : not available

Compared with the present FFE process ("before" columns), the customized FFE framework has been further improved with the use of methods and tools in "after" columns.

4.4.4. Formality and Integration Improvement

Refer to the checklist again, the customized FFE was re-assessed and resulted into the Figure 4.11.

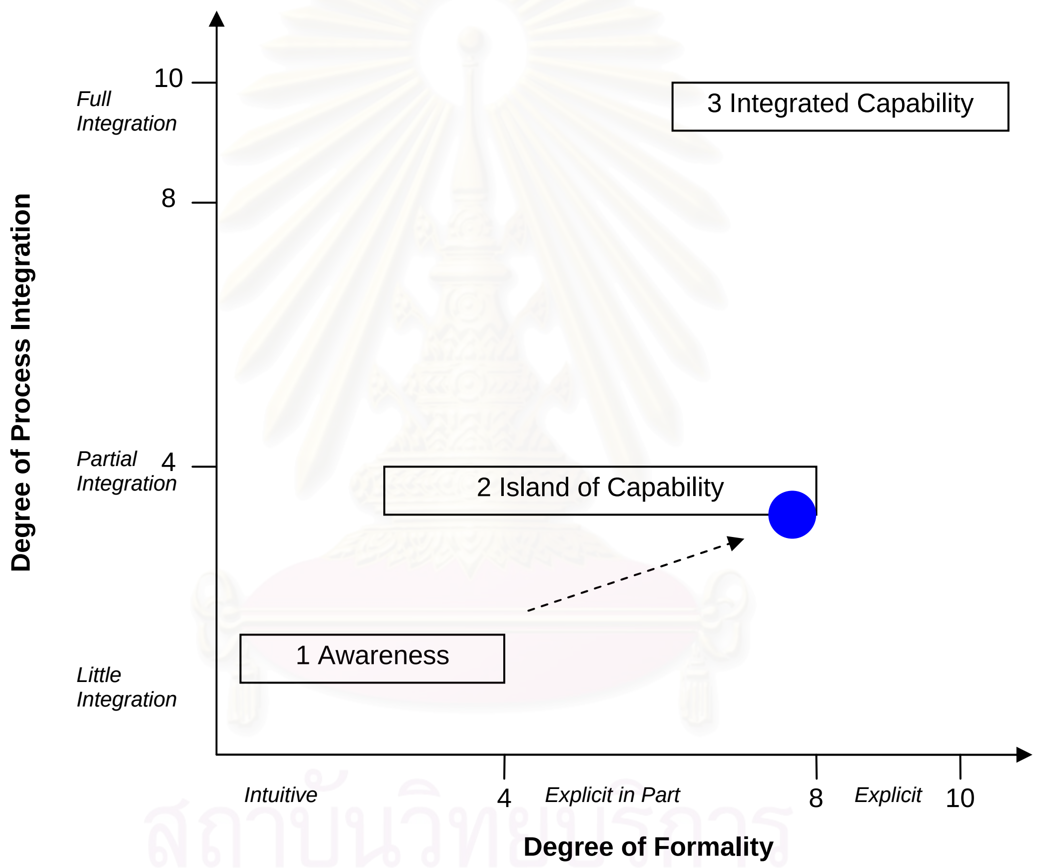

Figure 4.11 Re-Assess Front-End Capability

The result of diagnosing FFE capability showed that the customized framework was improved from the awareness level to **the island of capability level**. This means the case company has more capability to effectively execute the FFE activities.

CHAPTER 5
A Demonstration Project

In this chapter, the developed FFE framework will be implemented into a demonstration project, a new platform project namely as Multi-2 Meter (M2M).

Prior to the implementation, the author explained the framework to people who involve in this implementation. The core team then performed pre-development activities with the use of this framework including the suggested practical methods and tools. Finally, the core team ends up with the deliberated documents: product plan and development control sheet. See Appendix 3. At the end of this demonstration project, the author also conducted a post project review with the key personal in order to capture how the new FFE framework benefited to the case company.

Since some data are confidential to the case company, some names or figures has either been disguised or removed all together.

5.1. PROJECT BACKGROUND

5.1.1. The Multi-2 Meter (M2M)

Nowadays, electronic technologies are rapidly changing. Upcoming of new technologies encourages new electricity meters to be more advance in functions at lower cost. In the electronic meter markets, the new models will come out and replace the old ones every a half decade. Since the previous model - M1M - has been in the markets for several years and is facing with new products from fierce competitors, the case company needs a new platform model, M2M.

5.1.2. New Product Strategy & Product Family Roadmap

Required as supporting elements, the product strategy formulation and product family planning should be set out prior to the FFE activities. According to the company's annual plan, the new product strategy is provided as:

"The development of M2M for network application will begin in 2xxx. In order to serve arising demand of expansive function meters, this new platform model will be released in the 2xxx. After that, the development of derivative versions of M2M will be performed in a continuum."

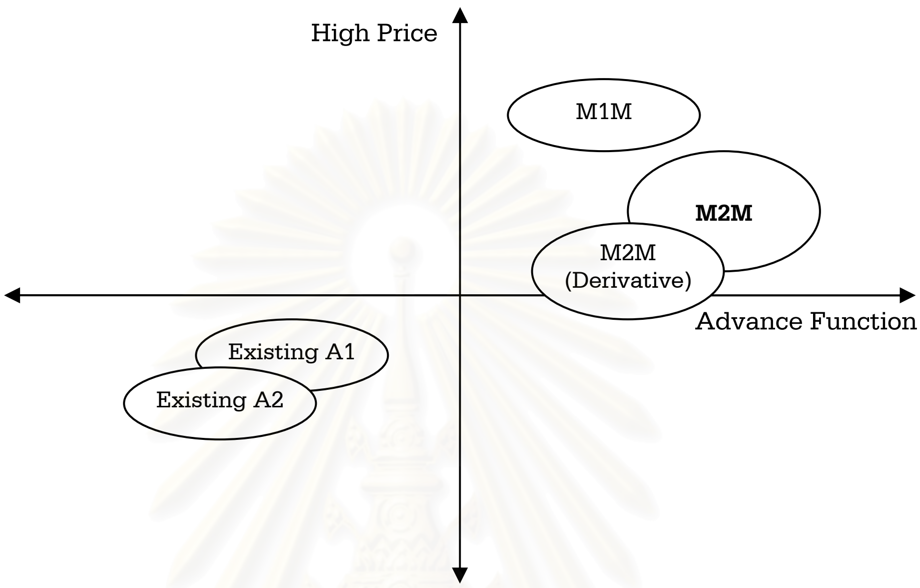

Figure 5.1 Product Family Map

As directed by the company strategies, within the focused arenas, the new product and its derivative models are mapped out as in the Figure 5.1.

5.1.3. The Project Leader and the Core Team

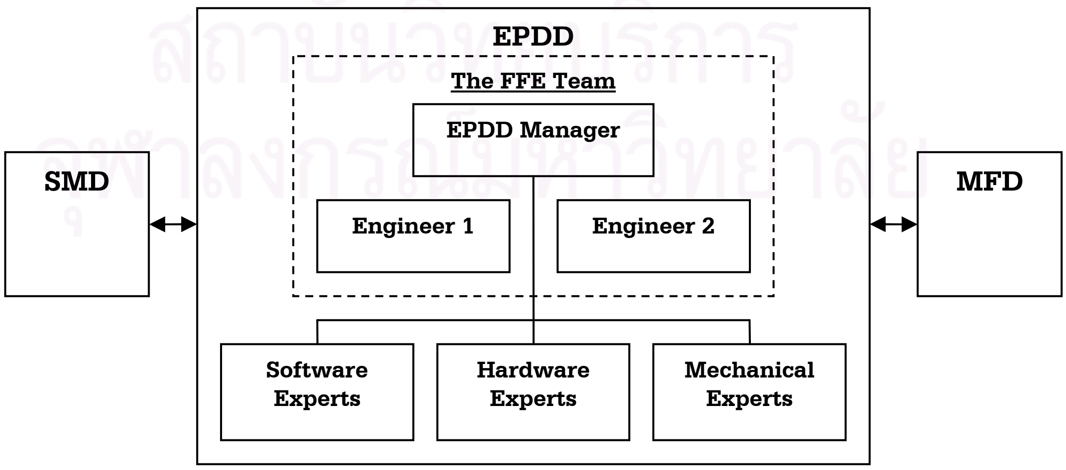

Figure 5.2 The Front-End Team

Once the new product was initiated, the senior management assembled a small FFE team, including a project leader (EPDD manager) and a core team (engineer 1 and engineer 2). While the EPDD manager leads performing all FFE activities, the core team acts as representatives from marketing and technical areas. For instant, engineer 1 requested SMD to acquire customer information and sometimes contacted the experts to suggest for possible techniques. As a result, together with the relevant departments and technical experts, the FFE tried to match foreseen market opportunities with available technology options.

5.2. FFE ACTIVITIES

Form the outlined framework, the FFE team followed the instruction and adopted the practical methods and tools as appropriate.

5.2.1. Ideation

(1.) Opportunity Identification

The first step in the ideation is to identify market opportunities. This can be done through defining clear picture of product/market segment and well-understanding current and future needs.

To obtain current information in the electricity meter market, the core team appointed meetings with the sales forces. From the former market information, the core team tried to update the current situation by questioning about:

- Is the market still segmented in the same pattern as in previous information? Is there any new or emerging segment?
- How many competitors do address each segment? What makers and models? Is there any new product coming? Is there any competitor moving out? Is there a new comer?
- Can sales get any new requirements in the form of tender specification or problems/difficulties that the customers are encountering?

- Can sales obtain competitors information in the forms of catalogues, manuals, samples, and company information?

From the above sources of information, the core team analyzed the data and tried to understand opportunities. The core team then asks SMD to visit customer site in order to gain in-depth understanding of customer needs.

(1.1.) Defining the Product/Market Segment

Figure 5.3 is the market segment grid for XYZ products. It shows a total of four potential competitors serving five market segments: A, B, C, D, and E. For customer 1 only, the first competitor offers A-102 covering two market segments, the second one offers B-104, B-304, and B-102 covering all segments as well as specific needs, and the third one offers C-104 and C-103. The fourth competitor offers D-104 for customer 1 and 2, and is going to launch a new model, D-104+, to compete with A, B, and C in the lower price range area. The last one, E, just offers a single model E 104 to serve customer 2 only.

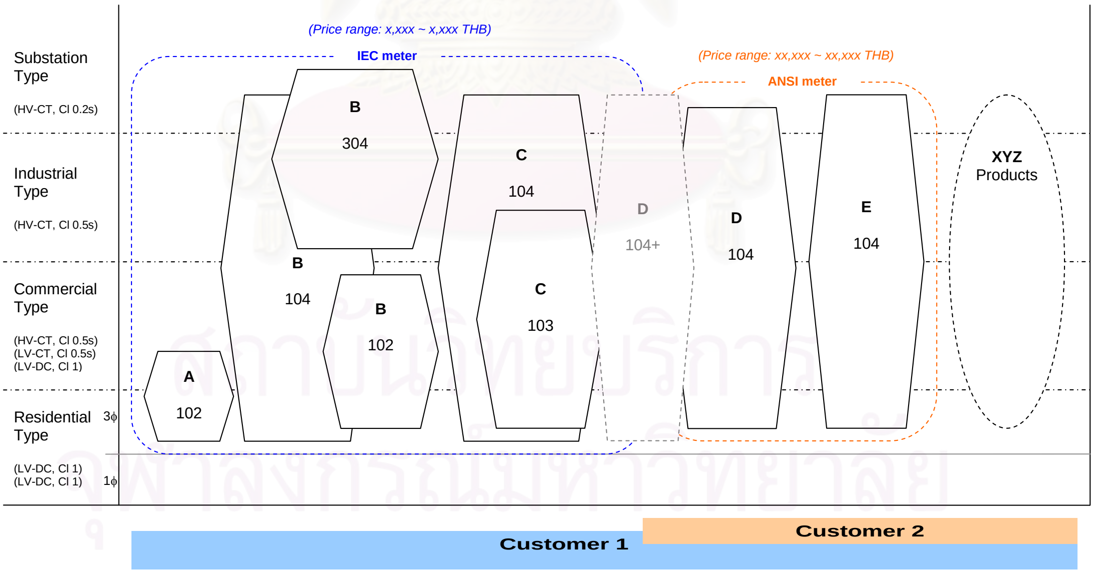

Figure 5.3 Market Segment Grid

(1.2.) Understanding Customer Needs

The case company's customers consists of two major power transmission and distribution (T&D) companies, namely as customer 1 and customer 2. Since they normally purchase electricity meters products through bidding approaches, the primary requirements are stated in the tender specification documents.

Although the articulated needs are specified in technical terms, they don't include every need. There are still some latent needs which cannot be clearly stated and these may come up within the next few years. Therefore to obtain such hidden requirements, the FFE team employed additional methods; VOC and customer visit program. The team requested SMD to capture every complaint, and every emerging idea from the customers. In addition, the core team conducted customer visit program to gain in-depth understandings in particular issues.

Finally, these customer needs were collected and listed up in the table 5.1.

Table 5.1 Customer Needs Lists

List up the Needs — *4 Market Segments / 2 Primary Customers*

CUSTOMER NEEDS	Substation		Residential	
	Customer 1	Customer 2	Customer 1	Customer 2
Primary Needs				
Basic Specification				
Voltage	xxxxx	xxxxx	xxxxx	xxxxx
Current	xxxx	xxxx	xxxx	xxxx
Frequency	xx	xx	xxxx	xxxx
Operating Temperature	xxx ~ xxx	xxx ~ xxx	xxx ~ xxx	xxx ~ xxx
Features				
Local Intetface	xxxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxxx	xxxxxxxxxxxx
Remote Interface	xxxxxxxxxxxx	n/a	xxxxxxxxxxxx	n/a
Key Function A				
A1	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx
A2	n/a	X	n/a	X
A3	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx
A4	xxxxxxxxxxxx	n/a	xxxxxxxxxxxx	n/a
Key Function B				
B1	xxxxxxxxxxxx	n/a	xxxxxxxxxxxx	n/a
B2	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxxx
Key Function C				
C1	xxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxx	xxxxxxxxxxxx
C2	n/a	xxxxxxxxxxxx	n/a	xxxxxxxxxxxx
C3	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx
Latent Needs				
Group 1				
xxxxxxxxx	O	Yes	O	Yes
xxxxxxxxx	n/a	Yes	n/a	Yes
xxxxxxxxx	n/a	X	n/a	X
Group 2				
xxxxxxxxx	Yes	n/a	Yes	n/a
xxxxxxxxx	n/a	n/a	n/a	n/a

O : Yes, X :No, n/a : not available

(1.3.) Assessing Competitive Situation

Once the markets and the customer requirements were understood, a competition analysis is essential to determine how well each product fulfills the specific needs and how vulnerable they are. Based on a defined market segment map, the FFE team focused on specific competitors to explore their product specifications including features and functions and their strong/weak points.

Table 5.2 Competitors Analysis

COMPETITIVE PRODUCTS	STRENGTHS	WEAKNESSES	REMARK
A-102	• very low price	• xxxxxxxxxxxxxx • xxxxxxxxxxxxxx • xxxxxxxxxxxxxx	xxxxx
B-104 B-102 B-304	• xxxxxxxxxxxxxx • Local Manufacturer • Xxxxxxxxxxxxxx • xxxxxxxxxxxxxx	• xxxxxxxxxxxxxx	xxxxx
C-103 C-104	• xxxxxxxxxxxxxx • xxxxxxxxxxxxxx • xxxxxxxxxxxxxx	• xxxxxxxxxxxxxx • xxxxxxxxxxxxxx	
D-104 D-104+	• xxxxxxxxxxxxxx • High product benefits/cost ration with the new model (D-104+) • xxxxxxxxxxxxxx • xxxxxxxxxxxxxx	• xxxxxxxxxxxxxx	xxxxx
E-104	• Xxxxxxxxxxxxxx • xxxxxxxxxxxxxx	• xxxxxxxxxxxxxx • xxxxxxxxxxxxxx	

By using the competitor information derived from several sources, such as Internet, catalogues, and brochures, the core team analyzed competitor's products. See Table 5.2.

(2.) Idea Generation and Selection

(2.1.) Getting Sources of Ideas

The previous steps didn't only facilitate the core team to gather market, customer, and competitor information, but also provided valuable sources of ideas. For instant, during Sales meetings and customer visit programs, the core team took opportunities to capture ideas from them. In addition, to analyze competitors products the core team tried to understand weak and strong points by making comparison table for their specification, function, and features and tearing their samples down to its basic components.

Recently some of the core team members attended the Metering Asia exhibition. This chance provided the case company to obtain oversea sources of product ideas. Many new meter products were brought to show in such exhibition. While some companies presented their novel features, the other companies pointed out their strong points.

Apart from that, the core team made contacts with electronic part suppliers to know new components and devices. These new options enabled the case company to develop a new meter with sophisticated function as well as at very competitive cost.

(2.2.) Selecting the Potential Idea

As indicated in the Table 5.3, the core team listed up the evaluation factors. Then the core team conducted team-approach evaluation by scoring each idea and finally summed up the total score. The highest one – IDEA 2, was chosen for defining product concept in the further step.

Table 5.3 Factors for selecting the suitable idea.

SELECTION CRITERIA		IDEA 1		IDEA 2	
	Weight (%)	Rate (1-5)	Weighted Score	Rate (1-5)	Weighted Score
Product Factors					
1. Fills an unmet need	25%	4	1	4	1
2. Higher Performance/Function	15%	3	0.45	4	0.6
3. Lower Product Cost	10%	3	0.3	5	0.5
Market Factors					
1. Strength to competition	20%	3	0.6	4	0.8
Company Factors					
1. Fit with existing manufacturing facilities	15%	3	0.45	3	0.45
2. Utilization of labor intensive units	5%	3	0.15	4	0.2
Financial Factors					
1. Less investment for facilities / tools	10%	4	0.4	3	0.3
TOTAL SCORE			**3.35**		**3.85**

5.2.2. Concept

(1.) Establishing Basic Specification

Through comparing the customer needs listed in Table 5.1 with the specifications extracted from competitive products, the FFE team is able to set the specification values. The primary approach relied on in-depth discussion which finally resulted into the target characteristics (Table 5.4).

Table 5.4 Establish Target Characteristics

Customer Needs	Customer Requirements		Our Targets	Competitors	
	1	2		A	B
Primary Needs					
Basic Specification					
Voltage	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx
Current	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Frequency	xx	xx	xx	xx	xx
Operation Temperature	xxx ~ xxx	xxx ~ xxx	xxx ~ xxx	xxx ~ xxx	xxx ~ xxx

O : Yes, X :No, n/a : not available

(2.) Designing the Concept

(2.1.) Key functions and features

The FFE team divided main functions and features into four categories: interface features, key function A, key function B, and key function C. Again by using the customer requirement specifications compared with the available products, the FFE team researched for available techniques and technologies to define the key functions and features. For specific topics, the FFE team conducted meetings to discuss with relevant experts about how the features and functions should be.

(2.2.) Physical appearance and aesthetic attributes

Once the preliminary concept was defined, the FFE team then requested mechanical designers draw up construction models which showed physical appearance as well as aesthetic attributes. Particularly this also includes how large dimensions of the casing and how displayable pattern of the liquid-crystal display are.

(2.3.) Operating principle and product architecture

The core team set up meeting with relevant engineers to consider key operating principle of the new meter. This includes discussion of how the meter should operate. Figure 5.4 gives an example of the electronic block diagram including strategic components and general parts.

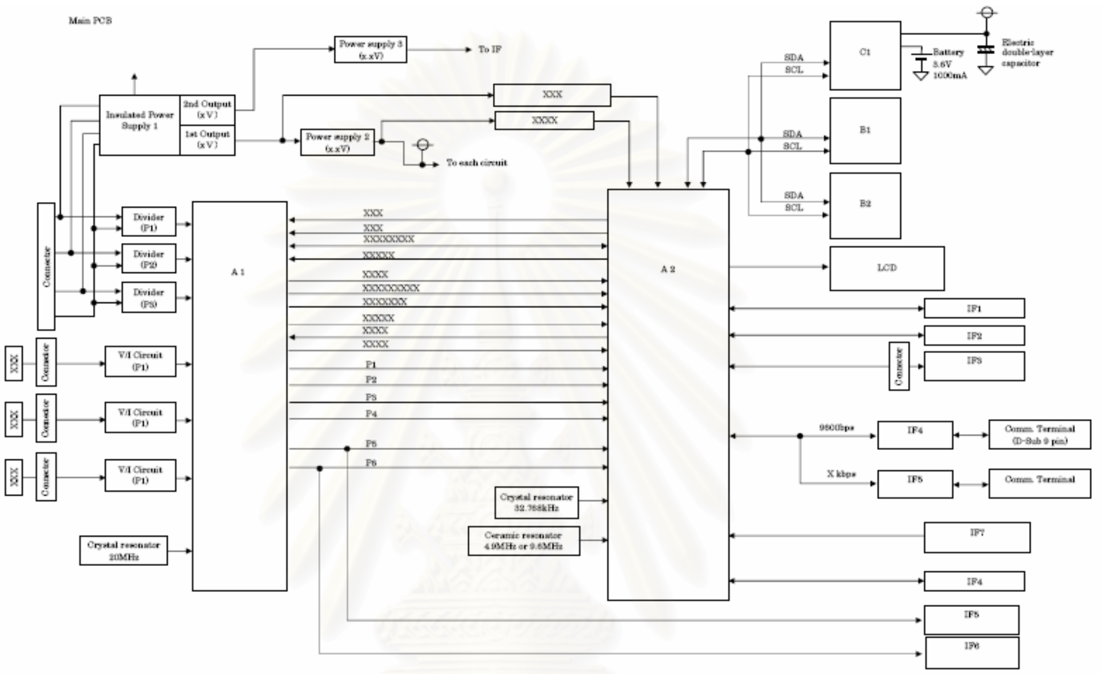

Figure 5.4 Electronics Block Diagram

(2.4.) Consideration for the product family

Previously the FFE team focused on a single model, the primary platform. This step is to consider the derivative sets (Figure 5.5).

Model	XXX	Current Rating	Ref. Voltage (Operating Range)	Accuracy Class	Protection Class	Note
M2M/1	XXX	XXX A	XXXX V (XXX – XXX V)	xxx xxx	IPxx	xxx Type
	XXX		XXX (XXX– XXX V)			xxx Type
			XXXX V (XXX – XXX V)			xxx Type
M2M/2	XXX	XXX A	XXXX V (XXX – XXX V)	xxx xxx		Commercial & Residential Use
	XXX		XXXX V (XXX – XXX V)	xxx		Commercial & Residential Use with kWh only

Figure 5.5 Product Family Models

(3.) Assessing Product/Market Feasibility

In order to reduce development risks, the FFE team decided to perform the feasibility assessment. This is through computer visualization, product cost modeling, and concept test.

(3.1.) Perform Preliminary Technical Investigation

(i.) Computer Visualization

Once the mechanical engineers drawn up the physical construction, it is essential to make sure in computer visualization. The three-dimensional model made of computer aided design software was employed to facilitate a technical feasibility assessment. This enabled the FFE team not only to see how the new meter looks like, but also how it will be assembled in mass production.

(ii.) Product Cost Modeling

From the key functions and features, electronic block diagram, and mechanical concept, the product cost was modeled to explore possible profit margin. See Table 5.5. By using this method, the FFE team is able to evaluate the commercial aspects.

Table 5.5 Product Target Cost

XXXX units/month

Item			Target Cost(THB)		Note
			M2M/1	M2M/2	
	Material Cost	Electronic parts	XXX	XXXX	xxxx xxxxxxxx xxxxxxx
		Mechanical parts	XXX	XXXX	xxxxxxxxxxxxxxxxxxxxxx
	Manufacturing Cost in Subcontractor	Board Assembly	XXX	XXX	
	Manufacturing Cost in XYZ	Assembly	XX	XXX	
		Fabrication	XX	XXX	
Shop Cost (SC)			XXXX	XXXX	
Total Cost (TC)			XXXX	XXXX	SC×x.xx
Technology Licensing Royalty			XXX	XXX	x% of Sale Price
Profit (Profit rate)			XXXX (xx.x%)	XXXX (xx.x%)	
Sale Price			XXXX	XXXX	

(3.2.) Test the concept with the customers

At this point, almost product concept was created. It is time to bring the conceptual specifications, functions/features, and mechanical models to discuss with the key customers. The project leader requested SMD people to set up a customer visit program again. Finally, the visiting results indicated that taking this early concept to talk with customers gave the FFE team very much benefit. It is not only receiving early comments, but also getting customer involvement and commitment.

5.2.3. Planning

(1.) Development Schedule and Human Resource Allocation

The core team began with the work breakdown structure to identify all work packages required in the development stage. According to Figure 5.6, the full development task was hierarchically broken down into two major activities: DT development and PT development. These major activities were then split into partial tasks until to the smallest packages.

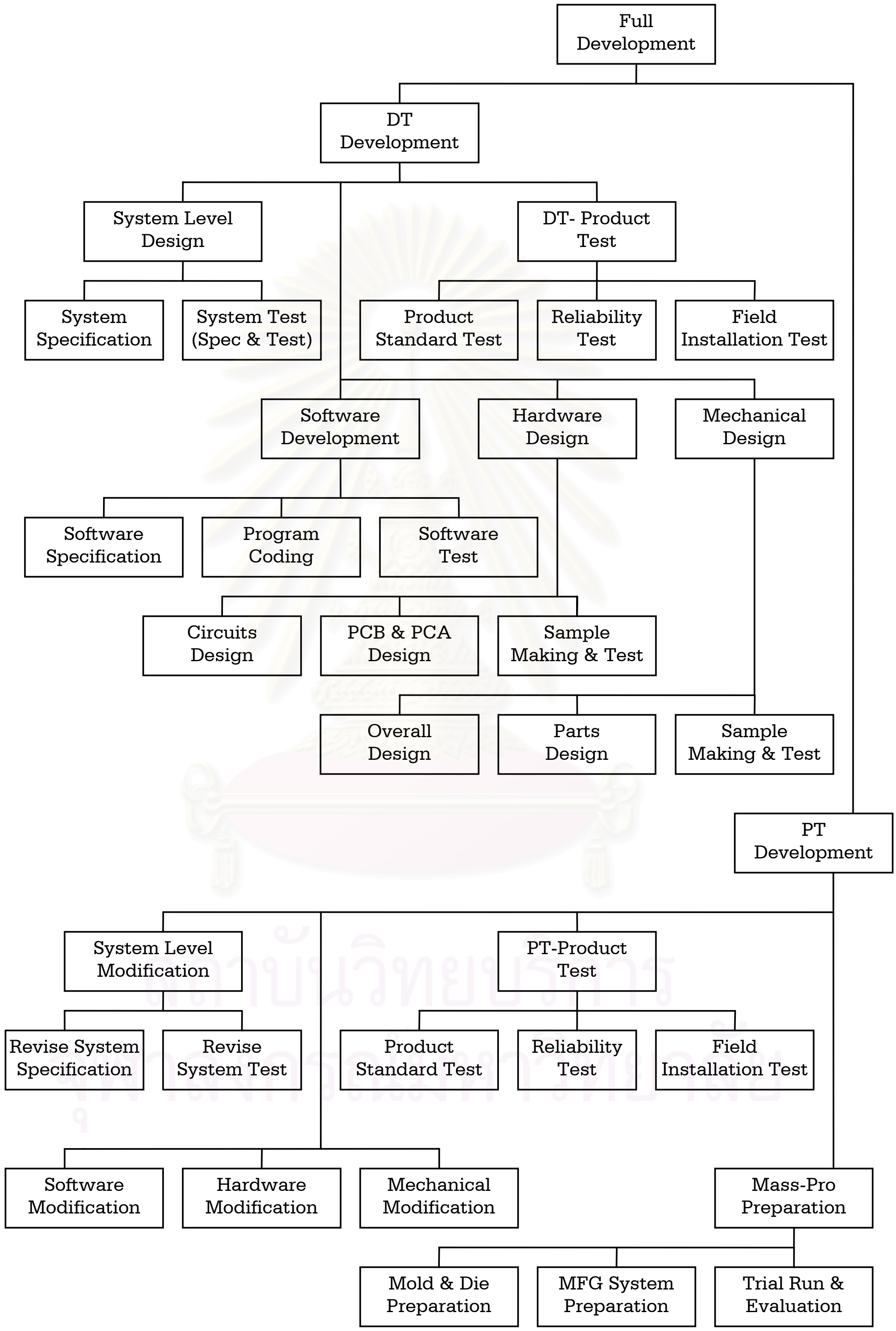

Figure 5.6 Work Breakdown Structure

To plan for time and resource, the Gantt charts were used for ease of understanding. Once the major milestones were predefined, the core team then arranged timing/sequence and allocated duration for each work package (Figure 5.7).

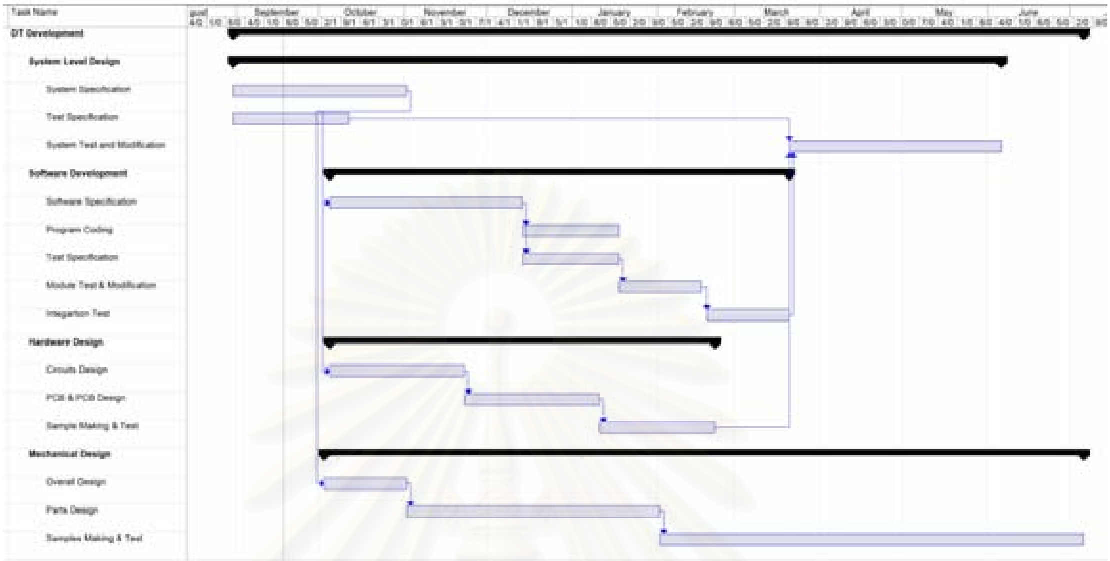

Figure 5.7 Gantt Charts

(2.) Development Expense and Tools/Facility Investments

Table 5.6 – 5.8 tabulate the development expense and the tools/facility investments for the M2M project. The listed items are based on core team experience and the cost estimates are derived supplier's quotations.

Table 5.6 Development Expense

EXPENSE ITEM	COST	NOTE
LCD Initial	฿XX,XXX	
PCB Initial	฿XXX,XXX	
Making sample for evaluation	฿XXX,XXX	xxx units (DT:xx units, PT: xx units)
Making sample for Customers	฿XXX,XXX	xxx units
Mechanical Evaluation	฿XXX,XXX	Circuits and Mechanical Parts
Outsource Testing Fee	฿XXX,XXX	Reliability, EMC
PCB Design Training	฿XXX,XXX	Singarepore PCB House
Complex S/W Development Training	฿X,XXX,XXX	Meter S/W
Outsource S/W Development Fee	฿XXX,XXX	Meter S/W
Outsource S/W Development Fee	฿XXX,XXX	Application S/W
	฿X,XXX,XXX	

Table 5.7 Tools Investments

MOLD/DIE/TOOL ITEM	COST	NOTE
LCD Tooling	฿XXX,XXX	Bending LCD pin
Die	฿XXX,XXX	Current conductor
Die	฿XX,XXX	Optical port plate
Mold	฿X,XXX,XXX	Terminal block
Mold	฿XXX,XXX	Base
Mold	฿X,XXX,XXX	Front cover
Mold	฿XXX,XXX	Switch
Mold	฿XXX,XXX	Terminal cover
Mold	฿XXX,XXX	Communication box
Rubber mold	฿XXX,XXX	Gasket
Mold and rubber mold modification	฿X,XXX,XXX	For Direct Connect type
Jig and tool for manufacturing line	฿XX,XXX	Terminal Cover Gasket
	฿X,XXX,XXX	

Table 5.8 Facility Investments

EQUIPMENT ITEM	COST	NOTE
Testing Equipment	฿X,XXX,XXX	Power source and standard meter
Testing tool for PCA	฿XXX,XXX	F/T, ICT for PCA manufacture
Testing facilities for production line	฿XXX,XXX	Rack, S/W, Pulse converter, etc
PCA Programming & Test tools	฿XXX,XXX	PC, Opt-probe, ICE, Compiler
	฿X,XXX,XXX	

(3.) Sales Plan/Marketing Strategy

From the product concept proposed by the FFE team, SMD then set up the marketing strategy as:

"SMD will first establish connection channels with network providers. Throughout the development period XYZ will try to update business information in order to re-enter to the market at suitable time. Up on the M2M is available; SMD will try to share the market with competitor D with the advantage of competitive price and a local manufacturer."

By using this strategy, the SMD expected the sales plan as in Table 5.9.

Table 5.9 Sales Target

ITEM	ANNUAL DEMAND				
	Year 1	Year 2	Year 3	Year 4	Year 5
Total Demand (1000 units/year) *[1]	XX	XX	XX	XX	XX
Target Sales Volume (1000 unit/year) *[2]	XX	XX	XX	XX	XX
(Million Baht/year) *[1] x [2]	XX	XX	XX	XX	XX
Target Cost Shop Cost (Baht) *[3]	XXXX	XXXX	XXXX	XXXX	XXXX
Total Cost (Baht) *[3] x factor	XXXX	XXXX	XXXX	XXXX	XXXX
Target Price (Baht)	XXXX	XXXX	XXXX	XXXX	XXXX
Target Profit Profit (Baht)	XXXX	XXXX	XXXX	XXXX	XXXX
Profit Rate (%)	XX	XX	XX	XX	XX
Target Profit Volume (Million Baht/year)	XX	XX	XX	XX	XX

(4.) Manufacturing and Supply Chain

Figure 5.8 shows a preliminary manufacturing and supply chain plan. All components, parts, and materials will be purchased by the XYZ company. Some parts will be brought out to a subcontractor to assembly into a component level. Finally, all parts will be assembly together and tested at the XYZ plant and results into finish goods stored in XYZ distribution areas.

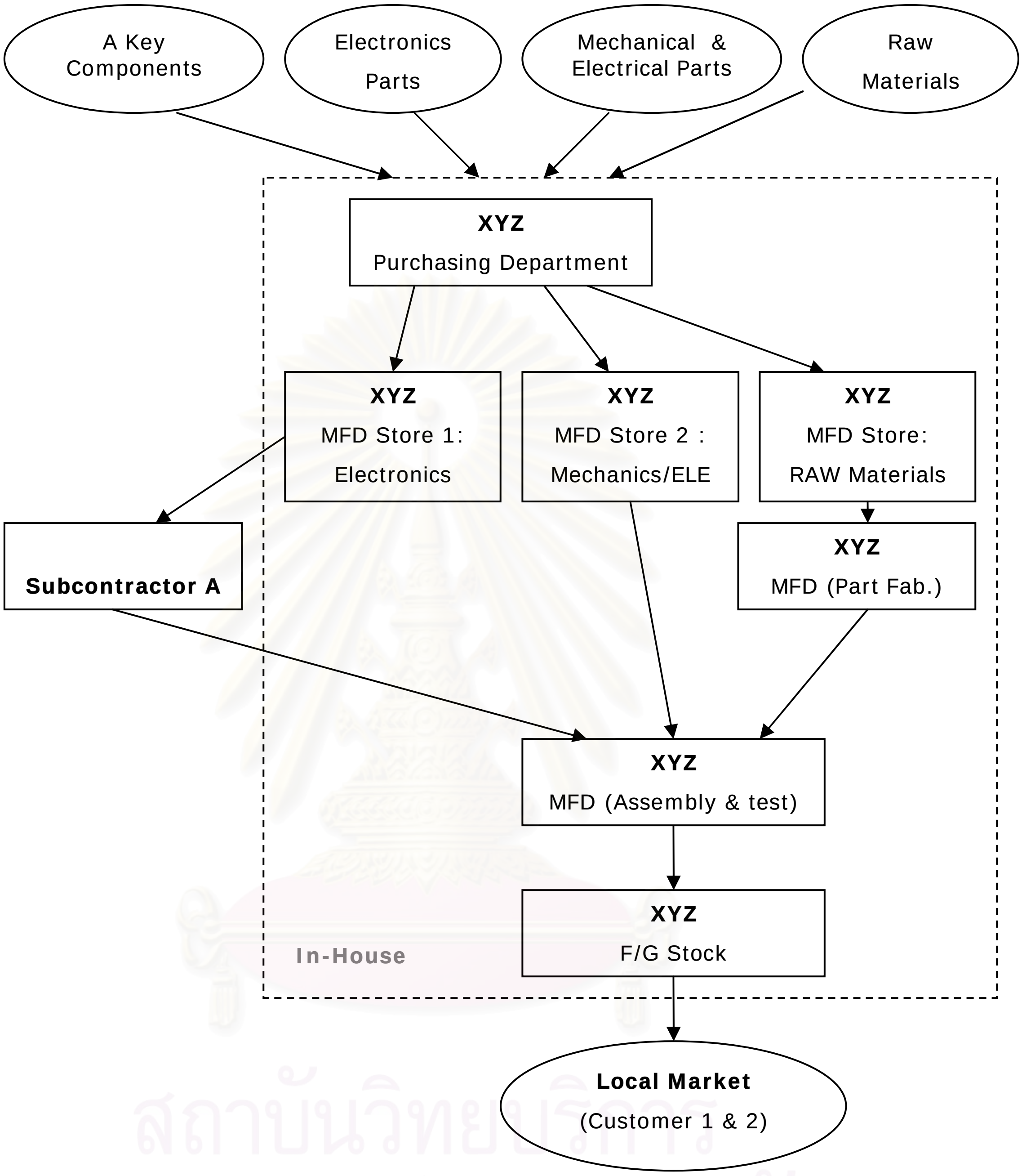

Figure 5.8 Manufacturing and Supply Chain

(5.) Financial and Business Analysis

As shown in Table 5.10, all numbers were put together in to the financial/business case analysis. This is to make sure that the proposed new product is worthy for further investment.

Table 5.10 Financial / Business Case Analysis

BUSINESS CASE	Year 1	Year 2	Year 3	Year 4	Year 5
1. Sales target (unit/Yr)	XX,XXX	XX,XXX	XX,XXX	XX,XXX	XX,XXX
2. Total sales (1 KB/Yr)	XX,XXX	XX,XXX	XX,XXX	XX,XXX	XX,XXX
3. Target cost (Baht)	X,XXX	X,XXX	X,XXX	X,XXX	X,XXX
4. Profits Rate (%)	XX	XX	XX	XX	XX
5. Annual Profit (1 KB/Yr)	XX,XXX	XX,XXX	XX,XXX	XX,XXX	XX,XXX
6. Cumulative Profit (1 KB/Yr)	XX,XXX	XX,XXX	XX,XXX	XX,XXX	XX,XXX
7. Cost Reduction Expense (1KB/Yr)	X,XXX	X,XXX	X,XXX	X,XXX	X,XXX
8. Development Cost (1 KB /Yr)	X,XXX	X,XXX	X,XXX	X,XXX	X,XXX
9. Cumulative Total of [8] (1 KB/Yr)	X,XXX	X,XXX	X,XXX	X,XXX	X,XXX
10. Facilities Investment (1MB/Yr)	X.X	X.X	X.X	X.X	X.X
11. Cumulative Total of [10] (1MB/Yr)	X.X	X.X	X.X	X.X	X.X
12. Mold/Die/Tool (1 MB/Yr)	X.X	X.X	X.X	X.X	X.X
13. Cumulative Total of [12] (1MB/Yr)	X.X	X.X	X.X	X.X	X.X

5.3. POST PROJECT REVIEW

5.3.1. Feedbacks from the Front-End Team

In order to know how the customized framework facilitates and benefits to carrying FFE activities, the key personal from the Front-End team were interviewed.

Compared with the previous FFE method, the new framework gave the Front-End team much more benefits. **The previous vague activities were re-arranged and grouped into three elements. This facilitated the Front-End team to focus on specific issues**. For instant, the ideation allowed the team to come out with a roughly concept – an idea – before going to sharpening the product concept. This doesn't only enable the team to preliminarily understand product/market needs, but also provides the team with rapid sources of valuable ideas.

Apart form that, the suitable methods and tools also represent as easy-step procedures that facilitate the team to get start the FFE tasks quickly. **The customized methods help the team to get start of the pre-development tasks more quickly than before.** The team members do not need to pay more attention on the FFE methods. Rather, the members just follow the proposed framework and grab the supported tools along the FFE steps.

5.3.2. Management Opinion on the Proposed FFE Framework

As observers, the management feels that FFE processes were improved after the implementation. Although the **FFE cycle time was reduced from 20 weeks to only 6 weeks (see Appendix 2),** the new method still delivered ample outcomes (e.g. product plan) as required in the ISO manual as well as successful necessities for the further development stage.

In Addition, **the framework allows the Front-End members perform FFE tasks with less dependence on individual experience.** Form the developed methods and tools which were customized and recommended for the case company applications, the FFE activities can be carried out more reliable than before.

CHAPTER 6
Conclusion and Recommendation

The goal of this thesis is to provide an easy-step approach, the FFE framework, for the case company in accomplishing pre-development activities. The outcomes of this customization contain identification of prerequisites, sub-divisions of essential tasks, description of recommended methods, and offerings of supporting tools. Besides, it is also hoped that the product planning activities will be executed in a quicker manner and more effective ways.

6.1. SUMMARY OF THE FFE FRAMEWORK DEVELOPMENT

The thesis process began with extensive review of FFE literature in order to recognize theoretical models as well as favorable practices. Then the case company's process was investigated to reveal deficiencies. After that, an articulated FFE model was developed by employing the same analogy as in general design processes. Finally, to demonstrate how the proposed model is applicable, the FFE framework was implemented into a new product platform project.

6.1.1. Set up the Design Requirements

Prior to redesign of the FFE process, the design inputs and constrains are essential to be set out. These help the author to focus on the specific issues as well as to choose the appropriate methods and tools for the case company. Initially the case company's process was investigated to reveal deficiencies, which include:

- The FFE must fit within the case company structure and process
- The FFE must deliver desirable outcomes required by the ISO procedures
- The methods for reducing uncertainty should be additionally adopted
- The FFE must be improved in terms of formality and integration

6.1.2. Create the Outline Framework

Regarding those requirements, the author then outlined the preliminary FFE model. This is aimed to aggregate and to scope the FFE activities before considering for supporting methods and tools. As predefined, the FFE model is divided into three elements: ideation, concept, and planning. The first element is used to select an appropriate product idea. The second one is used to define the product concept including major specification, features, and functions. The last one is used to create a suitable project plan.

6.1.3. Develop Practical Methods and Tools

Through looking at specific elements in the outlined model, the author developed practical methods and tools to aid execution of such early phase activities. The ideation element can be divided into two steps: opportunity identification, and idea generation and selection. For the first step, Market Segment Grid, VOC research, Customer Visit Program, and the competitive analysis table are proposed as suggested methods and supporting tools. For another step, rich sources of ideas are introduced and idea selection table are proposed.

The next element, concept, begins with establishment of product specification, then moves to design of product concept, and ends up with assessment of technical and market feasibility. In order to facilitate these activities, descriptive methods and tabulate tools are developed or created for the case company.

For the final element, planning, a list of viable items is proposed. This includes plan for project schedule and resources, estimates of development expense and tools/facility investments, identification of technical risks/issues, formulation of sales/marketing strategy, clarification of manufacturing and supply chains, and analysis of financial and business figures.

6.1.4. Verify the FFE Framework

Once the new FFE process was created, the verification was needed in order to check whether the proposed approach meets the design requirements or not. The developed framework was then reviewed against the four criteria, which resulted into that it still fit in the company structure and process, it is able to deliver the desired outcomes, it is additionally adopted with uncertainty reduction ways, and its formality and integration is enhanced. Thus, it obviously indicates that the customized FFE meets the design targets.

6.2. DISCUSSIONS AND RECOMMENDATIONS

6.2.1. Benefits from Using the Framework

Prior to having the customized framework, the pre-development activities were carried out in a difficult manner. This arose from FFE characteristic itself, in which is ambiguous, chaotic, and unstructured. Thus, to accomplish such up front efforts, the FFE team faced much obscurity in getting start as well as completing jobs. Fortunately, through following the articulated FFE model, the team knows what activities should be done, what methods should be followed, and what tools can be referred. As a result, the FFE team is able to start quickly and complete their jobs faster than ever.

Without the suggested methods, the FFE team merely relies on their own experience and skill. Therefore, occasionally missing of necessary analysis is possible. The use of framework helps FFE member to ensure that vital information and critical analysis are not overlooked in the early development phase. By following this easy-step approach, the FFE team is able to execute such up front activities effectively, as verified by the diagnostic checklist which indicates that the new FFE process is on the island of capability level.

6.2.2. Recommendations for the Case Company

In fact, there are still other categories of product developments in the case company; electromechanical products, incremental improvement, and minor change. Whether perceiving benefits of using the FFE framework or not, the case company should investigate deficiencies of the current practices as well. While developing some products is not necessary to follow such sophisticated process, the others might need. Thus, in order to fully appreciate the benefits of this FFE framework, the case company should extensively apply or customize this developed model to cover other kinds of product development projects.

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APPENDICES

APPENDIX 1
List of Abbreviations

NPD	New Product Development
FFE	Fuzzy Front End
NCD	New Concept Development
EPDD	Electronic Product Development Department
MFD	Manufacturing Department
SMD	Sales/Marketing Department
QCD	Quality Control Department
VOC	Voice-of-Customer
R&D	Research and Development
WBS	Work Breakdown Structure
M1M	Multi-1 Meter
M2M	Multi-2 Meter
T&D	Transmission and Distribution
DT	Design Trial
PT	Production Trial
PCB	Printed Circuit Board
PCA	Printed Circuit Board Assembly

LCD	Liquid Crystal Display
S/W	Software
EMC	Electromagnetic Compatibility
F/T	Functional Tester
ICT	In-Circuit Tester
PC	Personal Computer
ICE	In-Circuit Emulator

APPENDIX 2

Formal Planning Activity Cycle Time

Japanese Project	Time Spent (weeks)
Industrial Meter 01	4
Industrial Multi Meter 08	5
Residential Multi-Function Meter 08	4
Multi-Function Meter 1	3

XYZ Previous Project	Time Spent (weeks)
Residential Meter 1	20

XYZ Demonstration Project	Time Spent (weeks)
Multi-2 Meter	6

APPENDIX 3
M2M Product Plan

<u>Note</u>

Since some data are confidential to the case company, some names or figures has either been disguised or removed all together.

1. PRODUCT STRATEGY

1.1. Development Purpose

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

1.2. Development Model

XYZ shall develop the following models:

Table 1.1 Development Model

<table>
<tr><th>Model</th><th>XXX</th><th>Current Rating</th><th>Ref. Voltage (Operating Range)</th><th>Accuracy Class</th><th>Protection Class</th><th>Note</th></tr>
<tr><td rowspan="3">M2M/1</td><td>XXX</td><td rowspan="3">XXX A</td><td>XXXX V
(XXX – XXX V)</td><td rowspan="3">xxx
xxx</td><td rowspan="5">IPxx</td><td>xxx Type</td></tr>
<tr><td rowspan="2">XXX</td><td>XXX
(XXX– XXX V)</td><td>xxx Type</td></tr>
<tr><td>XXXX V
(XXX – XXX V)</td><td>xxx Type</td></tr>
<tr><td rowspan="2">M2M/2</td><td>XXX</td><td rowspan="2">XXX A</td><td>XXXX V
(XXX – XXX V)</td><td>xxx
xxx</td><td>Commercial & Residential Use</td></tr>
<tr><td>XXX</td><td>XXXX V
(XXX – XXX V)</td><td>xxx</td><td>Commercial & Residential Use with kWh only</td></tr>
</table>

1.3. Sale/Marketing Strategy

(1) Market Trend

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(2) Estimated Market Price

xxxxxxxxxxxxxxxxxxxxxxxxxxxxx

(3) Estimated Annual Demand

xxxxxxxxxxxxxxxxxxxxxxxxxxxxx

(4) Sale Target

xxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Table 1.2 Sales Target

ITEM	ANNUAL DEMAND				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Total Demand (1000 units/year) *[1]	XX	XX	XX	XX	XX
Target Sales Volume					
(1000 unit/year) *[2]	XX	XX	XX	XX	XX
(Million Baht/year) *[1] x [2]	XX	XX	XX	XX	XX
Target Cost					
Shop Cost (Baht) *[3]	XXXX	XXXX	XXXX	XXXX	XXXX
Total Cost (Baht) *[3] x factor	XXXX	XXXX	XXXX	XXXX	XXXX
Target Price (Baht)	XXXX	XXXX	XXXX	XXXX	XXXX
Target Profit					
Profit (Baht)	XXXX	XXXX	XXXX	XXXX	XXXX
Profit Rate (%)	XX	XX	XX	XX	XX
Target Profit Volume (Million Baht/year)	XX	XX	XX	XX	XX

(5) Sale Route

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxxxx

(6) After Sale Service Arrangement

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xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxxxx

(7) Sales/Marketing Strategy

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xxxxxxxxxxxxxxxxxxxx

SMD will first establish connection channels with network providers. Throughout the development period XYZ will try to update business information in order to re-enter to the market at suitable time. Up on the M2M is available; SMD will try to share the market with competitor D with the advantage of competitive price and a local manufacturer.

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxxxxx

2. DESIGN SPECIFICATION

2.1. Features/Functions

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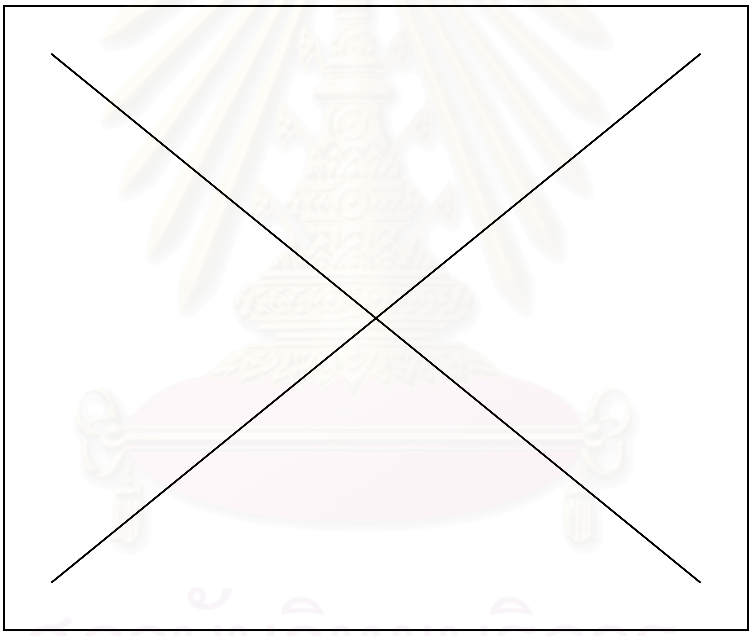
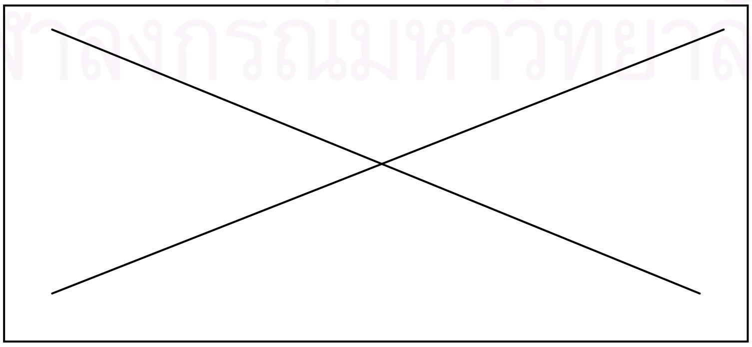
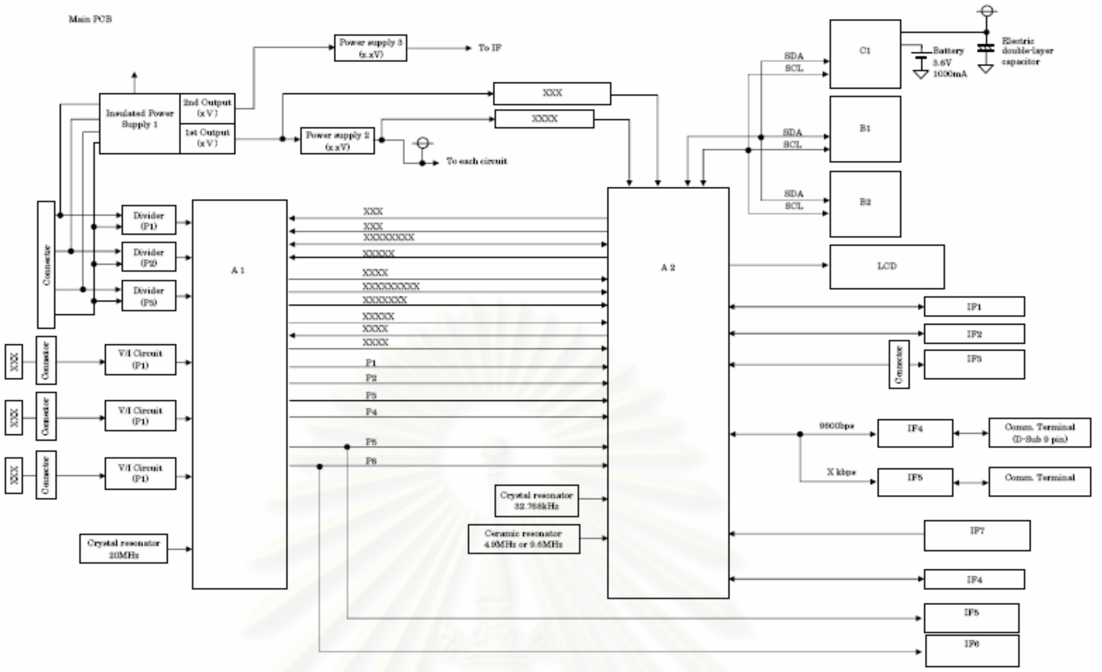
2.2. Mechanical Construction





2.3. Circuits Block Diagram



2.4. Applicable Condition

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

3. DESIGN STANDARD

3.1 Environmental Standards

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3.2 Product Standards

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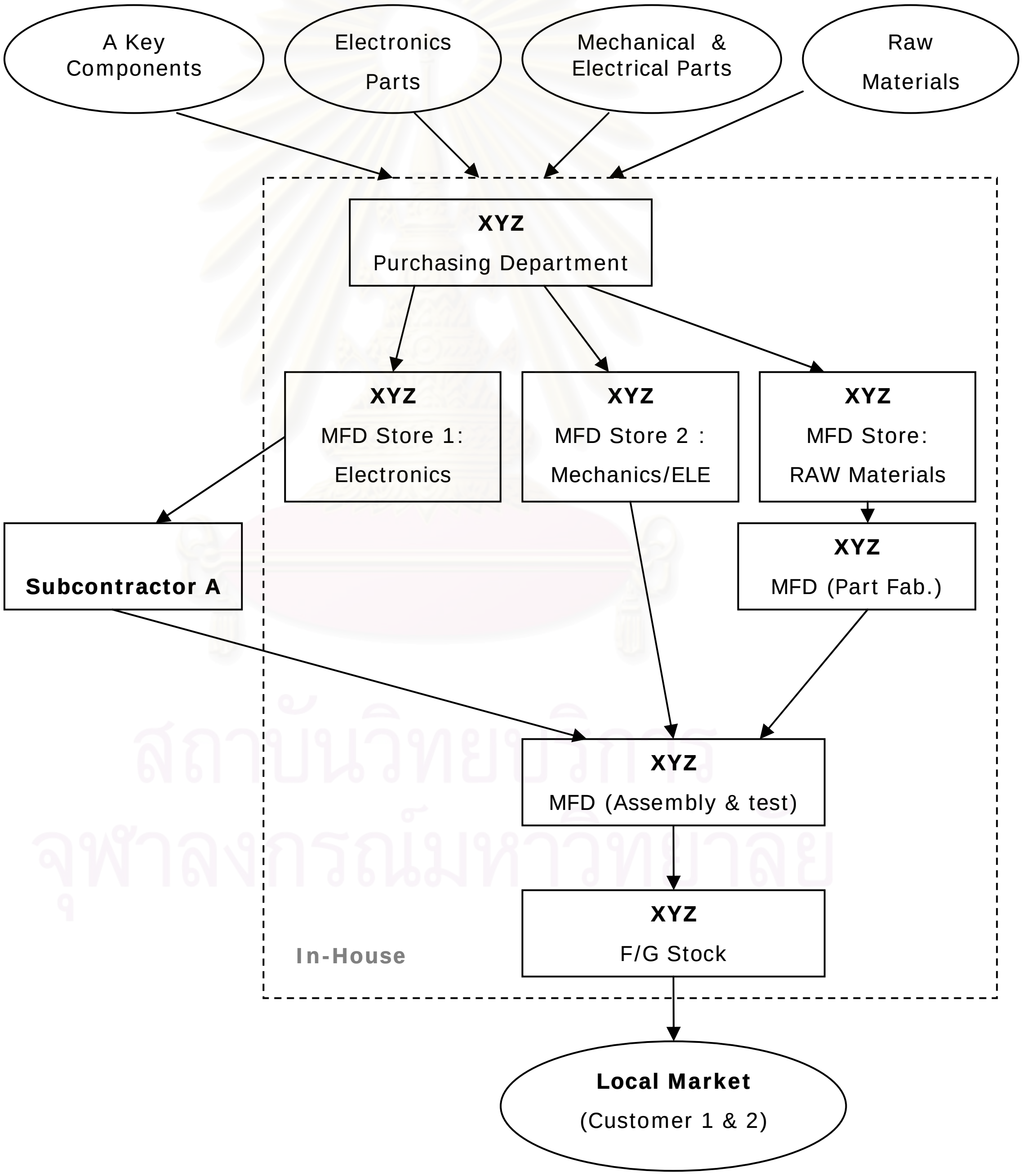
4. MANUFACTURING AND SUPPLY CHAIN



5. COST ANALYSIS

5.1. Target Product Cost

XXXX units/month

Item			Target Cost(THB)		Note
			M2M/1	M2M/2	
	Material Cost	Electronic parts	XXX	XXXX	xxxx xxxxxxxx xxxxxxx
		Mechanical parts	XXX	XXXX	xxxxxxxxxxxxxxxxxxxxxxx
	Manufacturing Cost in Subcontractor	Board Assembly	XXX	XXX	
	Manufacturing Cost in XYZ	Assembly	XX	XXX	
		Fabrication	XX	XXX	
Shop Cost (SC)			XXXX	XXXX	
Total Cost (TC)			XXXX	XXXX	SC×x.xx
Technology Licensing Royalty			XXX	XXX	x% of Sale Price
Profit (Profit rate)			XXXX (xx.x%)	XXXX (xx.x%)	
Sale Price			XXXX	XXXX	

5.2. Mold/Die/Tool Estimates

MOLD/DIE/TOOL ITEM	COST	NOTE
LCD Tooling	฿XXX,XXX	Bending LCD pin
Die	฿XXX,XXX	Current conductor
Die	฿XX,XXX	Optical port plate
Mold	฿X,XXX,XXX	Terminal block
Mold	฿XXX,XXX	Base
Mold	฿X,XXX,XXX	Front cover
Mold	฿XXX,XXX	Switch
Mold	฿XXX,XXX	Terminal cover
Mold	฿XXX,XXX	Communication box
Rubber mold	฿XXX,XXX	Gasket
Mold and rubber mold modification	฿X,XXX,XXX	For Direct Connect type
Jig and tool for manufacturing line	฿XX,XXX	Terminal Cover Gasket
	฿X,XXX,XXX	

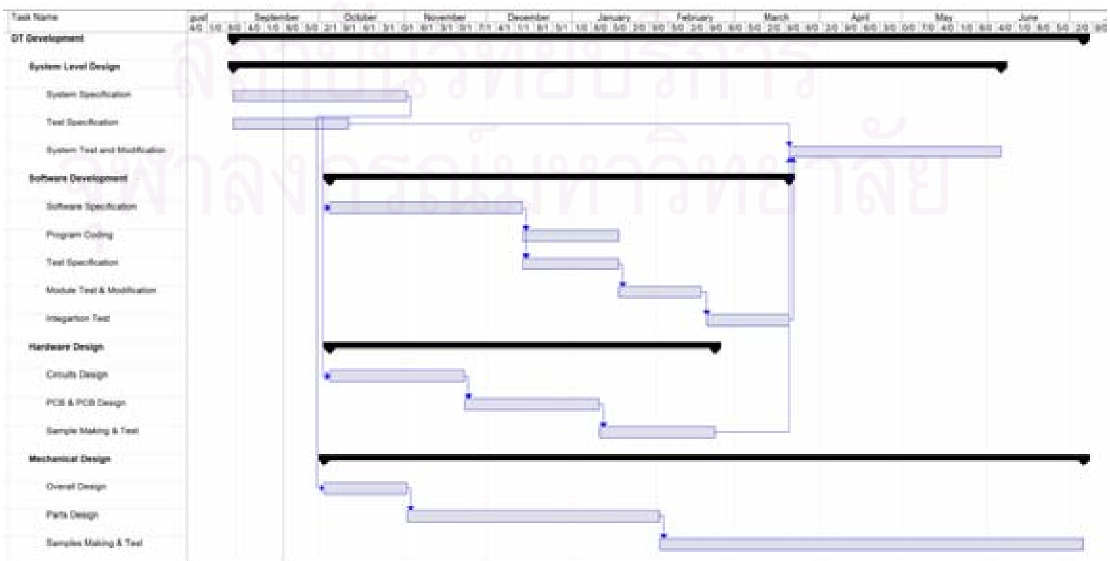
5.3. MFG Facility Investment Plan

EQUIPMENT ITEM	COST	NOTE
Testing Equipment	฿X,XXX,XXX	Power source and standard meter
Testing tool for PCA	฿XXX,XXX	F/T, ICT for PCA manufacture
Testing facilities for production line	฿XXX,XXX	Rack, S/W, Pulse converter, etc
PCA Programming & Test tools	฿XXX,XXX	PC, Opt-probe, ICE, Compiler
	฿X,XXX,XXX	

5.4. Development Cost

EXPENSE ITEM	COST	NOTE
LCD Initial	฿XX,XXX	
PCB Initial	฿XXX,XXX	
Making sample for evaluation	฿XXX,XXX	xxx units (DT:xx units, PT: xx units)
Making sample for Customers	฿XXX,XXX	xxx units
Mechanical Evaluation	฿XXX,XXX	Circuits and Mechanical Parts
Outsource Testing Fee	฿XXX,XXX	Reliability, EMC
PCB Design Training	฿XXX,XXX	Singarepore PCB House
Complex S/W Development Training	฿X,XXX,XXX	Meter S/W
Outsource S/W Development Fee	฿XXX,XXX	Meter S/W
Outsource S/W Development Fee	฿XXX,XXX	Application S/W
	฿X,XXX,XXX	

6. DEVELOPMENT SCHEDULE



Biography

Mr. Suttisak Suriyachanhom was born on September 16th, 1978 in Bangkok, Thailand. In April, 2000, he graduated from the department of Control Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang. In the same year, he started early jobs as a product design engineer in a well-know Japanese company. In 2003, he was promoted to be an assistant manager of an electronic product development department. At the time, his primary role was altered from engineering operation to strategic management fields. As he realized the needs for engineering management disciplines, he then went to become a post graduate student in the engineering management program at Chulalongkorn University.