Initiating an integrated roadmap process at Philips Medical Systems

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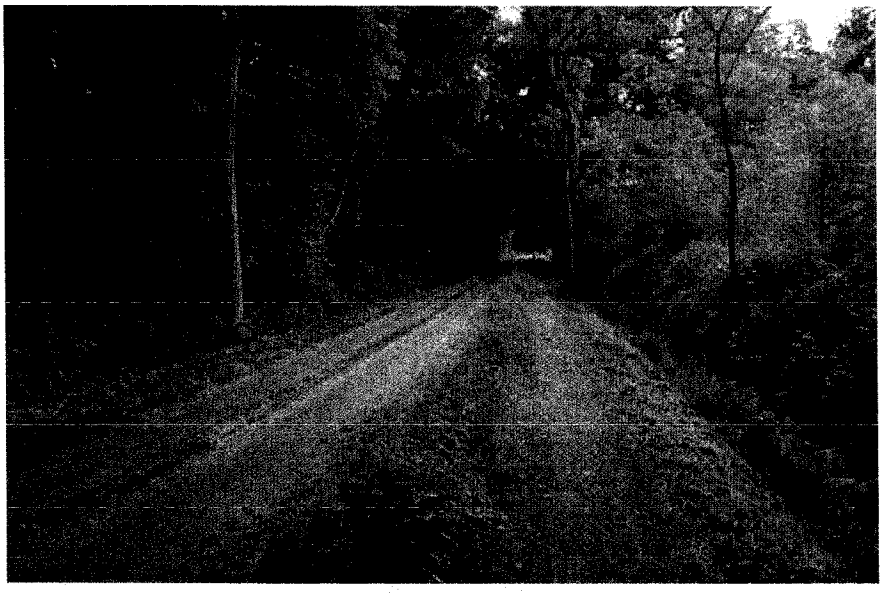

Maryll Koenraadt
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Initiating an Integrated Roadmap Process at Philips Medical Systems

"By three methods we may learn wisdom: First, by reflection, which is noblest; Second, by imitation, which is easiest; and third by experience, which is the bitterest."

-Confucius

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Abstract

The objective of this research is to develop an effective roadmap process for C/V, considering its many aspects, in order to align the different organisation processes involved. Goal is to realise the partly implementation within the organisation, so that a blueprint for further application exists.
This report describes the approach, leading to the effective roadmap process for C/V, the final design and practical application.

Executive Summary

Research Model

The past time, the Cardiovascular department (C/V) of Philips Medical Systems (PMS) is paying attention to better organisation of the first phase of the Product Creation Process, trying to reduce the time-to-market. Since technology is an important enabler and strategic asset for the development of medical systems, the inclusion of technological considerations in strategy and planning processes is essential. Roadmapping is a tool that can contribute to the alignment of different processes, like technology and strategy, and the commercial and technological processes. Although C/V is in possession of roadmaps, there was a need for improvement of the management of process alignment, and especially alignment of the application, marketing and technology processes. This resulted in the following research objective:

> Align the roadmap process and integrate the product, application and technology roadmaps, which results in better alignment of the market demand and the required technologies to satisfy this demand in the future.
> Define roles and responsibilities.
> Establish the process by means of a process description.
> Set up the implementation of the roadmap process in the organisation'.

The primary deliverables of this research are an aligned roadmap process to support C/V in critical decision making and efficient resource allocation during the first stage of the PCP, and in communicating the results to the people involved.
The result of these deliverables should lead to an effective roadmap process in order to meet the following objectives:

- Reduction of the time to market of innovative products, which results in the sustenance of the current leading market / competitive position.
- Product quality exceeding the product quality of competition.

This research has been conducted within the Product Market Group (PMG) C/V of Philips Medical Systems, within the framework of graduating in Industrial Engineering and Management Science at the Eindhoven University of Technology. Philips Medical Systems delivers worldwide diagnostic imageprocessing equipment and services, like X-ray, Magnetic Resonance, Computed Tomography and Ultrasound.

Method of Research

First, the organisation has been analysed through desk research and interviews. Reviewing the current professional literature about roadmapping, combined with expert knowledge, the roadmapping framework has been developed. After addition of experiences of similar roadmap processes of other businesses, the functional specification has been determined, which the effective roadmap process should satisfy. Based on this specification and reflection of findings to C/V employees, several scenarios to improve the current roadmap process have been developed. Meanwhile, practical exercises have been executed with selected groups of employees. The combination of the scenario design and the practical experiences resulted in a final effective roadmap process for C/V. The start has been made with implementing this process into the organisation.

Roadmapping Framework

Based on the professional literature about roadmapping and expert knowledge in this field, the roadmapping framework has been developed. The roadmapping framework consists of the following elements:

1. Roadmapping consists of more than just maintaining a product roadmap. It needs to be integrated with other processes.
2. Roadmaps have to be a guide for the organisation as a whole.
3. Important aspects from the Strategic Plan need to be the basis and steering force of roadmaps.
4. Roadmaps per key driver are an explicit way to structure roadmaps.

In the determination of key drivers an answer should be found to the question what the essence is of a certain key driver for the customer.

5. A long-term vision is required, based on close cooperation between all disciplines.
6. An important aspect of the roadmapping technique is the multidiscipline, crossfunctional working. Teamwork, integral engagement to the organisation and good communication are characteristics of vital importance to the process.
   Roadmap creation is a common effort of all stakeholders.
7. Management has to be involved to the process, the role of the roadmap manager needs to be defined and the competence of the Roadmapteam needs to be sufficient.
8. At least twice a year new visions/roadmap versions should be revised and consolidated.

To this framework, the current roadmap process of C/V has been compared. In addition, similar processes of Semiconductors and other PMG's have been compared to the C/V process to provide possible areas for improvement. This combination resulted in the functional specification of the effective roadmap process for C/V.

Functional Specification

The functional specification of the effective roadmap process design consists of the following elements:

- The C/V-roadmap process needs to be extended and aligned.
- In the future roadmap process, roadmaps should not be created in isolation and roadmapping should be an interactive, cross-functional activity.
  Also, teams in the process have to consist of a proportional composition of different disciplines.
- Contrary to the current situation, an obvious relation needs to be established between the roadmaps and the business drivers stated in the Strategic Plan. Therefore, the Key Success Factors of C/V, which are the business drivers for C/V, should be kept in mind. The KSF's are [Stratplan02]:
  - Reliability,
  - Ease of Use / Workflow / Interoperability,
  - Image Quality / Dose Management,
  - Multi modality applications,
  - Volumatric Imaging.
- Future C/V roadmaps have to cover a longer timeframe; they have to look further than the next project and need to contain more vision.
- Constantly, the level desired should be weighed against the time and effort required to reach this level: a selection criterion that indicates which roadmaps should be created needs to be determined.
- Roadmapping should be market-driven, which means concentrated on trends and competition moves.

Scenario Generation & Evaluation

Different scenarios have been generated that could improve the current roadmap process of C/V. To determine the value of these scenarios and the match with C/V, they have been evaluated to criteria. These criteria were developed from four points of view:

- The functional specification
- The reflection of earlier findings to people involved
- The inefficiencies of the composition of current roadmap process
- The kind of decisions the different departments have to make

Meeting the criteria will be essential to fill the gap between the current process and the effective roadmap process, which needs to enable alignment and optimal allocation of available resources!

To be effective, the roadmap process design should provide a positive answer to as many of the following questions.

Questions based on the theoretical findings of chapter 4:

1. Does the new process result in roadmaps with vision and outside-in oriented planning?
2. Does the process contain a mechanism to make the appropriate roadmap selection?
3. Does the process contain a mechanism to base roadmapping on core competencies?

4. Does the process change the functional thinking into process-oriented thinking?
5. Does the process fit the organisation and the strategy?

Question based on the assignment, the reflection of theoretical findings, the reflection of the current composition of the process and the decision making aspects:

6. Is decision making of the departments application, marketing and technology aligned in the overall roadmap?

Questions based on the reflection of the theoretical findings to stakeholders:

7. Does the process execution require as little teams and (management) effort as possible?
8. Are the appropriate people responsible for the final decision making?
9. Is the process recognisable and acceptable to people involved?

Question based on the reflection of the current composition of the process:

10. Does the process enable the mutual alignment of different technology aspects?
11. Does the process create one focus of final roadmaps? (e.g. market segments or functional areas)

During scenario generation, practical exercises were executed with selected groups of people involved, to learn in practice of the response of the organisation.
The following practical events contributed to the development of the roadmap process:

- A workshop based on the T-Plan, which is a framework that has been developed at the University of Cambridge to start up a roadmap process.
- The application initiative that resulted in application 'Trendmaps'.
- Cardiac workshops, which resulted in priority setting of the application trends and the technical needs they require. The results can be a building block for future roadmapping.
- The navigation workshop, which was only one (successful) workshop until now, but plans exist to continue this workshop soon.

These practical experiences influenced the scenario development. The three most important insights generated were:

1) The importance of bringing vision into the process.
2) The importance of the role of communication, crossfunctional working and process-oriented thinking to the process.
3) The probability of underestimation of time needed during workshops. This underlines the fact that a 'lean and mean' structure, containing as little teams and meetings as possible, is important.

The current C/V-roadmap process and the different alternatives that were created have been evaluated to the criteria mentioned before. Also, the final design, which raised from the combination of the positively contributing scenario characteristics and the practical exercises, has been evaluated to the same criteria. This resulted in a table, expressing for each structure the positive, negative or neutral attribution to each of the criteria mentioned. The results are presented in table 0.1.

Table 0.1: Evaluation of the current process and the designs to the criteria

Criterion	Final Design	Current Process	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
1	+	-	-	+	-	+	+
2	+	-	-	-	+	+	+
3	+	-	+/-	-	+/-	+	+
4	+	-	+	+	+	+	+
5	+	+/-	+/-	+/-	-	+/-	+/-
6	+	-	-	-	+	-	-
7	+/-	-	+	+/-	+/-	-	-
8	+/-	-	+	+	+	-	+
9	+	+	+	+	-	-	+
10	+	-	+/-	+	+	+	-
11	+	-	-	+	+	+	-
Total positive score	9	1	4	6	6	6	6

The final design fulfils almost all of the criteria and therefore, in agreement with members of the MT, the decision has been made to deploy this structure for further implementation.

Description of the final design

In the final design, trends are a driving factor. Based on trends from application, marketing and technology, each View-team creates roadmaps for the View it is responsible for, provided with input, where needed, from people inside and outside C/V. These View-roadmaps provide input for the technology, application and marketing roadmaps. Finally, the Roadmapteam will check these roadmaps with the Strategic Plan and Staffing Plan.

Hierarchical structure

The hierarchical structure of this final design can be seen in figure 0.1. It consists of the MT at the top, to which the Roadmapteam has the responsibility to submit the proposal for roadmap consolidation. This proposal has to be submitted timely, before the Strategic Planning takes place. The application, marketing and technology teams have the responsibility to the Roadmapteam of providing Trendmaps before Trendmap consolidation has been planned. They also have to provide roadmap implications to the Roadmapteam timely. The market team directs the Product Teams, as well as the Technology Team directs the View-teams. Chapter 7 of this report describes this process in more detail.

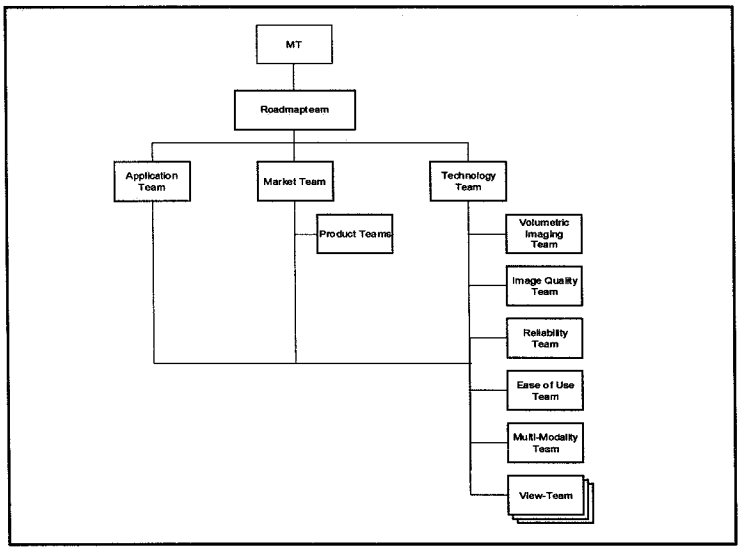

Figure 0.1: Hierarchical structure of the effective process for C/V

Process Flow Chart

This report portrays the flow chart showing the steps that the different parties involved have to execute, provided with the input needed before the step can be executed and the output the step delivers. It also provides a short description of each of the steps shown.

Possible roadblocks

The chance exists that complications occur with the introduction and implementation of the new roadmap process structure into the organisation. These are:

- The necessity for the people responsible for the Views to employ sufficient skills for the management of all responsibilities the ownership of the View brings.
- Meetings will be arranged formally more than before, while some people like the informal way of information exchange.
- People might be afraid of losing current roles, which impacts acceptation.
- It is difficult to change an organisation from functional to process-oriented thinking. Working in cross-functional teams needs a lot of management attention [Jas01].

Furthermore, the report describes the parties involved, their roles, tasks, and the relation to the year calendar of C/V, which is important to consider. Roadmapping has to be tuned to the yearly Strategic Planning and Budget Round, but also to other yearly returning events, like seminars, fairs and assemblies. Furthermore, it is very important to tune roadmapping to the Budget Round of hospitals.

Conclusions and Recommendations

This report ends with conclusions with respect to the assignment and some conclusions beyond the scope of the research. Steps for further deployment in the organisation are described. From the conclusions, recommendations have been deduced. These are described in short here.
It is recommended to C/V:

- To give higher priority to the roadmap process to make it successful.
- To keep in mind the time needed to realise the complete roadmap and to further continuation of the process.
- To spend a few days completely on roadmapping twice a year, with full management attendance and without daily interruptions.
- To put more emphasis to the management of people and skills, in addition to paying attention to the formal aspects.
- To appoint roles and responsibilities soon to be able to continue the process.
- To adopt an innovation strategy that matches the C/V-culture.
- To integrate the roadmap process with other PMG's and external suppliers.
- To pay attention to understanding competition and resource availability & allocation.
- To constantly pay attention to the technological lifecycle during product development.

Acknowledgements

This report describes the course of the final assignment to gain my degree in Industrial Engineering & Management Science at the Eindhoven University of Technology. This report is an overview of the research conducted from March 2002 until December 2002 within the Cardiovascular department (C/V) of Philips Medical Systems (PMS) in Best, regarding the alignment of the roadmap process and many of its aspects involved.

Due to the novelty of the roadmapping subject and my interest for innovation and technology, the assignment was an excellent opportunity for me to obtain a better view on these topics. The PMS employees and employees of other PMG's interviewed, gave me a clear picture about the current state of affairs within PMS and the upcoming challenges. Moreover, they provided valuable input for the creation of an aligned roadmap process for C/V.
Without all the support and advice of others, I could not have accomplished this assignment.

First, I am very grateful for the priceless support and guidance of my company supervisor, Jacco Wesselius. Jacco, thank you for always taking time to explain me all the ins and outs of C/V and for discussing roadmapping aspects. Also, all practical exercises we had gave much insight in organisational issues in reality. I have learned a lot from you and will never forget your outlook on several aspects!
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"I am a part of all that I have seen"

Maryll Koenraadt
Best, November 2002

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Introduction

Technology is an essential enabler and an important strategic asset for the development of medical systems. There is an increasing need to include technological considerations in strategy and planning processes. Having the right technologies at the right time, ahead of competition, is a prerequisite for successful product innovation.

It is very important to couple technology to other processes, because technology decoupled from market and business inputs results in innovation based mainly on technology push rather than market pull. Innovative technology applied in product development increases risk and may result in delays or unacceptable quality. Missing technology and know-how when new markets emerge may result in missing markets or slower penetration, with all the corresponding consequences.

However, establishing and communicating the linkages between technology resources and company objectives, and between the commercial and the technological perspective, is a very complex process.
Roadmapping is a technique that visualises the alignment of processes, by integrating the vision that is shared by management and key-players. This results in more cooperation and better communication. It also places the processes in a wider scope: from single product to product portfolio and from single generation to several years.
But what exactly is roadmapping? How should it be organised to create this alignment between the several organisation processes? How does this influence already existing processes and communication structures?

This research describes the development and application of a roadmap process that supports the alignment of the departments involved within the PMG Cardiovascular of Philips Medical Systems. Based on a theoretical perspective and practical experiences on roadmapping, the current roadmap process has been analysed. A process that enables improvement of this process has been identified and applied in practice, to create a blueprint for continuation of the roadmap process implementation.

This report is interesting for those who are directly or sideways concerned with this research project within Philips Medical Systems (PMS) or within the Eindhoven University of Technology (TU/e). Furthermore, this report can be helpful for those who want to get a better insight in roadmapping.

Chapter 1 Assignment

This chapter presents the assignment as it has been conducted at Philips Medical Systems in Best, The Netherlands. The first section gives the background of the research that leads to the assignment. In section 1.2, the definition of the problem that was the reason for starting the project is described. Next, section 1.3 handles the orientation to the assignment. In section 1.4 the research objective is discussed, followed by the research model in section 1.5. Finally, in section 1.6 the structure of this report is discussed.

1.1 Background of the research

Cardiovascular diseases are disorders to the heart and vessels. These diseases are still the number one cause of death. That is why the biggest challenge of the medical industry is to reach an effective diagnosis and effective treatment of these diseases.
Philips Medical Systems (PMS) is the world's leader in the development of cardiac and vascular systems. These systems are used in hospitals. They are used to image heart and vessels for diagnostics and intervention.
50% of all cardiac examinations worldwide are done using Philips equipment. These systems are developed by the Product Market Group Cardiovascular (C/V). The Integris Allura is an example of such a system; it is the world's first interventional X-ray system for 3D reconstructions. A picture of this system can be seen in figure 1.1.

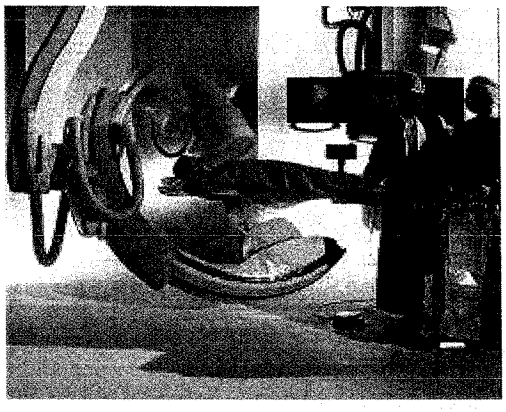

Figure 1.1: The Integris Allura

Overall, Philips Medical Systems is global market leader in X-ray systems.
For an innovative leader, coming to the market with a continuous stream of products and maintenance of this stream by means of technology management is of vital importance to stay competitive. This requires a good planning system, especially because the application field of these cardiovascular systems is characterised by innovations with a long lead-time.

To realise this effective planning, the Product Creation Process (PCP) has been developed. This is a product development process that consists of three stages: project & product definition, project execution and life-cycle management. For each stage, resources are employed to execute the phase. The distribution of resources is as follows:

- 27% of the available resources is spent on life-cycle management,
- 64% is spent on project execution, and
- only 2% is available for the product & project definition phase.

Figure 1.2. shows the PCP with the three stages and the distribution of resources.

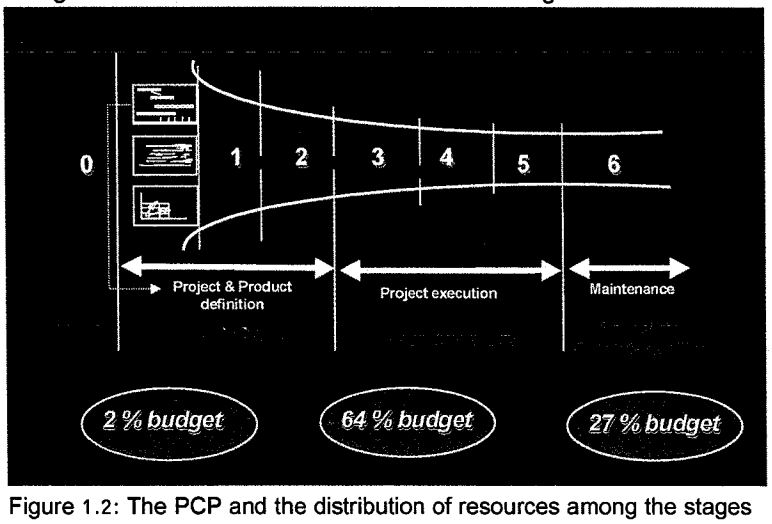

Figure 1.2: The PCP and the distribution of resources among the stages

The reason for the availability of only 2% of the budget for the definition phase, is that many resources are necessary in the other two phases. Currently, competition often enters the market before C/V is ready to introduce a similar product. At the moment competition enters the market with this product, many resources of C/V are required during the project execution phase, to enable following

competition as fast as possible.
As a result there is a scarcity of resources in the first phase, which is the reason for development to be slow. People cannot spend much of their time on development. This slow first stage influences the time-to-market negatively. The time-to-market is the total time from the product definition until the introduction of the product into the market.
Another cause of increasing the time-to-market during the first phase, is that the scarce development resources are not allocated as efficient as possible. At this moment, when a new idea for product development arises, common goals are not established in advance and development processes are not aligned sufficiently. This causes the scattering of resources. Common agreement in an early stage will influence the lead-time of product development positively, and will prevent the use of resource effort that is not going to be used later. Altogether, better planning and alignment in the first phase can improve the time-to-market and the related competitive position.

1.2 Problem definition

From the research background, it appears that for C/V better planning and alignment can contribute to more effective and efficient product development. This mainly concerns the first stage of product development.
The initial assignment description, as stated below, serves as a starting point for this research:

'The assignment will concern the improvement of the front-end process of product development. The focus will be on the first stage of the PCP and how development can be improved during that phase'.

The aim is to reduce the time-to-market. Since the belief exists that a considerable amount of time can be saved during the first development phase, a solution to improve the total process of innovation and development will be searched for.

1.3 Orientation

Technology and the management of technology are very important for an innovative company like C/V to create value and competitive advantage compared to other companies. Technology can be seen as a specific type of knowledge, focussing on the 'know-how' of the organisation. Effective communication and knowledge management, establishing the link between technological resources and company objectives is of vital importance, as well as appropriate knowledge flows between commercial and technological perspectives of an organisation to achieve a balance between market 'pull' and technology 'push'.

An important element of integrating technology and strategy, is the capacity to apply systematic technological prediction.
Roadmapping is a useful tool to reach this integration of technology and strategy. Because roadmapping is a term that is not yet familiar to many people, a short explanation will follow first. A more detailed description will be given in chapter 3.

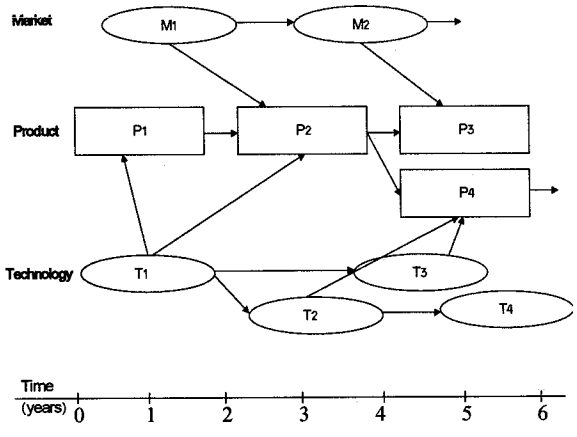

Figure 1.3: Example of a roadmap, showing the links between the market, product and

Roadmapping is a needs-driven technology planning process to help identify, select, and develop technology alternatives to satisfy a set of product needs. Given a set of needs, the roadmap process provides a way to develop, organise, and present information about the critical system requirements and performance targets that must be achieved in a certain time frame. It also identifies technologies that need to be developed to meet those targets. Finally, it provides the information needed to make trade-offs among different technology alternatives [Gar98].

The main function of a roadmap is to provide a shared vision in and overview of the expected business evolution during a longer timespan. The value lies in the possibility to anticipate, which is specifically important to everything having a long lead-time [CE01].
An example of a roadmap is shown in figure 1.3. It shows the links between the market needs, the products that can fulfil those needs and the technology required to realise this.

Tools exist that support the integration of technology and strategy and to translate commercial requirements into product features. An example of such a tool is Quality Function Deployment (QFD). This is a customer-oriented approach that guides product managers and design teams through the concept and idea phase of the product creation process. It helps to focus on the functional customer requirements and translates these requirements into appropriate product characteristics [Groen97]. It is important to know that there is a difference between such tools and roadmapping. Roadmapping goes further and is a process, during which techniques like QFD can be used to better perform the process. Roadmapping and supporting tools do not exclude one another.
In this research, a few reasons gave rise to the choice of the roadmapping approach:

1. From the beginning, the assignment has been well-defined to the alignment of the roadmap process. Philips Medical Systems uses the 'Process Survey Tool' to evaluate the maturity of the PCP and to identify business improvement opportunities. The next step C/V needs to take to move up the maturity scale, is the integrated roadmap process, containing aligned roadmaps [Process Survey Tool]. Other methods than roadmapping would not have satisfied the requirements of PMS.
2. Besides the function to translate the commercial side into product features, roadmapping has additional advantages. Roadmapping goes further, by translating the product features into the technology that is required to realise these features. It also provides a framework to plot the results in time. In this way, systematic technological prediction is made visible to people in all parts of the organisation.
3. Roadmapping has already been applied in other parts of the Philips organisation. This contributes to the preference to apply this tool. Internal knowledge and experience exist.
4. C/V possesses a few roadmaps already, which contributes to the wish to extent this process. This wish is also shown by the decision of the development manager to start an improvement plan to realise strategic roadmap alignment. The description of this plan can be found in Appendix 1.

Although roadmapping knowledge and experience exists within the Philips organisation, it should be kept in mind that roadmapping is not always a suitable solution and rashly applicable in every organisation. During interviews within other parts of the Philips organisation, this was noticed. Here, also sceptical statements raised, for example about the lack of continuous effort after the introduction period.

Where the project and product definition phase of the PCP concerns the long term strategic planning, the project execution phase concerns the day-to-day project planning. Within C/V a distinction in roles and responsibility exists for these two phases. The Management Team (MT) is responsible for the strategic planning, after which the Project Team Coordination Meeting (PTCM) takes over the short-term planning responsibility in the project execution phase.
It is important to understand that roadmaps concern the long-term strategic planning, directed by the MT. When the roadmaps are consolidated, they are used by the PTCM to base the day to day planning on. Figure 1.4 shows the relation between the strategic planning, for which roadmapping can be a useful process, and the operational planning, which is the project execution managed by the PTCM.

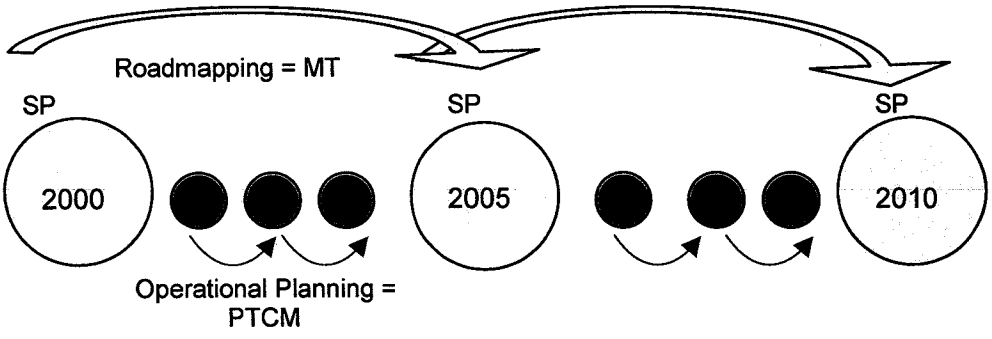

Figure 1.4: Relation between Roadmapping and Operational Planning

At the start of the project, existing roadmaps within C/V are the product roadmap, in which product releases are plotted in time, accompanied by the underlying component roadmaps. Furthermore, a few technology roadmaps exist, which are made independent of other processes, by different parts of the technology department.
Market and clinical roadmaps do not exist at the start of this research.

1.4 Research objective

Objective of the assignment is to provide insight in how the roadmap process should be organised to improve development during the first stage of the PCP.
Both the problem definition and orientation led to the following research objective:

- 'Align the roadmap process and integrate the product, application and technology roadmaps, which results in better alignment of the market demand and the required technologies to satisfy this demand in the future.
- Define roles and responsibilities.
- Establish the process by means of a process description.
- Set up the implementation of the roadmap process in the organisation'.

1.4.1 Research questions

Research questions that can be derived from the assignment description are:

1. In which way does the implementation of an aligned roadmap process influence the existing roadmap process?
2. Which requirements and conditions should the roadmap process satisfy, according to stakeholders and literature statements?
3. Which roadmaps should be created, in view of the trade-off between roadmap development / update time and the advantages certain roadmaps bring?
4. What will be the distribution of roles and responsibilities?
5. Which processes are related to the roadmap process? Which processes influence the roadmap process and which processes does the roadmap process influence?
6. How should the process be initiated and introduced into the organisation?
7. Which characteristics of the organisation are an opportunity or threat during implementation and continuation of the process?

The part of the business used for answering the research questions consists of the application, the marketing and the technology processes. In agreement with the client, these three processes are taken to serve as a blueprint for the total process. When this part is implemented successfully, it can be extended with the alignment of resources and processes.

1.4.2 Deliverables

The primary deliverable of this research is an aligned roadmap process, to support C/V in critical decision making and efficient resource allocation during the first stage of the PCP and in communicating the results to the people involved.
The result of this deliverable should lead to an effective roadmap process in order to meet the following objectives:

- Reduction of the time to market of innovative products, which results in the sustenance of the current leading market / competitive position.
- Product quality exceeding the product quality of competition.

1.5 Research model

The research model structures the project activities, as it shows the logical steps during the project to fulfil the research objective. The model, based on Verschuren & Doorewaard [Schu98], is shown in figure 1.5. The steps mentioned are explained below. The colours of the steps are in line with the colours of the chapters indicated in figure 1.6, to show the relations between the steps and the chapters.

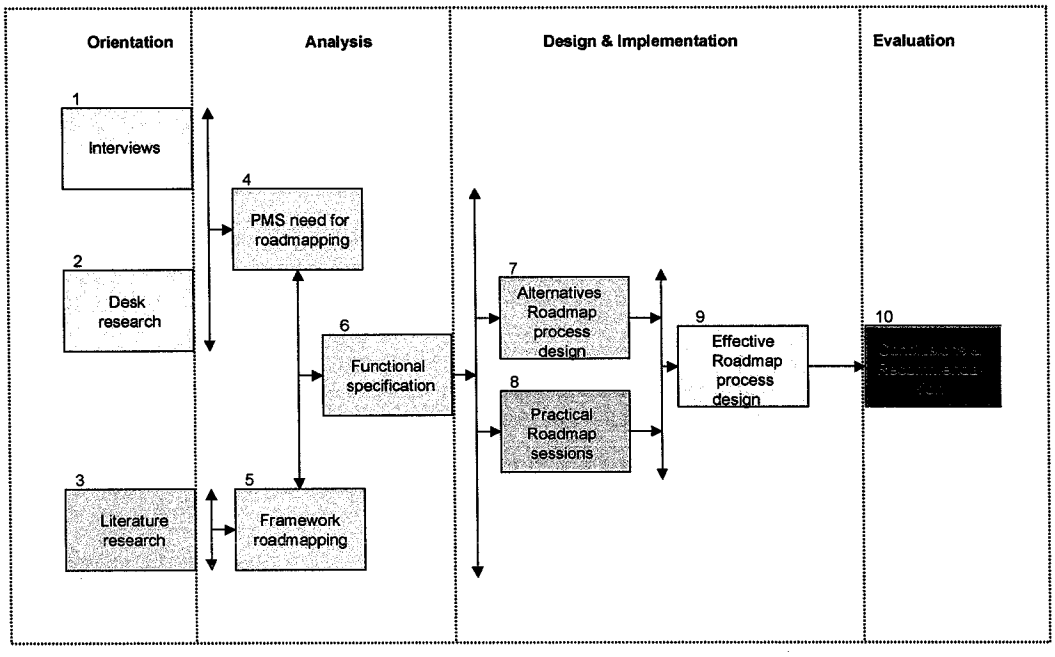

Figure 1.5: Research model based on Verschuren & Doorewaard [Schu98]

Orientation phase

The orientation phase consists of three steps:

Step 1 & 2: The first and second steps consist of interviews and desk research, with the objective to gain more insight into the organisation of C/V, the product development and roadmap process. The interviews also took place at other PMG's of PMS (CIS and MR) and at other divisions of Philips (CE, CFT and Semiconductors), to learn from their experiences in the field of roadmapping.

Step 3: Parallel to the first two steps, a literature research has been conducted to gain more knowledge about technology development and roadmapping.

Analysis phase

The analysis phase contains three steps:

Step 4: After gaining more insight into both C/V and roadmapping and roadmap processes, it is useful to investigate the similarities, differences and points of attention, comparing the process within C/V with processes in other PMG's and divisions. These results have to be analysed thoroughly.

Step 5: Parallel to this, knowledge gained from the literature research, can be translated into a framework for roadmapping. This roadmapping framework can be applied to compare the current C/V roadmap process to.

Step 6: Analysis of Steps 4 & 5 leads to functional specifications, which the roadmap process should satisfy.

Design & Implementation phase:

The design and implementation take place parallel to one another. During the design of an improved roadmap process, in practice, exercises will be started to create awareness and to be able to apply the facts learned to the process design. After this step, the specifications will be turned into a process design improving the current roadmap process.

Step 7: Based on the functional specifications, exploration will take place to identify different alternatives to improve the current roadmap process. These alternatives will be evaluated against criteria. Awareness, involvement and agreement within the organisation are vital elements during the design. This is why the stakeholders, who consist of management and the people involved to the roadmap process, should be involved intensively during the development of the design.

Step 8: Roadmap sessions will be organised, to serve as a first shared roadmapping exercise. When these tryout-sessions result into useful roadmaps, these

roadmaps and the process to create them will be presented and carried out, so that they can serve as a blueprint to the total roadmap process. Because awareness and cooperation are very important, people involved should have an important role during the implementation.

Step 9: From the scenarios and the results of practical exercises, an effective roadmap process will be developed. Also the roles and responsibilities have to be defined and the process needs to be described.

Evaluation phase:
The evaluation of the research will be carried out in this phase.

Step 10: In this step of the research model, the experiences during the internship will be given and used to draw conclusions and give relevant recommendations.

As can be seen in the model, this research is executed by placing the theory next to the practice twice; first the PMS need for roadmapping is compared with the theoretical framework for roadmapping. The result, the functional specification, leads to the theoretical and the practical development of the roadmap process, from which the effective roadmap process design arises.

1.6 Structure of the report

The structure of this report is based upon the different steps used in the research model in figure 1.5.
Chapter 2 starts with the Philips organisation, PMS and the position C/V has within this company. Also, the relations and positions of the departments application, marketing and technology within C/V will be explained, because these three departments play an important role in the project.
Chapter 3 discusses the theory about roadmapping and about a few general aspects that influence the design phase.
Before the roadmap process can be developed, the current situation needs to be analysed to the roadmapping framework, which is based on roadmapping literature. Also other Philips divisions and PMG's will be involved. The analysis will be discussed in chapter 4, leading to the functional specification of the roadmap process at the end of the chapter.
Chapter 5 deals with the process to create the effective roadmap process design. Different alternatives will be designed and evaluated against criteria.
Chapter 6 describes the practical experience, which is gained parallel to the design of the roadmap process.
The combination of the development of different alternatives and the practical experience, lead to the effective roadmap process design, which will be described in chapter 7. The effective process identified will be explained, accompanied by a process flow diagram.
Finally, Chapter 8 provides answers to the research questions, draws conclusions and gives recommendations.

An overview of the structure is shown by figure 1.6.
The corresponding colours of the figures 1.5 and 1.6 show the relation between the research steps and the chapters.

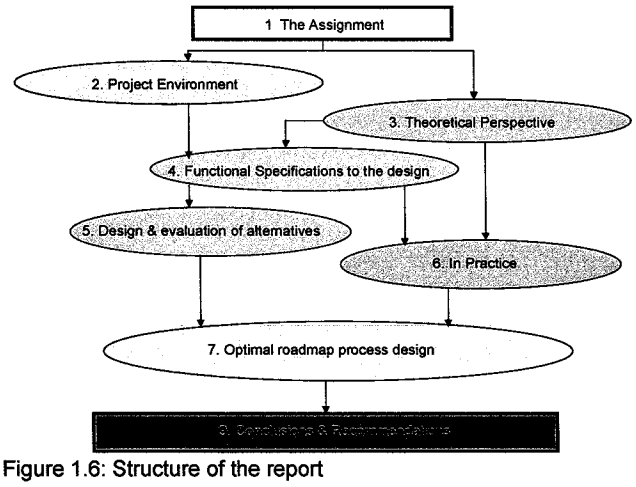

Figure 1.6: Structure of the report

Chapter 2 Project Environment

This chapter first introduces Royal Philips Electronics in section 2.1, followed by an introduction to Philips Medical Systems, where this research was conducted, in section 2.2. In section 2.3 the department Cardiovascular is described, containing the introduction, the mission and vision of C/V and the description of relevant positions and relations of the departments application, marketing and technology.

2.1 Royal Philips Electronics

Philips Medical Systems (PMS) is part of Royal Philips Electronics, one of the world's largest electronics companies.
Royal Philips Electronics is a company active in many areas. It is a multinational with more than 234.000 employees, spread over more than 60 countries.
The Philips organisation consists of the following 6 businesses: Components, Consumer Electronics, Domestic Appliences & Personal Care, Lighting, Medical Systems and Semiconductors [Philips internet].

Figure 2.1 shows the position of Philips Medical Systems within the Philips organisation.

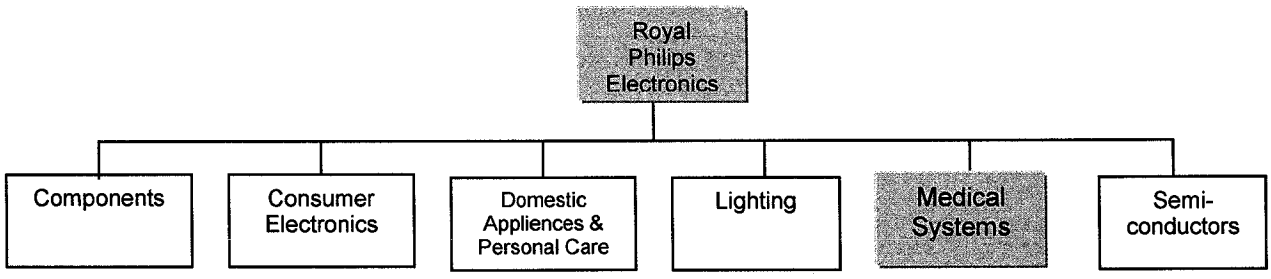

Figure 2.1 Position of PMS within the Philips organisation.

2.2 Philips Medical Systems

The mission of PMS is to be the fastest growing, most competent and responsible supplier of medical systems in the world. At this moment PMS belongs, besides General Electric (USA) and Siemens (GER), to the largest producers of these systems.

Philips Medical Systems has pro forma sales of US $6.5 billion, is represented in 63 countries and employs over 22,000 people. All products are supported by Philips' worldwide network of research and development and sales and service organisations.
PMS has manufacturing sites in Best and Heerlen, The Netherlands; in Hamburg, Germany and in Seattle, USA.
From 1988 onwards more than 5 billion dollar has been spent on taking-over purchases and alliances. Companies in which PMS has its share are Medquist (60%), SHL Telemedicine Ltd. (18.5%), Philips Heartcare Telemedicine Services (80%), and Trixell (24,5%). Last purchase was the medical division of Marconi.
Thanks to these investments in taking-over purchases and alliances, but also by autonomic growth, Philips Medical Systems has grown enormously. The last two years a rise in turnover of 20 percent has been realised [PMS internet].

The PMS organisation consists of two main parts: the Sales & Services Regions (SSR) and the Business Lines (BL) (formerly called Program Management Centres). The main objective of the SSRs is to sell and service the PMS equipment worldwide, whereas the task of the BLs is to develop, produce, market and supply this equipment. Both SSRs and BLs resort under the PMS Management Committee.

The different BLs en SSRs are depicted in Figure 2.2. The different business lines are the following:

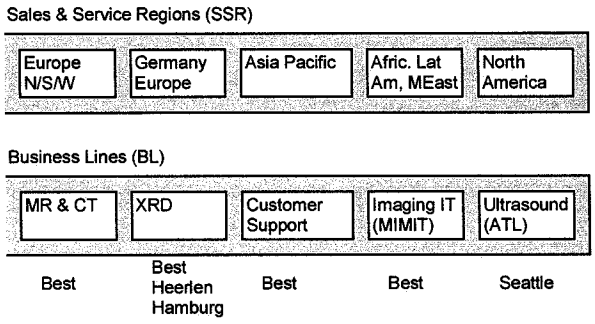

Figure 2.2: The PMS Organisation

- Magnetic Resonance (MR) & Computed Tomography (CT) provide diagnostic medical equipment involving other techniques than X-ray, like magnetic resonance imaging and computed tomography.
- X-ray Diagnostics (XRD) is the largest BL of Philips Medical systems. It develops and produces diagnostic X-ray equipment.
- Customer Support consists of different supportive activities to PMS customers, e.g. health care consultancy.
- Imaging IT (MIMIT) provides integral solutions for medical information systems.
- Ultrasound is a line of business resulting from the 1998 PMS acquisition of ATL Ultrasound. Ultrasound is an imaging technique using high frequency sound.

PMS Cardio / Vascular equipment is used to make arteriograms, x-ray images of particular blood vessels and organs. A patient at the Duke University Medical Centre (USA) experiences this procedure in the following way:

"When you arrive in the radiology department the day of the procedure, you will be escorted to the vascular suite where you will be asked to change into a hospital gown and lie down on the radiographic table. A nurse will start an intravenous line (IV), which will provide fluids for you during the procedure. You will also be connected to a (...) monitor so that a nurse can keep a close watch on all of your vital signs during the exam.

At the start of the procedure, an area of your arm or leg will be shaved if necessary, cleaned with a sterile solution, and then draped with sterile towels. A local anesthetic will be injected into the area to prevent any pain. The Vascular Radiologist will then insert a catheter (small plastic tube) into the vein or artery and direct it towards the region of interest. The movement of the catheter in the body is painless. Your radiologist will then inject small amounts of contrast (x-ray dye) into your blood vessels to make them visible to the x-ray equipment. (...) Once the catheter is properly positioned, a rapid series of x-ray images will be taken. During this time, you will be asked to lie perfectly still and hold your breath for 5-15 seconds. This segment of the examination may be done several times until all of the vessels are properly evaluated. After the procedure is completed, the catheter will be removed and pressure will be applied to the puncture site for approximately 10-20 minutes. (...) After the arteriogram is over, you will be moved to a recovery room where you will lie flat. Your nurse will continue giving you intravenous fluids, encourage you to take oral fluids, monitor your blood pressure and pulse periodically, and make sure there is no leakage from the catheter entry site".

Box 1: X-ray in Practice at the Duke University Medical Centre (USA) [Duke01].

2.3 Cardiovascular Department

2.3.1 Introduction

The initiator of the assignment is the Product Market Group (PMG) Cardiovascular. C/V is part of the BL XRD, which consists of 5 Product Market Groups (PMG): General X-ray, Cardiovascular, Common Imaging Subsystems, X-ray Generation and X-ray Tubes. The last two of these are situated in Hamburg. The position of C/V within PMS and XRD is shown in figure 2.3.

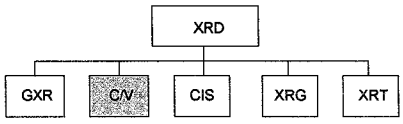

Figure 2.3: The position of C/V within XRD

Philips is the world's leader in cardiac and vascular imaging for diagnostics and intervention. Its Integris Allura is the world's first interventional x-ray system for 3D reconstructions. The Integris Allura Flat Detector system is set to raise the standard of cardiovascular imaging worldwide. Philips broke new boundaries with its Integris 3D-RA (rotational angiography) interventional tool that is compatible with the Integris Allura Image Intensifier. This system has the fastest rotational angiography speed in the market and offers high speed of 3D reconstruction.

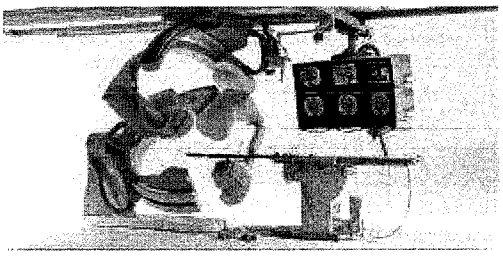

Figure 2.4: The Integris Allura

C/V has sales of approximately Euro 300 million and profit of approximately Euro 50 million. The organisation consists of approximately 160 employees. C/V is engaged in the development of hardware, software, mechanics and system design. In the market there is a strong focus on increasing the efficiency of health care delivery systems.
In cooperation with specialists, customer-friendly and people-friendly systems are built. This creates a field of tension; the organisation has to keep in mind ease-of-use and workflow. Development is characterised by innovations having a long lead-time. Innovation projects, like the project for a new geometry, approximately take 4 to 5 years.

In 2001, the market share of C/V was 42%, compared to the market share of GE and Siemens of 25% each. The past time GE is slowly taking over the leading market position of C/V. Since lately C/V is not able to introduce its products in the market before GE, C/V is transforming from market leader into fast follower of GE. C/V needs to realise a reduction in its time-to-market to keep its leading position.

2.3.2 The Mission and Vision of the PMG Cardiovascular

In line with the mission and vision of both PMS and the Business Line XRD the mission of CV is defined as [Stratplan02]:
'To provide systems, solutions and value added services for Xray-imaging based diagnostics and intervention/therapy in the clinical segments cardiac- and vascular angiography.
Being an enabler to integrate and interface with other modalities, image- and information management systems for the global healthcare market'.

The vision of Cardiovascular is:
To have reached in 2004, within the scope as defined in the mission, the following targets [Stratplan02]:

- An expanded nr. 1 market position, both financially and in customer perception, in each of the defined segments
- Leadership in products and solutions, based on cutting edge innovation and superior interoperability
- Highly professional organisation and processes which are respected and appreciated by all stakeholders

Looking at the position in the market, and the strengths and opportunities, C/V has identified the Key Success Factors for its products are:

- Reliability
- Ease of use / workflow / interoperability
- Image quality / dose management
- Multi modality applications
- Volumetric imaging

2.3.3 Relevant Relations & Positions

As can be seen in figure 2.5, the C/V organisation consists of different functional departments. It has already been explained in chapter 1 that the three relevant processes for this research are the marketing, the application and the technology departments.
Project management consists of the project leaders, who get the capacity required to execute their projects from the other departments.
Each of the departments has its own tasks and responsibilities, but alignment with the other departments is necessary. The tasks and responsibilities of the three departments that are involved in the research will be described next.

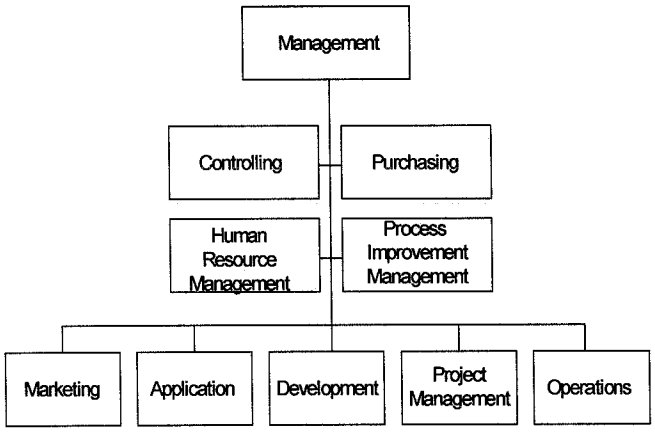

Figure 2.5: Functional organisation of the PMG C/V

Application department
The application department is responsible for the integration of clinical application aspects into the business processes of the PMG C/V. This contains contribution to the PMG-strategy and product policy based on knowledge of applications, clinical trends and changes in the medical care.
By the creation of a referention-site network and support of marcom activities, congresses and sales activities application supports the marketing and sales processes [handboek_C/V00].

Tasks of the application department can be divided into [handboek_C/V00]:

- Upstream tasks: contribution to the PMG strategy and product policy, to product innovation and to business development.
- Downstream tasks: support to existing products and projects.
- Support tasks: technical support and referentionsite-management

Marketing department
The marketing department is supposed to execute the following tasks [handboek_C/V00]:

- Defining the Business Strategy & Planning Process and realising the worldwide marketing policy for the PMG C/V.
- The introduction into the market of new, and the phasing of existing PMG C/V products, according to consolidated roadmaps of the Product Teams, which results in the ability of the organisation to defend its leading position against competition.
- The development of selling plans, accompanied by commercial parameters, like prices, product positioning and sales.
- Communication with the MT in a way the decision making about business aspects takes advantage of the knowledge and experience available, and leans on a well-balanced input of the collective functional departments.

- Selection of key suppliers for complete products and the communication with them, such that the make-or-buy policy can be developed, together with the departments Development and Purchasing XRD.
- The planning, building and maintenance of relations with medical experts and institutes in close cooperation with the department application, which results in referential sites for product and technology development and the promotion of new products, as well as the ability to observe and analyse new medical applications and techniques.

Development department

The mission of the development department is:

- To contribute to the PMG strategy and product policy, to product innovation and to business development.
- The development, maintenance and support of products in line with the overall PMG strategy and policy.

This implies:

Realising together with marketing, application, operations and project management, the specification, development, improvement and release of cardiovascular systems in all its aspects (like Image Quality, design, functionality, serviceability, quality, performance, flexibility, price, installability).

The development department supplies in innovative and cost-effective products and realises solutions for the problems of its clients (internal and external).

Flexibility, creativity and initiative of its employees accompanied by a customer-oriented attitude are cornerstones to the completion of the mission. [handboek_C/V00].

Chapter 3 Theoretical Perspective

This chapter forms the theoretical background for the research. In section 3.1, it will describe the roadmapping theory that is required to develop a roadmap process. Furthermore, in section 3.2, theory about innovation and aspects of organisational change will be handled, which are necessary to keep in mind during the design of the C/V roadmap process.
A full description of all general literature used during the project can be found in Appendix 4, and about roadmapping in Appendix 5.

3.1 Roadmapping theory

In this part of the report, a selection of theoretical perspectives on roadmapping is discussed. This selection contains the aspects that contributed most to the design of an improved roadmap process. In section 3.1.1, roadmapping literature is described, after which in section 3.1.2 the expertise that has been passed on by experts of other Philips divisions will be treated.

3.1.1 Roadmapping literature

Definition
Technology roadmapping is a needs-driven technology planning process to help identify, select, and develop technology alternatives to satisfy a set of product needs. It brings together a team of experts to develop a framework for organising and presenting the critical technology-planning information to make the appropriate technology investment decisions and to leverage those investments.

Given a set of needs, the technology roadmapping process provides a way to develop, organise, and present information about the critical system requirements and performance targets that must be achieved in a certain time frame. It also identifies technologies that need to be developed to meet those targets. Finally, it provides the information needed to make trade-offs among different technology alternatives [Gar98].

Figure 3.1 shows the typical content of a roadmap. These are the five typical layers a mature roadmap consists of. These layers are shown on one sheet of paper, to create the overall view. This overall view is called the top-level roadmap and it contains the most important aspects, milestones and mutual links for each of the layers.
Each of the layers mentioned has underlying roadmaps, which show more detail. For the product roadmap for example, these underlying roadmaps can be component roadmaps. Supporting roadmaps can also concentrate on specific relations, for instance between key driver and a required technology. These supporting roadmaps should be linked to the highest level roadmap by the time axis and a small set of recognisable landmarks, for instance quantified key drivers and the main products [Mul01]. In all roadmaps, the horizontal axis shows the time dimension.

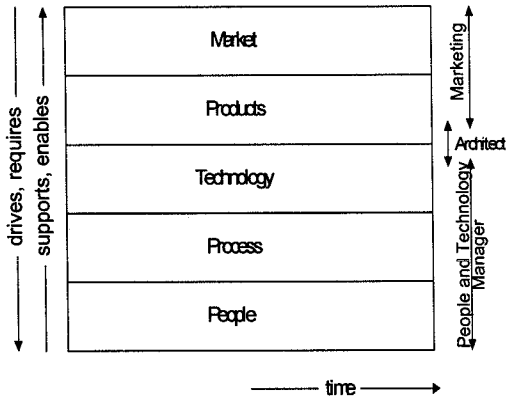

Figure 3.1: Typical content of a roadmap [Mul01]

Figure 3.1 shows at the right hand side the owner of the view, while the left hand side shows that the market is driving, while technology, people and process are enabling.

Roadmap Creation
The most essential art of making a roadmap is the selection of the most relevant issues. A technology roadmap per key driver is an explicit way to visualise the relation between the

market in terms of key drivers and the technology. At the marketing side, the trend in these key drivers must be visible in the roadmap.
If possible, facts should be used as input for roadmap creation: market analysis reports, installed base, manufacturing, suppliers and internal reports.
The top-level roadmap should fit on a single sheet of paper. This is a challenge, because it should contain the information entirely, to enable everyone to see the broader perspective and to see the many underlying relationships.

In literature, roadmapping is not a topic that is often discussed. The only promising support that could be found about the set-up of a roadmap process is given by the lecture 'T-Plan, Fast Start Technology Roadmapping' of the University of Cambridge [Phaal01b]. This lecture consists of four sessions: the market, the product, technology and roadmapping. By means of practising the four workshops in a row, the final roadmap can be drawn in the last session. The workshop provides a way of linking the business and market drivers to the technology required. These links become visible in the final roadmap. The total process requires communication and common expressing of terms, which is the key to an aligned roadmap process. The content per session is described next.

Workshop 1: The market
This workshop aims to establish a set of prioritised market and business drivers for the future, reflecting external and internal factors. First, a set of 'performance dimensions' should be defined. These are aspects of product performance that are (or might be) important to the customer, and that technology can enable. This is practical, because these are related directly to the product and most of the time can be identified fast.
Product performance is a fundamental factor that can be used to relate market drivers to technological capacity.
After determining performance dimensions the 'market / business drivers' should be determined. These are the external market and internal organisation drivers, which reflect the underlying customer and organisation motivation, needs and advantages.

Workshop 2: The product
This workshop aims to establish a set of 'product feature concepts' which could satisfy the drivers identified in workshop 1. The market / business drivers and product feature concepts together define a simple grid which can be used to investigate the relationship between features and drivers. This grid can be seen in figure 3.2. The grid at the right side, covering the business/market and the product/service areas are filled in during this workshop. The product feature concepts are grouped and their impact ranked for each market and business driver, and alternative product strategies considered (in combinations of market and business drivers). The ranking results are noted in the grid.

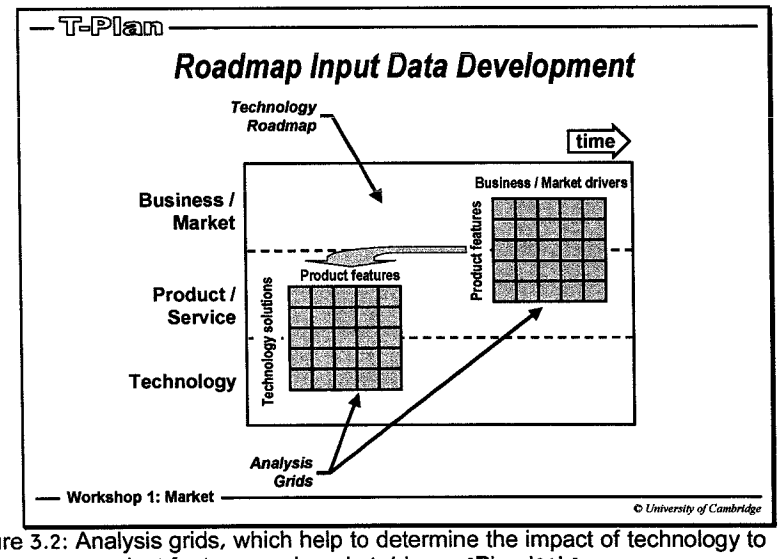

Figure 3.2: Analysis grids, which help to determine the impact of technology to product features and market drivers. [Phaal01b].

Workshop 3: Technology
This workshop aims to identify possible technological solutions that could deliver the desired product features. These solutions are grouped into technical areas (or 'routes'), which taken with the product features defined in Workshop 2, define a second analysis grid. This is the grid shown on the left side in figure 3.2. This grid links directly to the market-product grid. The impact of the technology areas on the desired product features is then ranked. The two analysis grids link together, and provide a means of relating the impact of technology to product features and market / business drivers, connecting various levels of the roadmap.

Workshop 4: Roadmapping
Workshops 1-3 enable a simple framework for linking the three levels of the roadmap to be developed, together with a 'language' for supporting the construction of the roadmap. Workshop 4 draws the marketing and technology strands together to produce the first roadmap. The format of the technology roadmap is defined, in terms of time scales, levels, and product strategy (e.g. platforms). Key milestones are identified, product evolution plotted, and technological programs identified, together with linkages between the roadmap levels, bearing in mind the prioritised market drivers, high impact product features, and most attractive technological solutions.

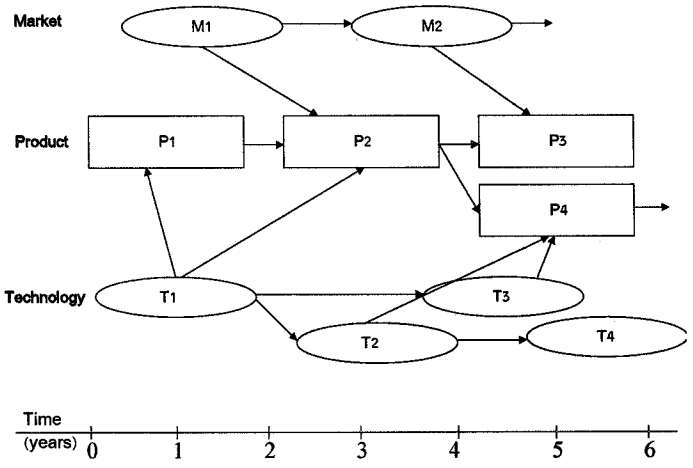

Figure 3.3: Generic overall roadmap, showing nodes and links

The final roadmaps that result from the workshops should be a draft of the product roadmap, which shows product releases in time, key milestones and the linkages between the products and the market and technology roadmaps. The market roadmap shows the market drivers plotted in time and the technology roadmap shows the technological solutions to realise the product indicated in the product roadmap. An attempt should be made to put the three roadmaps on one sheet of paper. The result will be an overall roadmap, which will look like the roadmap shown in figure 3.3. The market, product and technology roadmaps that result from workshop 4 will not be complete, because roadmapping is an iterative process that needs to be carried out several times to move to completion. The roadmaps can be completed to the level of detail desired. This depends on the amount of time and effort the company reserves to spend on roadmapping.

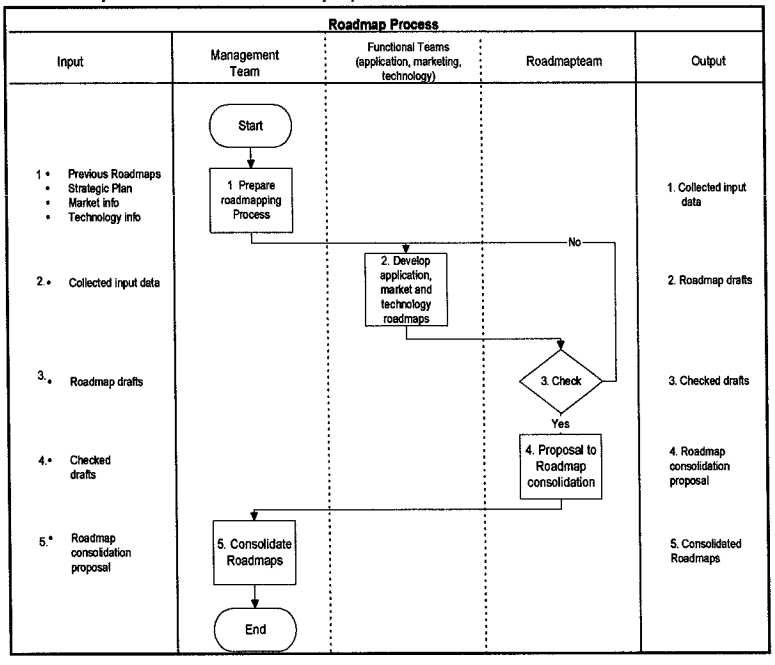

Figure 3.4: Global process flow of roadmap creation

An example of the process of roadmap creation is shown, at a high level of aggregation, in figure 3.4.

Advantages

Literature describes many advantages roadmapping can have for the organisation. The most important advantages from literature are listed here:

- One of the biggest advantages of technology roadmapping is that it provides information, which enables better decision making concerning investments [Kost01].
- An advantage of roadmapping is the improvement of the time-to-market and time-to-money which results in an improvement of the competitive position [Groen97].
- A good organised roadmap process enables better identifying, evaluating and selection of strategic alternatives [Kost01].
- One of the advantages of roadmapping is the creation of a connected approach for long term product and technology planning and the building of a vision [Groen97].
- An observed effect of not applying roadmapping is a late start of activities with a long lead-time. Roadmaps have the value of anticipation, which is especially important to projects with a long lead-time [CE01] [CE02] [Mul01].
- Besides the technology needed, properly aligned roadmaps enable early determination of skills and resources required, and the alignment with other projects [Kap01] [CE01].

Organisational aspects of interest

Besides advantages, literature appoints aspects that deserve special attention at the start of a roadmap process. The most important aspects are:

- An important aspect of the roadmapping technique is the multidiscipline, crossfunctional working. [Kost01].
- Management has to be involved to the process [Kost01] [Mul01] [Groen97] [CE01] [CE02] [Mor00] [Gar98] [Phaal01b].
- Roadmap creation is a common effort of all stakeholders [CE01] [Mul01].
- Roadmaps need to be a guide for the organisation as a whole [Kost01].
- Roles of roadmap managers and teams have to be defined unambiguously and have to be common knowledge of all parties concerned [Kost01] [Mul01].
- Attention should be paid to the fact that roadmapping is not a 'black box' methodology. Each practice is a learning experience. A flexible approach, adapted to the specific circumstances has to be adopted [Phaal01a].
- Roadmapping needs to be integrated with other decision processes and tools within the organisation [Kost01].
- Roadmaps per key driver are an explicit way to structure roadmaps [Mul01].
- Necessarily, roadmapping is an iterative process [Kost01].
- Do not underestimate the amount of time and concentration required to continuously change the content and to optimise the use of roadmaps [Groen97].
- At least twice a year new visions/ roadmap versions should be consolidated [Mul01].
- Factors that should be considered before roadmapping can be started [Phaal01b]:
  - Identification of the appropriate participants
  - Required resources and scheduling of workshops
  - Identification of available information
  - Definition of the unit of analysis
  - Clear articulation of company objectives for the process

Relation to other organisation processes

The roadmap process is related to four main processes of the organisation:

- The policy and planning process
- The Product Creation Process
- The people and technology management process
- The customer oriented process

Roadmaps give a vision on how to realise the objectives committed to in the strategic planning. The other way round, the vision of the future that roadmaps have, influences the

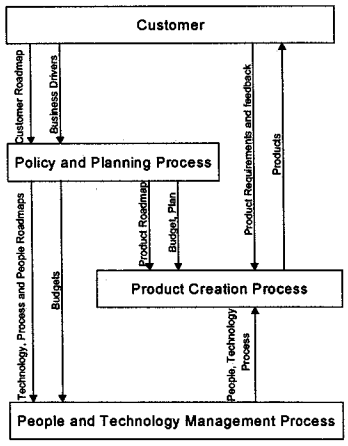

Figure 3.4: The context of organisation processes and relations

strategic planning. These processes are mutually linked and influence one another. They cover the first phase of the PCP. Because the people and technology management process delivers the people, processes and technologies that enable the PCP, these also should be part of the long-term planning with the help of roadmaps. The customer-oriented process is the customer of the PCP, which should be optimally served. This is why roadmaps should contain an outside-in vision.
The context of these processes, their mutual relations and the role roadmaps play related to the main processes, are shown in figure 3.4 [Mul01].

3.1.2 Expert knowledge

To gain insight in the field of roadmapping in practice, interviews have been conducted with roadmap experts within other divisions of Philips; the Centre for industrial Technology (CFT), the Natlab, and Consumer Electronics (CE). These experts also wrote articles and some of them give lectures about roadmapping. This knowledge approximately provides the same value as professional literature for this research.
The most relevant aspects for the design of the roadmap process of C/V, not yet mentioned in literature, were:

- Many companies and business units should extend their roadmapping activities, because they do not practise it continuously or they just have limited activities. For example, they just have a product roadmap.
- Important aspects from the Strategic Plan need to be the basis and steering force of roadmaps.
- Limiting conditions of the organisation play an important role and have to be reviewed.
- In the determination of key drivers, an answer should be found to the question what the essence is of a certain key driver for the customer.
- In a roadmap, technologies have to be separated from key drivers, because technologies may also be renewed unrelated to the key drivers.
- Besides application, also marketing people need to be involved in the roadmap teams.

The total list of statements from these interviews can be found in Appendix 5.

3.2 Innovation & Organisational Change

Since a few theoretical aspects of innovation and organisational change were needed to keep in mind during the design of the roadmap process, these are described shortly in this section. The full description can be found in Appendix 4.

3.2.1 Innovation

Technology is an enabler for innovation and relates highly to the competitive advantage of the company. Five categories of innovative capacities can be distinguished, which are shown in figure 3.5. The skills and know-how of employees are among the most influential competencies that determine innovation. When C/V realises an aligned roadmap process, it has the ability to manage human resources and skills according to the needs.

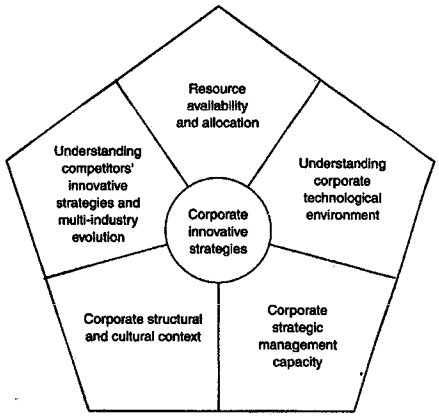

Figure 3.5: Innovative capabilities framework [Burg01].

The management of uncertainty is an important aspect of the innovation process. Uncertainty often concerns means; decisions about projects that are unviable have to be taken regarding future funding. Also time is an element that needs to be considered, because time is limited. Many decisions are made with imperfect knowledge.
The nature of uncertainty can be seen in Pearson's uncertainty map in figure 3.6.

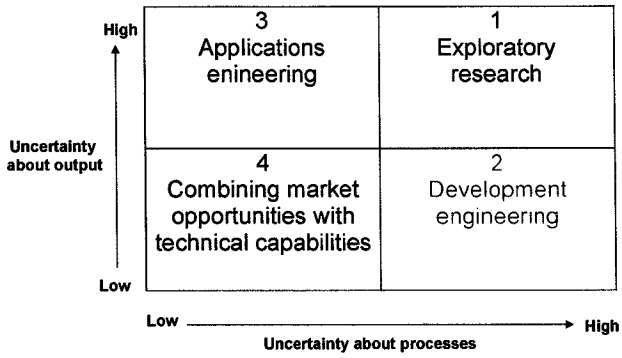

Figure 3.6: Pearson's uncertainty map [Trott02].

The innovation process of C/V can be situated in the second quadrant, development engineering: the end is clear, product releases are planned in time, but there is uncertainty about precisely how the organisation will achieve this target. It also occurs that the target is not achieved in time. For the organisation, it is important to create a mechanism that enables to control the uncertainty of means.

3.2.2 Organisational Change

Structure Parameters

Organisational structure determines the speed of adaptability to changing environments [Merwe02].
It is important to take into consideration structure parameters. These point out the type of organisation.
Three important parameters that are essential for the design of the structure are [Jäg95]:

1. Differentiation, grouping of people
2. (De)centralisation
3. Hierarchy

How the alignment of the roadmap process has to be organised with respect to these three parameters is important to consider during the process development. The grouping of people in the roadmap process has to fit with the way people are grouped in the organisation. The hierarchical structure and issues concerning the centralisation of decision making are important for the final design. These issues will be considered during the development of the roadmap process design in the chapters 5,6 and 7.

The TPC-model of Tichy

During the creation of the realisation process for the transformation, attention has to be paid to the fact that organisational changes most of the time do not stay restricted to the planned changes, but also may have (often unplanned) side effects.
This topic is described by the TPC-model of Tichy (1989).
It generally states that changes have their side effects in the technical/economical system (T), as well as in the political (P) and the cultural system (C) of the organisation [Aken93].

The elements from the 7S-framework can be related to Tichy's TPC-model.
These relations are shown in figure 3.7.
The TPC-model of Tichy can also be used to evaluate a realisation design afterwards, especially by questioning if the design pays sufficient attention to the political and cultural aspects of the transformation, and does not mainly focus to the technical/economical aspects. In this way the TPC-model is used in this research. This is described in chapter 8.1, where the TPC-model helps in providing an answer to research question 7.

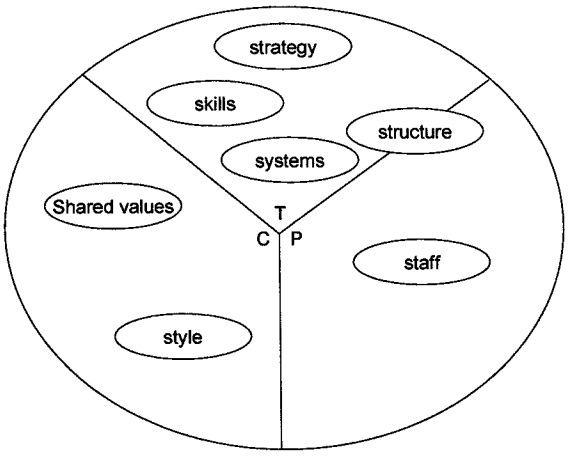

Figure 3.7: The seven elements of the 7S-framework and the TPC-model of Tichy.
T: Technical/economical aspect system
P: Political aspect system
C: Cultural aspect system

3.3 Summary

This chapter provided a theoretical background, which can be used as a guideline during the development of the C/V roadmap process.
First, roadmapping theory has been treated, obtained from professional literature. The definition of roadmapping has been given and the way roadmap creation should take place. Roadmapping is a topic that is not often discussed in literature, but a workshop of the University of Cambridge has been found about the set-up of a roadmap process. During the research, the decision has been made to take this workshop as a support and guideline for the start of the CV-roadmap process. The remark has to be made that this workshop is a guideline for the start of a roadmap process *from scratch*. Within C/V, the process does not have to be started from the beginning; people already know some things and a few roadmaps already exist. This is why the workshop did not have the effect expected. More about this practical experience can be read in chapter 6.
Furthermore, the roadmapping literature gave some advantages and organisational aspects of interest about roadmapping. Also the relation to other organisation processes have been shown.
Next, expert knowledge has been consulted from experts of other Philips divisions. This has been included in this chapter, since these experts wrote articles and some of them give lectures about roadmapping, which caused that this knowledge provided approximately the same value as professional literature.

The second part of this chapter provided a short description of a few general topics from literature, needed to keep in mind during the design of the roadmap process, which starts in chapter 5. First, chapter 4 will describe the comparison of the theoretical framework from this chapter, with the current roadmap process of C/V. This analysis will lead to the functional specification of the design of the C/V-roadmap process.

Chapter 4 Functional Specification of the roadmap process

This chapter deals with the comparison of the roadmapping framework, which can be formed from the information of the previous chapter, with the current C/V-roadmap process. This framework is a guide to the development of a roadmap process and will be given in section 4.1. The comparison of the current C/V-roadmap process to this framework will lead to differences, which are described in section 4.2. To gain additional knowledge, also experiences from other divisions and PMG's has been gained and described in section 4.3. These organisations already put effort in the creation of a roadmap process before the C/V-initiative raised. The total analysis described in this chapter provides the functional specification of the roadmap process design for C/V. The functional specifications will be described in section 4.4.
The composition of this chapter is pictured by the model in figure 4.1.

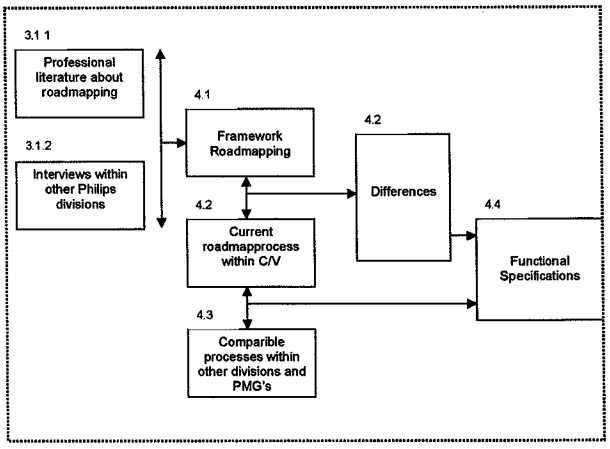

Figure 4.1: Model showing the composition of the chapter

4.1 Roadmapping Framework

From the roadmapping literature, combined with the insights gained from interviews with roadmap experts of other Philips divisions, a framework for roadmapping has been identified. The roadmapping framework consists of the following elements:

1. Roadmapping consists of more than just maintaining a product roadmap. It needs to be integrated with other processes.
2. Roadmaps have to be a guide for the organisation as a whole.
3. Important aspects from the Strategic Plan need to be the basis and steering force of roadmaps.
4. Roadmaps per key driver are an explicit way to structure roadmaps.
   In the determination of key drivers an answer should be found to the question what the essence is of a certain key driver for the customer.
5. A long-term vision is required, based on close cooperation between all disciplines.
6. An important aspect of the roadmapping technique is the multidiscipline, crossfunctional working. Teamwork, integral engagement to the organisation and good communication are characteristics of vital importance to the process.
7. Roadmap creation is a common effort of all stakeholders.
8. Management has to be involved to the process, the role of the roadmap manager needs to be defined and the competence of the Roadmapteam needs to be sufficient.
   At least twice a year new visions/roadmap versions should be revised and consolidated.

4.2 Analysis of differences

To gain insight in the differences between the current roadmap process within C/V and the framework provided by professionals, conversations and interviews have been arranged with people involved in the C/V-process from different disciplines and teams. A list of aspects mentioned during the interviews and conversations can be found in Appendix 2.
Here, only the relevant statements that show the differences with the framework are listed, in the same order as the framework elements:

1. At this moment only the product roadmap and underlying component roadmaps are linked. Also a few technology roadmaps exist, but these are not sufficiently tuned to the product roadmaps, to one another and to the market requirements.
2. Currently, not everyone concerned has access to the roadmaps. Since roadmaps are confidential, only management and the Roadmapteam have access.
3. Most of the people involved are not accustomed to the content of the Strategic Plan.
4. It is not clear for which aspects roadmaps should be created.
   Performance indicators have to be determined from the vision to the market more, so that C/V can distinguish itself from competition.

5. Roadmaps are made only for the short term of 2 to 3 years and are based on reality only. They do not contain enough vision.
   Marketing only brings in a limited view to the future. It does not carry out a long-term vision.
   The absence of application roadmaps is a deficiency for the development department, because development is not informed about market trends.
6. At this moment, too many roadmaps are created in isolation and roadmapping is not always an interactive, cross-functional activity.
   Technology should be involved more into the roadmap process. Many teams are mainly represented by marketing people.
7. At this moment a structured roadmap process does not exist and is not managed, but the intention to start this process exists. Management is involved to this intention and many people from different functional areas are involved already.
8. Roadmaps are not revised on a regular basis. Also, they are not revised simultaneously. A regular process to consolidate roadmaps at fixed points in time does not exist.

4.3 Comparable processes within other PMG's and divisions

To make the functional specification that will be described in the next section more complete, additional interviews within Semiconductors and within the PMG's Common Imaging Subsystems (CIS) and Magnetic Resonance (MR) have been arranged. These organisations already put effort in the creation of a roadmap process before the C/V-initiative raised.
CIS can be seen as the internal supplier of C/V for several components C/V needs for its systems. MR more and more expands to equal market segments as C/V and may possibly take over (part of) the C/V business in the future. Both these PMG's recently started with the set up of a roadmap process.
Relevant and new insights important to the roadmap process design are stated below. A complete list of statements can be found in Appendix 3.

Relevant and new insights from these interviews are:

- The absence of a vision is strongly related to the absence of the right skills. A good combination of skills is very important
- Many innovations within C/V are technology driven, although C/V delivers to a niche market, which enables gaining knowledge with respect to customer demand more easily.
- C/V should definitely have an application roadmap, which show the clinical needs in time.
- A tool that can be used for assisting in the creation of a technology roadmap is the 'technology tree'. This is a representation of a step by step more deepening specification of the required technology. Important aspects to pay attention to are the required level of detail and the relationships between the diverse technologies.
- Besides fitting in the Strategic Planning and the Budget Round, it is important to fit in other yearly activities that influence the long-term planning, like seminars, fairs, assemblies and, very important but often not considered, the budget round of hospitals.

4.4 Functional specification of the roadmap process design

Based on the comparison of the current situation of C/V with the framework, completed with aspects from interviews within Semiconductors and other PMG's, this section describes the functional specification of the design of the C/V-roadmap process.

The functional specification consists of the following elements:

- The C/V-roadmap process needs to be extended and aligned.
- In the future roadmap process, roadmaps should not be created in isolation and roadmapping should be an interactive, cross-functional activity.
  Also, roadmap teams have to consist of a proportional composition of different disciplines.
- Contrary to the current situation, an obvious relation needs to be established between the roadmaps and the business drivers stated in the Strategic Plan. Therefore, the Key Success Factors of C/V, which are the business drivers for C/V, should be kept in mind. The KSF's are [Stratplan02]:
  - Reliability,
  - Ease of Use / Workflow / Interoperability,
  - Image Quality / Dose Management,

  - Multi modality applications,
  - Volumatric Imaging.
- Future C/V roadmaps have to cover a longer timeframe than they do now; they have to look further than the next project and need to contain more vision.
- Constantly, the level desired should be weighed against the time and effort required to reach this level: a selection criterion that indicates which roadmaps should be created needs to be determined.
- Roadmapping should be market-driven, which means concentrated on trends and competition moves. At this moment competition roadmaps and market trend roadmaps do not exist. The focus on competition will become very important for the coming years [Stratplan02].
- Application/clinical roadmaps need to be created soon.

4.5 Summary

To find out what gaps exist between a good organised roadmap process according to literature and roadmap experts, and the current roadmap process of C/V, an analysis has been carried out in this chapter. The results of this analysis were completed with statements from interviews with people from other divisions and other PMG's. This in total resulted in the functional specification of the C/V-roadmap process design.
This will be the building block for creation of the C/V-roadmap process.

The next chapter describes the research to create the C/V-roadmap process. Different scenarios are developed to reach the effective roadmap process for C/V.

Chapter 5 Research to the effective roadmap process

In this chapter, a research is described to achieve a process structure that will improve alignment and efficiency of the roadmap process of C/V.
The research starts in section 5.1 with an extension of the functional specification, which results from presenting the basic roadmap idea developed in chapter 4, to people involved. Based on this extended specification, different possible scenarios to improve the current process are developed and evaluated in section 5.2. Section 5.3 provides some points learning points, experienced during the design phase. Finally, section 5.4 gives a summary of the chapter.

5.1 Extension of the functional specification

From the comparison of the current roadmap process of C/V with the roadmapping framework, the functional specification of the roadmap process has been identified. Keeping this in mind, the next step is to examine the current process composition of roles and teams and their relations, to find out which changes can lead to the most effective improvements. The ideas developed in chapter 4 and the current composition of roles and teams are reflected to C/V-people involved in the process. Also decision making aspects for each of the departments involved are considered. This results in the extension of the functional specification, providing criteria the design should meet.

5.1.1 Reflection of findings

From reflection of the earlier findings to management and other stakeholders of C/V, the following additional requirements raised:

- Senior management should only be involved in teams that have to discuss and decide about subjects essential to the business. This enables managers to spend more time on management issues and it might enlarge creativity of others.
- To enable easier embedding of the new roadmap process in the organisation, the process should be recognisable by the people involved.

5.1.2 The current organisation of the roadmap process

To reflect the findings of chapter 4 and the current composition of roles and teams, conversations with people of C/V were arranged. The current roadmap process, *as described in the user's manual of C/V,* can be found in Appendix 6. This provides an overview of the different teams, relationships and the information flow between the teams.
From the conversations, it appeared that the current roadmap process structure is *deviant from the structure described in the user's manual.* The structure as it is in reality, sketched by various people within C/V, is shown in figure 5.1.

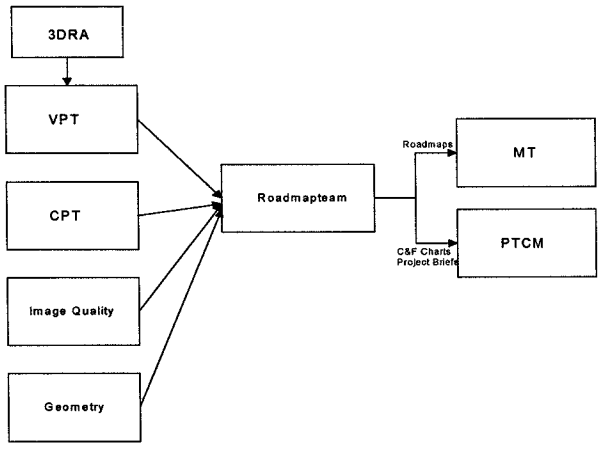

Figure 5.1: Current organisation of roles and teams in the roadmap process

The Vascular Product Team (VPT) and Cardiac Product Team (CPT) discuss aspects relevant to their market segment once every two weeks and draw a Product Policy. A concept Product Roadmap is created, which indicates the required availability of future products, the current products and products from committed projects.

Development of subsystem and system characteristic teams (see glossary) should be taken into account by the Product Teams, but in stead of providing input to the CPT and VPT, most of the subsystem and system

characteristic teams have a direct link with the Roadmapteam. Only the 3DRA-team does provide information to the VPT.

The information exchange between the subsystem and characteristic teams and the Roadmapteam is not organised on a structural basis, but every now and then the Roadmapteam invites these teams to present their roadmaps during the monthly Roadmapteam meeting.
The Roadmapteam checks the concept product roadmap to budget and capacity, resulting in the C/V product roadmap. This internal C/V product roadmap is reviewed and approved by the C/V Management Team (MT). PTCM uses the roadmaps for project execution.

Inefficiencies of this process:

- The absence of one main focus of the current roadmap process structure; it is based on the differentiation of market segments, by input coming from CPT and VPT, but also technology teams deliver input, without preliminary alignment.
- 'No convergence of technology to one overall technology plan'. Although expert teams exist that work on special technology areas, like the geometry and IQ, these teams do not mutually align their processes.
- 'No translation of the C/V strategy into a technology plan; there is no technology driven proposition to realise the C/V strategy'.
- The existence of many double roles and meetings.
- When 'the subsystem and system characteristic teams only present roadmaps at the moment the Roadmapteam indicates', existing knowledge may remain unused or get lost.

5.1.3 Decision making aspects

The main criteria that should be satisfied by the roadmap process in the future can, among other things, be derived from the critical decision making aspects of the different parties involved. Which information exchange is necessary between the departments determines the structure of the process. To determine these critical decision making aspects, relevance and goals of all parties involved in an aligned roadmap process have to be clear.

The primary goal to be reached by structuring and aligning the roadmap process is the ability to make responsible choices between different strategic options, based on the right information. This results in the realisation of organisational goals, which are for all participants, as already described in chapter 1:

1. Reduction of the time-to-market of innovative products, which results in sustaining the current leading market / competitive position.
2. A product quality exceeding the product quality of competition.

To realise these goals, optimal decision making, alignment and allocation of resources during the project and product definition phase by the different parties involved, is necessary. An 'inter-departmental dialogue' within C/V has to be set up during execution of the roadmap process. In this dialogue, aspects that influence critical decision making of each of the three departments involved should be communicated to one another.
Also, a hierarchical dialogue has to be developed between management and the lower layers. The information-exchange of strategic issues is essential.

Examples of decision making aspects during this phase for each of the three departments involved are:

- For application:
  - Which clinical needs / trends are the most important to concentrate on the coming years?
  - What does this mean for the cath lab? Which features do products need to possess to serve the cath lab?
- For marketing:
  - At what point in time the indicated trend / feature has to be introduced to the market to stay competitively strong?
  - What is the allowed costs-quality ratio to realise this product or product feature?

- Which trends arise in the marketing field, e.g. which geographical segments are becoming important, what are trends in reimbursement?

- For technology:
  - Given the requirements of application and marketing, how can we optimally combine our knowledge and competencies to one technology plan to realise these requirements?
  - Which are raising trends in technology important for the business to concentrate on?

At this moment, the requirements and knowledge of each of these groups are not regularly spread across the borders of these departments, and sometimes not inside the borders of the technology department. Business plans should be based more on shared visions that are exchanged with the help of structured processes.
Also, business plans should be based more on the core competencies of C/V. Since the KSF's are derived from the core competencies, roadmaps should be based on these KSF's. This influences reaching the second goal of attaining better product quality.

5.1.4 Definitive criteria the effective process should meet

From knowing

- the functional specification based on the roadmapping framework,
- the reflection of earlier findings to people involved
- the inefficiencies of the composition of the current roadmap process, and
- the kind of decisions, important for the different departments,

the definitive criteria the roadmap process should meet can be developed. Meeting these criteria will be essential to fill the gap between the current process and the effective roadmap process, which need to enable optimal decision making, alignment and allocation of available resources!

To be effective, the roadmap process design should provide a positive answer to as many of the following questions.
Questions based on the theoretical findings of chapter 4:

1. Does the new process result in roadmaps with vision and outside-in oriented planning?
2. Does the process contain a mechanism to make the appropriate roadmap selection?
3. Does the process contain a mechanism to base roadmapping on core competencies?
4. Does the process change the functional thinking into process-oriented thinking?
5. Does the process fit the organisation and the strategy?

Question based on the assignment, the reflection of theoretical findings, the reflection of the current composition of the process and the decision making aspects:

6. Is decision making of the departments application, marketing and technology aligned in the overall roadmap?

Questions based on the reflection of the theoretical findings to stakeholders:

7. Does the process execution require as little teams and (management) effort as possible?
8. Are the appropriate people responsible for the final decision making?
9. Is the process recognisable and acceptable to people involved?

Question based on the reflection of the current composition of the process:

10. Does the process enable the mutual alignment of different technology aspects?
11. Does the process create one focus of final roadmaps? (e.g. market segments or functional areas)

These criteria have been formulated by the researcher, after which they have been discussed and confirmed with management. Taking into account these criteria, in the remainder of this chapter a new roadmap process is going to be designed.
In this project, it has been found inappropriate to directly apply weight to the criteria, because the importance of the criteria changed during the design phase:
In the beginning, a few of these criteria (mainly 4 and 7) were seen as more important than others. During the course of the scenario development this view changed as a result of experience, and the criteria 1, 2, 3 and 4 (random order) were judged more and more important. Only at the end of the scenario development, when scenario 5 was presented, management made clear to be devoted mainly to criteria 5, 7, 8 and 9 (also random order). Criterion 6 should have been satisfied by each design, since meeting this criterion was required by the assignment. It was confusing that it came to light several times, that the

alignment to market segments was also important, since the existence of the different product teams has not been created just like that. Hospitals use the same separation and the market should be optimally served. For this reason, during the scenario design, final alignment to market segments also has been explored and reflected. Because people recognised these product teams, they agreed with this alignment, by which criterion 6 was overlooked for a while. Afterwards, looking back to the design phase, this final alignment has been the biggest struggle, although at the time the final design was created, it became obvious that alignment of the departments was the most important. The alignment of the functional domain can contribute to effective allocation of resources and can prevent scattering of resources, which was the initial problem and the reason for starting this project.
During the total scenario design, criterion 10 and 11 appeared to be least important.

5.2 Exploration for the effective roadmap process

In this section alternative roadmapping processes are described, with the goal to create a roadmap process that fills up the shortcomings of the current roadmap process, which were determined earlier in this project. The different alternatives raised from the reflection of previously developed scenarios to stakeholders of the process. At the start of each design, different criteria were set as a goal the design should meet, to create the feeling of what would be most important to the effective design. The scenarios are also based on practical roadmapping exercises, executed in parallel, which will be the topic of the next chapter. Five alternatives were developed, before management fully agreed with the sixth design. This sixth design raised from the experience of the researcher gained, and the reflection of scenario five to management.
The alternatives created are evaluated with respect to meeting the criteria that were discussed in the previous section. This evaluation will be handled after each scenario description, and a summary will be given in section 5.2.2, to provide the total overview. The term 'positive' means the alternative satisfies the criterion, 'negative' means it does not. If some doubt exists, or a criterion is judged as well positive as negative, it will get the review 'neutral'. The evaluation has been executed by the researcher. Although an independent critic has confirmed the results, the evaluation will still be rather subjective. Afterwards, it can be stated as learning point, that the acceptance and agreement of management has been more important than the quality or score of the design. More about this experience can be read in section 5.3, where all experience gained during the design phase will be discussed.

5.2.1 Description of alternatives

In this section, five alternatives will be described that can contribute to the improvement of the current roadmap process. The goal of each scenario will be described first, followed by the description of new characteristics compared to designs previously developed. Also, each scenario will be shown by a figure. Since these scenarios are only drafts that may help to reach the optimal structure, the figures combine the hierarchical structure and the process flow to one view.
The section will start with an evaluation of the current roadmap process of C/V, which was described in section 5.1.2 and shown in figure 5.1.

Evaluation of the current situation to the criteria:

1. Negative; current roadmaps do not look further than the next project and market roadmaps do not exist.
2. Negative; only product and a few randomly created technology roadmaps exist.
3. Negative; the subsystem and system characteristic teams do not cover all core competencies.
4. Negative; functional thinking is leading.
5. Neutral; it matches with the structure parameters hierarchy and centralisation, but it does not match with the functional departments and the strategy of specifically addressing the core competencies of C/V (a full description of structure parameters can be found in Appendix 4).
6. Negative; the absence of this alignment is a reason for initiating this project.
7. Negative; management is engaged in the product teams and the Roadmapteam.
8. Negative; the roadmapteam consists of many people to be effective; many double roles exist for people in the Product Teams and the Roadmapteam.
9. Positive; people are accustomed to this existing process.
10. Negative; subsystem and system characteristic teams do not align their plans.

11. Negative; there is not one focus to align the final roadmaps to.

Scenario 1: Cross-functional teams & less management effort

The goal of the first scenario is to create an iterative, interactive and cross-functional process for roadmap creation and to involve management in a late stage.

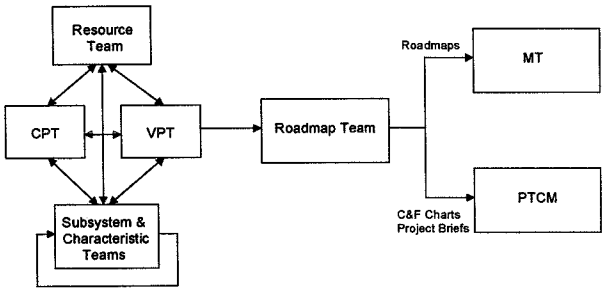

Figure 5.2: Roadmap process scenario 1

CPT, VPT, subsystem and system characteristic teams and the resource team interact with one another on a structural basis to tune their planning, findings and roadmaps. These are cross-functional teams, consisting of people from research, marketing, application, technology and resource management. This process is illustrated in figure 5.2.
Final roadmaps are presented to the Roadmapteam by 'linking pins', people that are member of a team in the first phase and the Roadmapteam.
In the first interactive, cross-functional process, senior management is not involved. This may result in more creative thinking and less time required by managers.
The Roadmapteam is a team that consists of managers and the linking pins.

Evaluation to the criteria:
1. Negative; no creation of more vision and outside-in attitude than before.
2. Negative; there is no clear roadmap selection criterion.
3. Neutral, a direct link to the KSF's that are derived from the core competencies of C/V is not shown, but the subsystem and system characteristic teams can be KSF-related teams in the future.
4. Positive; process-oriented thinking is facilitated by the cross-functional meetings
5. Neutral; it matches with the structure parameters hierarchy and centralisation, but it does not match with the functional departments and the strategy of specifically addressing the core competencies of C/V.
6. Negative; no alignment of the functional departments in the overall roadmap.
7. Positive; management spends less time by just being member of the Roadmapteam.
8. Positive; the Roadmapteam mainly consists of management. Because of the linking pins, fewer people have roles in both Product Teams and the Roadmapteam.
9. Positive; by the maintenance of existing teams, the structure will be recognisable.
10. Neutral; the subsystem and system characteristic teams here mutually communicate, but there is no overall technology roadmap creation.
11. Negative; there is not one focus to align the final roadmaps to.

Additional disadvantages:
- It will be difficult to organise a useful meeting consisting of members of all cross-functional teams to align roadmaps. For these meetings to be efficient, too many aspects will need to be discussed.
- Involvement of a resource team in this early phase may limit creativity.
- Management involvement might be needed in the first phase, to keep the processes and meetings structured.

Scenario 2: Outside-in view and vision, differentiation of market segments

The goal of this scenario, which is illustrated in figure 5.3, is the creation of a more outside-in view and vision.
Also differentiation on the market segments cardiac and vascular was taken into account, because this was mentioned to be important during reflection of the previous design.
Furthermore, it was mentioned that involvement of the resource team in an early stage of the

process would not be a good option. Since at the start of the project the decision was made to involve resource and process management later into the roadmap process, when the roadmap process will be more mature, in the remainder of the process design the resource team will be ignored.

The application, marketing and technology departments will provide 'Trendmaps' to these market segment teams. The phenomenon 'Trendmap' was 'invented' during the practical experiences and will be described in more detail in chapter 6.2. The Trendmap is the compilation of predictions of future trends that are most important to the business (for about the next 10 years), made for each discipline separately.
Besides trends, application will describe what this means for the cath lab. Marketing will also provide market knowledge and knowledge about competition. The technology department provides, besides technological trends, technological knowledge and constraints.
The Roadmapteam team will consist of management, supported by linking pins from each of the product teams.

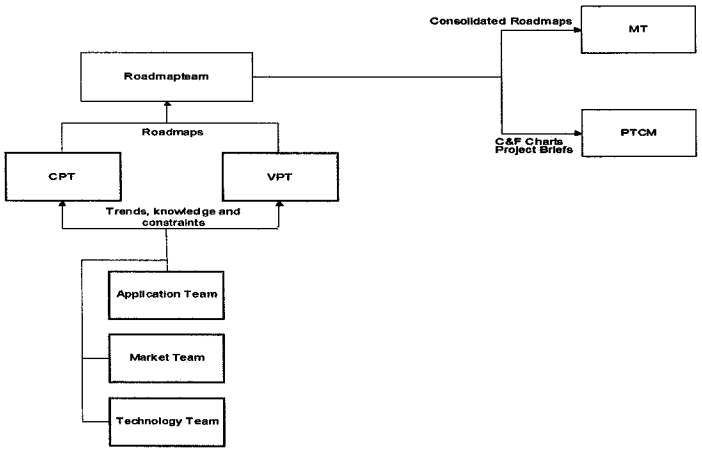

Figure 5.3: Roadmap process scenario 2

Evaluation to criteria

1. Positive; roadmapping is based more on market vision, by the prediction of trends.
2. Negative; there is no specific roadmap selection criterion.
3. Negative, no structured mechanism to create the link to the KSF's derived from the core competencies in the SP.
4. Positive; the CPT and VPT are cross-functional teams, consisting of a proportional amount of people from the different departments.
5. Neutral; it matches with the hierarchy and centralisation, but does not completely match with the functional departments and does not match with the strategy of addressing oneself to the core competencies.
6. Negative; no improvement of the alignment of the three departments in the overall roadmap. The departments just provide information in an early stage, and the roadmap alignment is based on the different market segments.
7. Neutral; here, it is not yet clear, if it is necessary to align the roadmaps to the market segments. These teams may be unnecessary for the roadmap alignment.
8. Positive; the Roadmapteam mainly consists of management. Because of the linking pins, fewer people have roles in the product teams and the Roadmapteam.
9. Positive; the current product teams exist, which will enlarge acceptation and recognition.
10. Positive; before technology trends, knowledge and constraints go to the product teams, they have to be aligned.
11. Positive; there is one focus; the focus on the market segments.

Scenario 3: Final alignment on functional domain & exploring the importance of technology aspects

The goal of this scenario is to base the final alignment on the functional domains. Another goal was to check, during the reflection, the importance to use technological aspects as a selection criterion to base roadmapping on.
Since not enough experience was gained yet to apply both the introduction of market vision and the introduction of attention to technology aspects, the first has been ignored here.

Subsystem and system characteristic teams provide roadmap information (technology aspects) to cross-functional market, application and technology teams on this subject. Based on this information, roadmaps in the different functional domains are created.
The subsystem and system characteristic teams consist of experts in their field. One linking pin of these teams provides information to the functional teams.

The functionally oriented teams consist of people of the functional domain, enriched by one person of each of the other three functional areas. Linking pins of each of the functional teams are members of the Roadmapteam, which furthermore consists of management members. This scenario is depicted in figure 5.4.

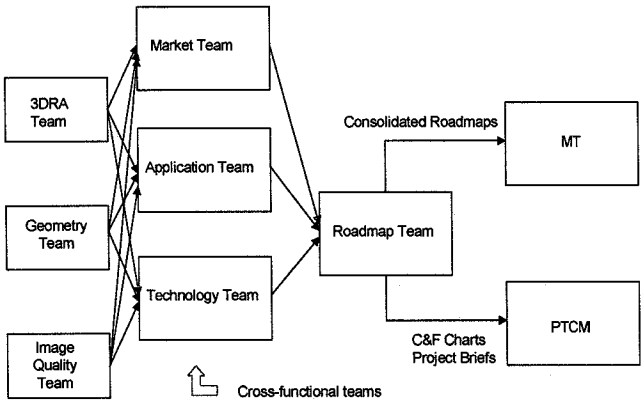

Figure 5.4: Roadmap process scenario 3

Evaluation to criteria:

1. Neutral; no introduction of market vision and an outside-in view.
2. Positive; the selection of roadmaps is based on the subsystems and system characteristics.
3. Neutral, the subsystem and system characteristic teams shown are not all based on the KSF's. But the possibility exists to add others.
4. Positive; the cross-functionality of the teams will improve process-oriented thinking, information exchange and creativity.
5. Neutral; it matches with the hierarchy, centralisation and functional departments. It does not match totally with the strategy, because not all subsystem and system characteristic teams are based on the core competencies of C/V.
6. Positive; in the final roadmaps, application, marketing and technology will be aligned.
7. Neutral; Because of the link of functional teams by one person, a reduction of meetings is possible. On the other hand, the linking pins of the teams have to attend many meetings (it can be decided that these linking pins should be managers; it would be negative if these managers should attend many meetings).
8. Positive; the Roadmapteam mainly consists of management.
9. Negative; the absence of the product teams will have negative influence.
10. Positive; technology will be converged to one technology plan by the Technology Team.
11. Positive; the focus will be on technology aspects.

Additional advantages:

- The possibility exists to create or end the subsystem and characteristic teams ad hoc.

Additional disadvantage:

- There is no formal aspect, which triggers ad hoc specialised component and characteristic team creation or ending; the input of subsystem and characteristic teams is not based on trends or strategic issues.

Scenario 4: Focus on trends and vision & introduction of effective selection criterion

The goal of this scenario, is the creation of roadmaps based on concentration on important market trends and vision, and special focus will be on trying to create a selection criterion, effective and fitting for C/V, to base roadmapping on.

The combination of trends and KSF's is 'invented' here and will be called a 'View' in the remainder of this report. A View is a characteristic or a feature of a system that is important to the business. It creates value to the system. These Views are derived from the trends in the Trendmap

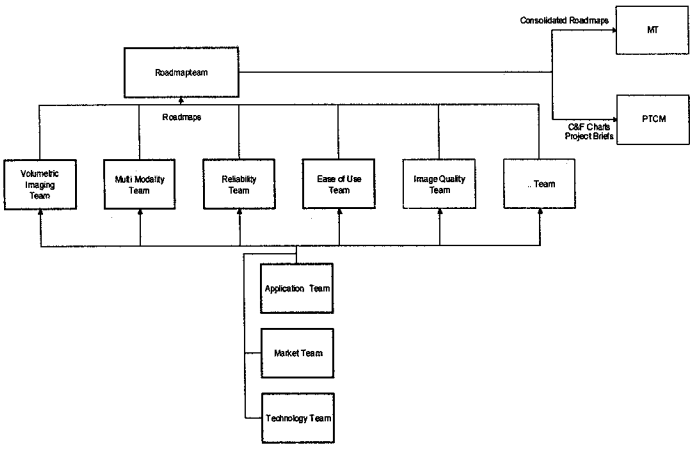

Figure 5.5: Roadmap process scenario 4.

and from the KSF's indicated in the Strategic Plan.
The illustration of this process scenario is depicted in figure 5.5.

As in scenario 2, the application, marketing and technology department will provide Trendmaps, knowledge and constraints to the View-Teams.
These View-teams are based on the influence of a View in the market, indicated by upcoming trends or the KSF's in the SP. Hereby, a selection criterion effective for C/V to use as a basis for roadmaps is introduced, which results in a reduction of the number of decision parameters, and consequently a reduction of the number of roadmaps and time spent on the creation.
View-teams can be added or removed, dependent on the content of the SP and important upcoming trends that need special attention.
The Roadmapteam will consist of management, supported by linking pins from the View-teams.

Evaluation to criteria:
1. Positive; by the prediction of trends roadmapping is based more on outside-in vision.
2. Positive; the creation of roadmaps based on Views, provides an effective selection criterion, matching with the C/V organisation.
3. Positive; the Views are a combination of trends and KSF's.
4. Positive; the View-teams are cross-functional teams, consisting of a combination of people from the different departments.
5. Neutral; it matches with the structure parameters hierarchy and centralisation, it does not optimally match with the functional departments, and it matches with the strategy of addressing oneself to the core competencies.
6. Negative; roadmaps will be based on information of application, marketing and technology, but in the overall roadmap they are not aligned.
7. Negative; the process will consist of many teams, which asks a lot of time spent in meetings and discussions. Also, the Roadmapteam will be very large, because linking pins of all View-teams will need to contribute.
8. Negative; besides management, too many people have to be a member of the Roadmapteam, which will complicate efficient decision making.
9. Negative; the absence of the product teams will have negative influence.
10. Positive; before technology trends, knowledge and constraints go to the View-teams, they have to be aligned.
11. Positive; the focus will be on the Views.

Additional advantages:
- The possibility to add or remove View-teams, based on an upcoming or diminishing trend or KSF.

Scenario 5: Focus on Trendmaps & core competencies & a selection criterion

Goals of this scenario:
- To base roadmaps on trends and vision
- To base roadmaps on core competencies
- To use a selection criterion to base roadmapping on
- To align final roadmaps to the market segments.
  This last goal was introduced after the reflection of this design without the alignment to market segments. Without this alignment, a part of management could not agree with this design in any case.

In this scenario, predicted trends and directions for application, market and technology are selected and aligned by a trend team, resulting in the 'aligned trendmap'. Based on these trends, View-teams are triggered to create roadmaps. These roadmaps will be tuned to one another and to market segment by the product teams.
The Roadmapteam consists of management and the leaders of the product teams. This roadmap process structure is visualised in figure 5.6.

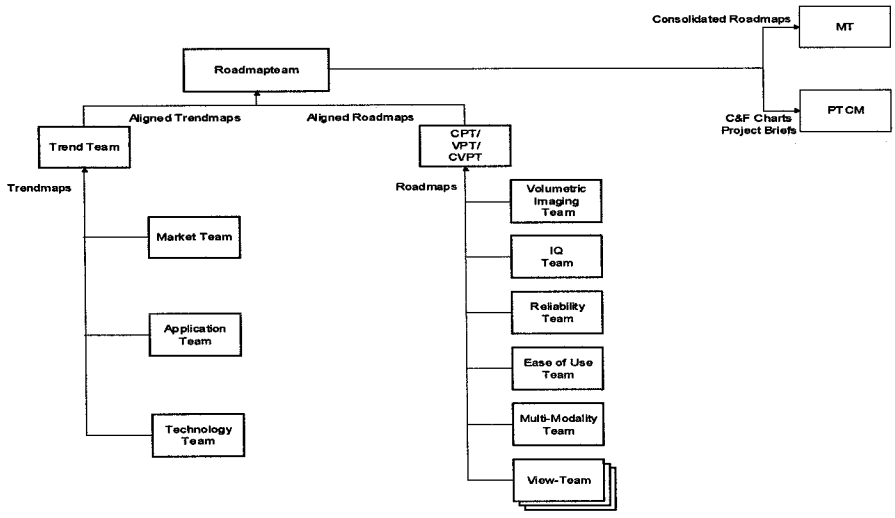

Figure 5.6: Roadmap Process scenario 5.

Evaluation on criteria:

1. Positive; the creation of trends and Trendmaps creates vision and outside-in orientation.
2. Positive; the roadmap creation based on the Views provides an effective selection criterion.
3. Positive; the Views are, besides being based on trends, based on the KSF's.
4. Positive; the View-teams are cross-functional teams.
5. Neutral; it matches with the structure parameters hierarchy and centralisation, it does not optimally match with the functional departments, and it matches with the strategy of addressing oneself to the core competencies.
6. Negative; only the trends are aligned between application, marketing and technology by means of the Trendmap, the overall roadmap is not functionally aligned.
7. Negative; this structure contains many different teams and as a result many meetings. Many people will be a member of multiple teams. It is possible, for example, that a member of the CPT also takes part in the market team, the Trendteam and a View-team.
8. Positive; the Roadmapteam will have to consist of management and just a few linking pins from the product teams, representing the different market segments.
9. Positive; the maintenance of the current product teams will enlarge recognition.
10. Negative; the separate technology aspects coming from the View-teams are not mutually aligned to one technology roadmap.
11. Negative; two views have been integrated: the market segment view, caused by the final alignment by the product teams, and the technology view, caused by the View-teams that will mainly focus on technological aspects.

Additional Advantages:

- View-teams can be created/ended ad hoc, based on the importance of trends to the market and the business.

Additional Disadvantages:

- By the early alignment of trends, View-teams themselves do not have the chance to determine which trends are important in the field of their View. This may limit possibilities and chances in innovation and will lower motivation.

5.2.2 Summary of evaluation results

Here, the evaluation results will be summarised to give a complete overview of all scenario reviews. For completion, the criteria the scenarios are evaluated on, are listed again:

1. Does the new process result in roadmaps with vision and outside-in oriented planning?
2. Does the process contain a mechanism to make the appropriate roadmap selection?
3. Does the process contain a mechanism to base roadmapping on core competencies?
4. Does the process change the functional thinking into process-oriented thinking?

5. Does the process fit the organisation and the strategy?
6. Is decision making of the departments application, marketing and technology aligned in the overall roadmap?
7. Does the process execution require as little teams and (management) effort as possible?
8. Are the appropriate people responsible for the final decision making?
9. Is the process recognisable and acceptable to people involved?
10. Does the process enable the mutual alignment of different technology aspects?
11. Does the process create one focus of final roadmaps? (e.g. market segments or functional areas)

The results of the evaluation are summarised in table 5.1.

Table 5.1: Evaluation results

Criterion	Current Process	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
1	-	-	+	-	+	+
2	-	-	-	+	+	+
3	-	+/-	-	+/-	+	+
4	-	+	+	+	+	+
5	+/-	+/-	+/-	-	+/-	+/-
6	-	-	-	+	-	-
7	-	+	+/-	+/-	-	-
8	-	+	+	+	-	+
9	+	+	+	-	-	+
10	-	+/-	+	+	+	-
11	-	-	+	+	+	-
Total positive score	1	4	6	6	6	6

From this table a few conclusions can be drawn:

- There is not one alternative that satisfies all criteria.
- In all scenarios, at least three criteria have not been satisfied.
- Not one alternative obviously emerges to be the best, if all criteria are judged equally.
- Alternative 1 is the least feasible design.
- The current structure meets just one of the criteria: people are accustomed to the structure.

From the researcher's point of view, scenario 5 seemed to be the most feasible. As described in section 5.1.4, some of the criteria were judged to be more important than others. The opinion about ranking of importance changed during the design phase, as a result of the experience that was gained. At the time scenario 5 was created, criteria 1, 2, 3 and 4 were judged to be important. Scenarios 4 and 5 both meet all four of these criteria. Criteria 10 and 11 were the criteria that were judged least important. Scenarios 2, 3 and 4, all possessing a high total score, gained 2 of their positive scores on criteria 10 and 11.
For these reasons scenario 5 was judged as the most feasible design by the researcher. Since management made clear during the feedback discussion to be devoted mainly to criteria 5, 7, 8 and 9, the decision was made by the researcher that further exploration had to take place to find a design more feasible.

Scenario five then has been discussed with the Process Improvement manager. The aim was to get a more objective view to the process, since this manager was not directly involved. The following drawbacks to the scenario from this discussion were important for further research:

a) To get the new roadmap process structure embedded in the organisation, it has to be as 'lean and mean' as possible.
   As little teams and meetings as possible to reduce meeting time should be an important requirement to realise this (criterion 7).

b) Two views have been integrated: the market view, caused by the final market segment roadmaps, and the technological view, caused by the View-teams that will mainly consist of technological experts (criterion 11).
The objective view of this manager drew attention to the importance of this characteristic.

Ad a) To transform scenario 5 into a process containing as little teams as possible, the (de)centralisation issue plays a role. The following questions should be taken notice of:
- Does a separate team have to exist that is responsible for the alignment of the trendmaps and the filtering of trends, or
- does the Roadmapteam carry the responsibility for prioritising trends, or
- do the View-teams themselves, which consist of experts in this field, get the allowance to decide which trends are most important for their View and create roadmaps based on their own decision?

Advantages of filtering by separate Trendteam:
- Cross-functional team with special knowledge about trends
- More efficient, because otherwise all teams have to make decisions apart from one another

Advantages of filtering by management:
- Early control and certainty
- More efficient, because otherwise all teams have to make decisions apart from one another

Advantages of filtering by View-teams:
- Expertise of View-teams in their field will be exploited
- View-teams have more information available to decide about the importance of trends to Views
- Higher motivation of View-teams, because they are not restricted to trends chosen by others

Ad b) To transform scenario 5 into a process focussing on whether the market segments or the technological aspects, consensus has to be reached among management.

5.3 Experience gained during the design phase

- Criteria that seemed to be less important to someone without practical organisational knowledge and experience, appeared to be crucial to the practical application and deployment of the design in the organisation.
- Acceptance and agreement of management to the design has been more important to the acceptance, than the quality of the proposed design itself. The chance of implementation of a structure, recognised and supported by management is bigger than the implementation of a qualitative better process, having less management support.
- It is important for someone with little practical experience to keep in mind the criteria stated in advance. By inexperience and enthusiasm, the chance exists criteria will be overlooked. This happened to criterion 6, which was the criterion based on the assignment, literature and the current situation, and therefore very important.
- Even for management, the judging of criteria is difficult and sometimes inconsistent.
- The exploration to the effective design takes a very long time and asks much iteration, especially for someone not involved and little experienced.
- The clearer definition of the approach to create and evaluate the different alternatives in advance, would probably have contributed to a more efficient design phase.

5.4 Summary

This chapter described the research to create an effective roadmap process for C/V. This research traject was complicated, because 'there is no straight line from the conditions and criteria to the fitting design' [Jäg95].

First, from four points of view, criteria have been set up, which the design should satisfy. Next, five different scenarios have been designed and evaluated to these criteria in section 5.2. The researcher's view of the fifth design did not match with the opinion of management about the design. This, and additional drawbacks to the design provided by the Process

Improvement manager, who had more distance to the process, triggered further research to a more feasible design.

Parallel to the desk research to reach the effective roadmap process, in practice some exercises have been executed, to get people involved in an early stage, and to be able to apply the aspects learned to the process design. This practical exercise provided deeper insights to the process and the way that it should be deployed in the organisation. From the discussions during the work sessions and all difficulties that came up, further ideas and requirements that should be considered during creation of the design came up.

The practical side of this research, describing the exercises and their results, is described in the next chapter.
The final design will be described in chapter 7.

Chapter 6 In Practice

The experience of the practical side of the start-up of the roadmap process has influenced the development of the roadmap process. This chapter deals with this practical learning aspect. The goal of these practical exercises was

- *to make people already ware of roadmapping in an early stage of the project,*
- *to learn from the experiences, reactions and reflections of people taking part, and*
- *to be able to directly apply these findings to the reality (the design phase and the workshops).*

Section 6.1 describes the course of the planned application of an existing lecture developed by the University of Cambridge. Because this did not work out the way it was planned, other practical exercises were applied. Section 6.2 describes the roadmapping initiative that came from the application department. Next, section 6.3 shows the results of the cardiac workshops, which were a successful first move to the development of cardiac roadmaps. Additional learning was based on a single workshop on navigation described in section 6.4. From all practice in general, not directly allocable to one of the practical exercises, learning points are described in section 6.5. Finally, section 6.6 gives a summary of this chapter.

6.1 Roadmapping workshops based on the T-Plan

6.1.1 Approach

The theory with respect to roadmapping provides not many practical guidelines to set up the roadmap process. The lecture 'T-Plan, Fast Start Technology Roadmapping' of the University of Cambridge, described in chapter 4, provided a framework to start up a roadmap process. Within this research this approach was taken as an example to start roadmapping within C/V. The choice to follow this approach was based on the following facts:

- There is not much practically-oriented literature available to support the roadmap creation process. The lecture of the University of Cambridge provides a clearly described and illustrated scheme of the workshops.
- The lecture contains a logical construction to come from the market drivers and business drivers to the required technology that gives response to the requirements of these drivers.
- The lecture gives a good hold to execute the process interactively and crossfunctional.
- The process will have to be executed by people who do not have much roadmapping experience. A well-structured example will ease this.

As described in chapter 4.1, the course consists of four workshops, during which step by step the roadmap will be tried to be created. The planned result of applying this course is to get a blueprint for the process to follow. This process will not be complete until a few iterations have been made.
Initially only application, product and technology roadmaps will be created. When the process will be more mature, competition, people, skills and process roadmaps can be added. During all workshops people from the three functional areas application, marketing and technology will be involved to reach consensus and alignment of drivers, product features, performance indicators and the way to make each of these aspects 'SMART' to everyone from the beginning.

6.1.2 Experience

Already during the first workshop, the process did not work out the way it was planned. The workshop was covered totally by a discussion about the approach to start up the process. From this discussion the following remarks could be made:

- Most of the people involved were not acquainted with the purpose of roadmapping.
- The crossfunctional aspect of roadmapping is an essential, but possibly difficult characteristic to reach.
- The existing ideas about roadmapping and attempts to create roadmaps are advanced to apply the T-Plan, because this approach is based on starting from scratch.

- Although most of the literature recommends starting top-down with the expression of market and business vision, marketing and application people involved at the same time want to start bottom-up from technology.
- Many of the persons present have problems with making explicit choices, with predicting the unexpected.
- Committing things on paper is a huge threshold, caused by the feeling of being tied down to this.
- It is very difficult to start roadmapping on paper, because no one has the complete picture in mind.
- The transformation of the functional terms each department uses to 'SMART' performance indicators might become very difficult and time consuming.
- The time required of people to spend on the process is underestimated by most of the persons present.
- The group contained too many people to come to results efficiently.
- If new sessions are arranged, in advance it has to be clear what should be achieved at the end of the meeting. Then everyone can do his 'homework'.

6.1.3 Result

The course of this meeting learned that the T-plan approach was not applicable to C/V exactly as described, but it has been kept in mind for application in different circumstances. The decision has been made not to continue the workshops in this format, but to start up smaller roadmapping groups on relevant issues.
Positive result of the discussion was the appointment the three departments made to soon come up with a first initiative to roadmapping separately.
Based on this appointment, the application department came with the first roadmapping initiative, which will be described in the next section.

6.2 The application initiative

6.2.1 Approach

The application department was the first department that came with a roadmapping initiative. This initiative appeared later to be very useful for the further roadmapping progress in practice. The application department created what they called 'roadmaps', showing the clinical trend issues and their estimated relevance in time by a percentage number in each year in the period 2002-2012. It also showed a description of the clinical need related to the trend, accompanied by a description of the technical needs for the cath lab that can be derived. These maps are created per market segment. An example of the layout, represented by the cardiac roadmap, can be found in Appendix 7.

6.2.2 Experience

The following aspects were learned from the application initiative:

- The so-called 'roadmaps' were no roadmaps, because by these maps only, no information about the critical system requirements and performance targets to satisfy by certain time frames is provided. The maps show a prediction of the directions the business might follow the coming years. To prevent miscommunication, the decision was made to call them 'Trendmaps'.
- The reluctance to commit things on paper expressed itself again: exchange of the Trendmaps and communication about them were not allowed until the definitive version was agreed upon within the department.
- Initially, people who created the Trendmaps did not want to prioritise or rank the trends listed, because they presumed that trends ranked low would be dropped from the list in advance.

6.2.3 Result

These maps served as a very good example to the rest of the organisation of the possibility to write down a vision. They also served as a starting point for roadmap creation on the market segment the trendmaps were developed for.

The decision has been made to start this roadmap creation, by starting cardiac workshops. The cardiac segment was chosen, because the people involved showed willingness to do something with the effort put in the Trendmap creation. The course of the cardiac workshops will be described in the next section.

6.3 Cardiac workshops

6.3.1 Approach

Although the T-Plan did not seem to work within C/V exactly as described, the approach was still kept in mind, because during the literature study the T-Plan was judged useful and it agreed with other articles concerning roadmapping.
Based on the knowledge about the T-Plan and the result of the application initiative described in the previous section, the decision has been made to invite the person experienced in the cardiac-marketing field to try to relate market values to the application trends. Estimations were made about when the indicated application trend needs to be introduced into the market with respect to competition. Also the relative business relevance of the trend was estimated by marketing. Furthermore, a value that indicates the importance (1,3, or 9) was attached to the technical needs for the cath lab in relation to the trend issue by application and marketing. This all has been processed in a table, and an approach similar to Quality Function Deployment was applied to it. This resulted in a score, indicating what technical needs for the cath lab are most important to pay attention to in time, which is also presented in a graph. The table and the graph can be found in Appendix 8.
From this priority setting the most important technical needs for the coming years are given. These technical needs indicate the aspects the development department should spend its budget on. To make a start in using the application and marketing efforts in the cardio segment, the technical needs were specified by representing them in technology-trees. These trees represent the hierarchical relations between the technologies and describe the technologies more specific. The technology-trees are shown in appendix 9. The creation of the technology-trees has been done by people from the application and technology department. This activity forced them to discuss and make explicit their terms and ideas.

6.3.2 Experience

These workshops delivered a lot of useful experience for the progress of the roadmap process in the future.
Learning points stemming from these workshops:

- It appears that technology roadmaps should be based on application and marketing vision and values. This agrees with literature, which describes to start with the indication of market and business drivers, followed by the required technologies to realise these. But also attention should be paid to the organisation of a bottom-up approach for technology, to profit by knowledge of the technology trends.
- People involved agree with the importance of priority setting, but find it very difficult, since this process is very immature and in development. No methods of operation exist yet.
- Most difficult is the definition of exactly what is meant by certain terms, and carrying this over to the other discipline precisely.
- The table, and the attribution of values and figures, ease the communication between people from different disciplines.
- The limited possibility of attributing only the values 1, 3 or 9, contributes to explicit choices, especially between the 3 and 9.
- It appeared to be difficult to express a need in figures. For a good grasp it might be better to express the need in words, like 'nice to have' and 'absolutely necessary', although it negatively influences the previous mentioned advantage of making explicit choices.
- The roadmap process itself has little priority; even when the groups are small, certain people make little effort to set time free.
- For the workshops a facilitator is required, who coordinates the information exchange and who pushes and directs people to get concrete answers.
- Parties from outside C/V should be involved to the workshops when information on unknown subjects is required to be able to make weighed decisions.

- To give an idea of the time spent to reach this result: approximately 4 workshops of 2 hours each have been arranged. Additional time for each of the people involved is required for preparation. Also, the facilitator needs time for preparation and processing of the information afterwards.

6.3.3 Result

The result of this workshop is the priority setting of application trends and the technical needs they require. The technical needs, indicated as most important, show the aspects the development department should spend its budget on. It creates a vision of the future, for which plans and decisions should be made today.
Now, the priority setting and technology-trees are ready to be used by the technology department. The technical needs indicated by application can be classified to the Views. The relations between the needs and the Views can be seen in Appendix 8. The creation of roadmaps with regard to the classified technical needs per View can be delegated to the View-teams (it is agreed with management that this first View will be navigation).

6.4 Navigation workshop

6.4.1 Approach

Parallel to the cardiac workshops, another workshop has been organised to serve as an exercise. This was a workshop with the subject 'navigation', because this is a dominant issue in the available clinical roadmaps, covering 3D and Multimodality features, which are two KSF's indicated in the SP.
Until now, this workshop only remained to one session, although it was a useful meeting. The persons attending were members of each of the three departments. Trends and needs for the cath lab were presented by the application department, leading to many questions from people from development. In this way, an interactive information exchange took place between the departments, during which definitions of professional and technical terms were made explicit.

6.4.2 Experience

From this workshop about navigation, the aspects have been experienced:

- It is possible to come to agreement and univocal interpretation of terms, if people involved reserve enough time in advance and are available for 100% during the meeting.
- By means of arranging the communication exchange between the departments, people get a broader picture of the whole and things have to be made explicit to be able to discuss them.
- People from the application department finally feel their vision is really applied.

6.4.3 Result

The result of the meeting, which covered 4 hours, was agreement, clearness and univocal interpretation of the required technical needs related to navigation for the cath lab. It was decided that a follow-up meeting would be useful to transform the application terms to development terms and to put these on a timeline.
To prepare this, persons from the application and technology department together drew up a technology tree for navigation to determine the relevant technologies and their relation.

6.5 Additional learning from the practice

From the practice in general, some points important to pay further attention to, came forward:

- ➢ At this moment, within C/V, fire fighting of other problems has more priority than the roadmapping process. There is too little allowance to long-term thinking by people other than management. Management as a whole does not really want to allocate resources to the roadmap process, although the process provides many advantages.
- ➢ For many people it is difficult to understand the distinction between roadmapping, which should contain vision, and the day-to-day planning. These are totally different issues, which has already been explained in chapter 1.

- The practice showed that it is useful, with respect to participation, if each department can decide itself how to structure the information people want to express. By means of meetings, aspects can be explained and made clear to others.
- In practice, the establishment of roles and responsibilities fails to occur.
  To be able to continue the cardiac roadmap creation, it is important to appoint these.

6.6 Summary

As can be read in this chapter, much has been learned from the practice, and all practical exercises were challenging activities.
The first learning experience was the way workshops should *not* be organised. This resulted in the start-up of smaller groups, which practised exercises that delivered learning output, applicable to further deployment of the roadmap process.

The cardiac workshops were based on the application initiative to create trendmaps. These workshops were a succession of meetings between application and marketing, resulting in the priority setting of trends and the expression of vision. It provided a way to display this priority setting, by means of a concrete table and graph, which are shown in Appendix 8. Based on this vision, a prediction of technical requirements for the future has been given, which the development department should consider and align its budget with. When the View-teams are constructed and roles ascribed, they can use the classified technical needs per View to create roadmaps per View.

Another workshop, with the topic navigation, was practised successfully. The result was agreement, clearness and univocal interpretation of terms, and the agreement to organise a follow-up workshop.

The practice in general provided supplementary conclusions and points to learn from.

Many of these practical experiences have influenced the development of the scenarios described in chapter 5 and to the final design of the roadmap process structure, which will be described in the next chapter.
The most important influences from the practice to the final design were:

- The real importance of bringing vision into the process.
- The real importance of the role of communication, crossfunctional working and process-oriented thinking to the process.
- The probability of underestimation of time needed during workshops. This underlines the fact that a 'lean and mean' structure, containing as little teams and meetings as possible, is very important.

Chapter 7 The effective roadmap process

This chapter describes the effective roadmap process for C/V, as it is developed from the scenario development described in chapter 5, and practical experiences, described in chapter 6.
Section 7.1 describes the final roadmap process design, the evaluation of this structure to the criteria described in chapter 5 and possible roadblocks that might arise during application. Section 7.2 contains a detailed description of the final process, consisting of the process flow chart, the tasks and responsibilities of people involved, the fit of the process with the yearly calendar of C/V and the relationships between the multiple existing maps. Finally, section 7.3 gives a summary of the chapter.

7.1 Final roadmap process design

From the total research described in chapter 5 and the practical experiences dealt with in chapter 6, finally an effective roadmap process matching with the C/V-organisation has been developed. The description of this process, the evaluation providing reasons to adopt this structure, and possible roadblocks that may complicate the introduction are explained in this section.

7.1.1 The effective roadmap process structure

In this roadmap process design, trends still are a driving factor. Based on trends from application, marketing and technology, the View-team creates roadmaps for the View it is responsible for, assisted where needed by input from people inside and outside C/V.
These View-roadmaps serve as input for the technology, application and marketing roadmap, which will be checked by the Roadmapteam.
Figure 7.1 shows the hierarchical structure of this process.

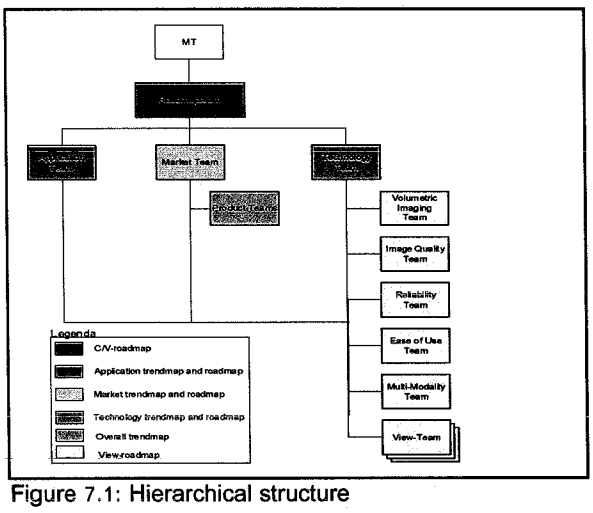

Figure 7.1: Hierarchical structure

Hierarchical structure
The hierarchical structure consists of the MT at the top. The Roadmapteam has responsibilities to the MT, in submitting the proposal to roadmap consolidation before the Strategic Planning takes place (for the indication in time: see section 7.2.3).
The application, market and technology teams have the responsibility to the Roadmapteam, of providing Trendmaps before the Trendmap consolidation (see section 7.2.3). They also have to provide roadmap implications to the Roadmapteam timely, so that the Roadmapteam has sufficient time to check them with the Strategic Plan and the Staffing plan.
The Market Team directs the Product Teams, as well as the Technology Team directs the View-Teams.
The colours indicate which team creates which trendmaps or roadmaps. They correspond to the colours of the maps shown in figure 7.4 at page 47.

The process in more detail
First, the application, market and technology teams predict trends and express relevant knowledge concerning their discipline. These teams consist of both experts in the cardiac and the vascular market segments within the discipline.

These trends go to the Product Teams, which prioritise them per market segment. The tool that enables prioritising is the matrix similar to the QFD-matrix, which was developed during the cardiac workshops described in chapter 6. The example can be found in Appendix 8. This

is a preselection step, after which these preselected trends go to the Roadmapteam for prioritisation. The Roadmapteam prioritises the trends from the business view.
The not-prioritised trends also go direct from the functional teams to the View-teams, for that they will get the total compilation of trends, which they can evaluate using their expertise and information. They check if the other teams did not oversee important issues.

The View-teams prioritise trends and check if these correspond to the trends the Product Teams and Roadmapteam have selected.
When agreement exists between the Roadmapteam and View-teams, the View-teams create roadmaps for the particular View they are responsible for.
These View-teams consist of a person with final responsibility for the View and the created roadmaps, supported by a cross-functional team of people inside and possibly outside C/V that are related to the View. The responsible person presumably will be an experienced system designer from the development department. This needs to be a technical expert on the particular View. To gain sufficient information to create the roadmaps, keeping contact with all parties involved with the evolution of the View or View-related components, subsystems and systems is required. These contacts are, for example, supplier-relations and information exchange with application-experts. The last is essential to keep their knowledge about applications and trends up to date.

The roadmaps they create, after acceptation of the roadmaps by the Roadmapteam, are the input for the Application, Market and Technology Teams to create roadmap implications per discipline. They integrate the View-roadmaps to overall roadmaps per discipline. They address both cardiac and vascular markets. From these roadmaps, the required resources and budget to realise the plans, is known.
The application, market and technology teams each have one owner that is responsible for the final roadmaps concerning that discipline.

Finally, the roadmaps and requirements on resources and budget are sent to the Roadmapteam, which checks the roadmaps and requirements with the Strategic Plan and Staffing Plan. After approval, the Roadmapteam sends a proposal to roadmap consolidation to the MT.
The Roadmapteam consists of management, supported by a few cardiac and vascular experts in the field of clinical science and marketing, and the leader of the technology team. The cardiac and vascular experts are needed to pay attention to the different market segments.

7.1.2 Evaluation of this structure

When the final design is evaluated on the criteria mentioned in chapter 5, it can be posed that the design fulfils many of them. This is shown in table 7.1, where the evaluation results of the final design are compared to the evaluation results of the alternatives. The design does not score 'negative' on any of the criteria.
Criteria not satisfied totally by the final design, are the reduction to a smaller amount of teams and the shrinking of the Roadmapteam to just management members. Although the amount of teams has not been reduced, the required meeting time of people has been reduced by the appointment of the View-manager. This experienced person can also maintain informal relations, which causes that the amount of meetings can be limited as much as possible and other team members are kept free from meetings.

Evaluation on criteria

1. Positive; by the creation of trends and Trendmaps, vision and outside-in orientation are introduced to the roadmap process.
2. Positive; the roadmap creation based on the Views results in an effective selection criterion. This also results in a better overview of the existence and updating of roadmaps.
3. Positive; the Views are besides being based on trends, based on the KSF's, which are derived from the core competencies in the SP.
4. Positive; the View-teams are cross-functional teams, consisting of a combination of people from the different departments

5. Positive; it matches with the structure parameters hierarchy, centralisation and the functional departments. It also matches the strategy of addressing oneself to the core competencies of the organisation.
6. Positive; in final roadmaps, application, marketing and technology will be aligned.
7. Neutral; this structure contains many different teams and consequently many meetings. Many people will be a member of multiple teams. But by the assignment of people responsible for each View, who also maintain informal relations, the amount of meetings can be limited as much as possible.
8. Neutral; members of the Roadmapteam are not just management, but also members of the product teams. These should be just key persons; it needs to be prevented that the Roadmapteam will consist of too many people to be optimally efficient.
   A positive remark is that management does not have to participate in a large part of the process. They mainly have to set priorities and are responsible for final decision making.
9. Positive; the maintenance of the current product teams will enlarge acceptation.
10. Positive; technology will be converged to one technology plan by the Technology Team.
11. Positive; the focus will be on the Views.

Additional advantage

- Application, marketing and technology trends, next to going to the Product Teams and the Roadmapteam, also immediately go to the View-teams, without filter. This will positively influence innovation activities and motivation.

Table 7.1: Comparison of final design with alternatives

Criterion	Final Design	Current Process	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
1	+	-	-	+	-	+	+
2	+	-	-	-	+	+	+
3	+	-	+/-	-	+/-	+	+
4	+	-	+	+	+	+	+
5	+	+/-	+/-	+/-	-	+/-	+/-
6	+	-	-	-	+	-	-
7	+/-	-	+	+/-	+/-	-	-
8	+/-	-	+	+	+	-	+
9	+	+	+	+	-	-	+
10	+	-	+/-	+	+	+	-
11	+	-	-	+	+	+	-
Total positive score	9	1	4	6	6	6	6

It can be seen that the final design satisfies more criteria than the scenarios discussed previously. This is why the researcher's preference is to choose for deployment of this roadmap process into the organisation. The design got full management agreement, which completed the research to the effective roadmap process.

7.1.3 Possible roadblocks

There might occur some complications with the introduction and implementation of the new roadmap process structure in the organisation.
By paying attention to these roadblocks in advance, they can contribute to higher acceptation and embedding of the structure in the organisation.

Possible roadblocks:

- Necessity for the View-managers to employ sufficient skills for the management of all responsibilities the ownership of the View brings.
- Some people like the informal way meetings take place at this moment.
- People are afraid of losing current roles. This will impact acceptation.
- It is difficult to change an organisation from functional to process-oriented thinking.
- Working in cross-functional teams needs a lot of management attention [Jas01].

7.2 Details of the new C/V roadmap process

This section will describe the final roadmap process in detail. The process flow chart will be outlined and the roles and responsibilities of teams, the fit with the year calendar of C/V, and the relationships between the multiple existing maps will be treated.

7.2.1 Process flow chart

The process flow chart shows the steps that the different parties involved have to execute, provided with the input needed before the step can be executed, and the output the step delivers.
The flow chart should be read as follows:

- In the left column, the inputs are described.
- In the mid columns, the subsequent process steps are indicated in a general flow chart format. The column is subdivided into columns concerning the executing teams, indicated above each column.
- In the right column, the outputs of the subsequent processes are described.

The flow chart is portrayed on the next page, followed by a short description of the steps.

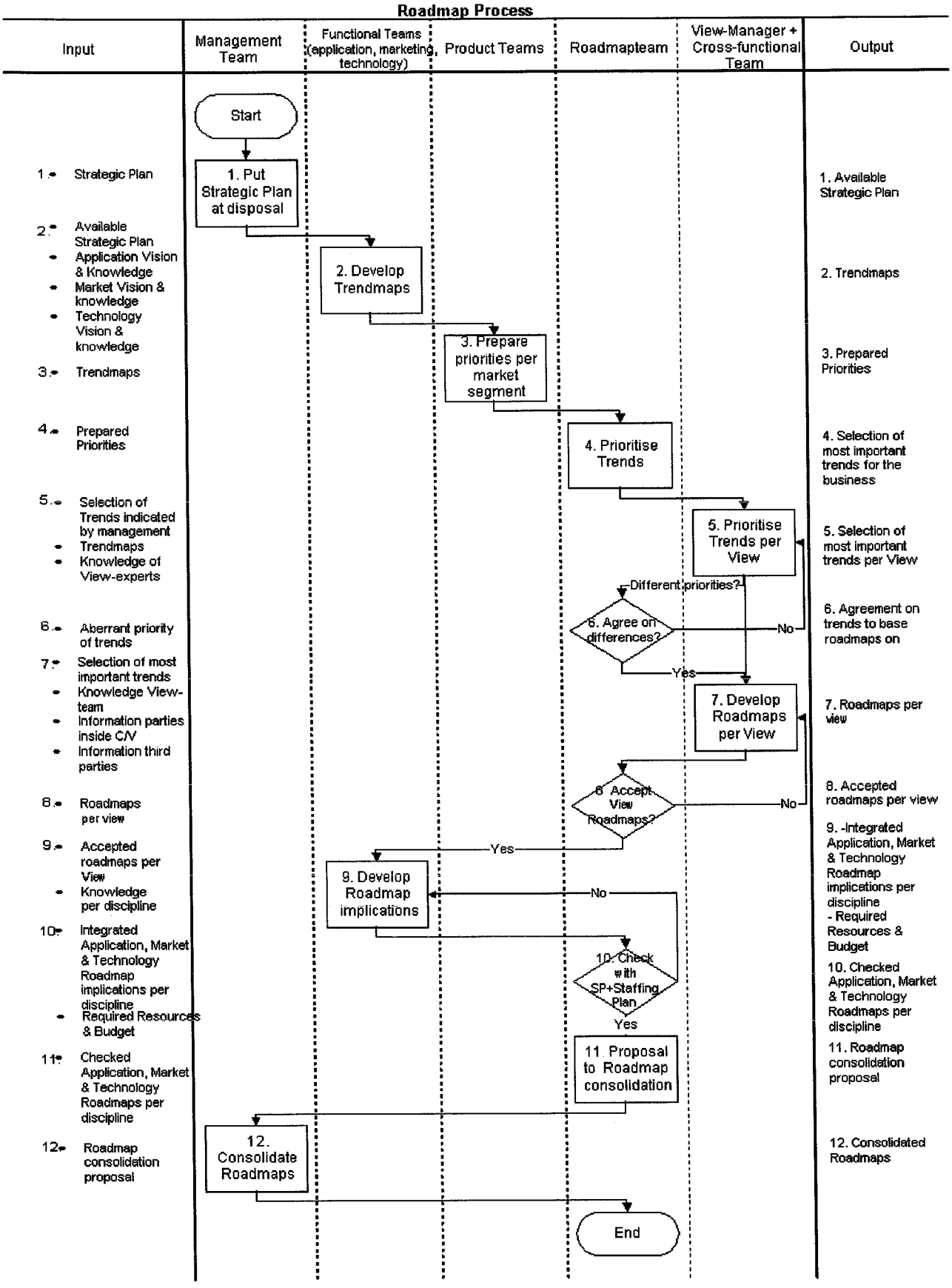

Figure 7.2: Roadmap Process Flow Chart

Brief description of the flow chart steps:

1. *Put Strategic Plan at disposal*
   Before any step in the roadmap process can be taken, the strategic issues described in the Strategic Plan that are important to the business should be at disposal to the parties involved in the process. The MT should make them available.

2. *Develop Trendmaps*
   The leader of each functional team appoints experts on issues relevant to predict trends for. Trendmaps are based on visions of these experts on trends in their domain.
   These issues will vary per discipline. Also the time scale to predict trends may vary between disciplines.
   The trendmaps per discipline are exchanged and discussed between disciplines.

3. *Prepare priorities per market segment*
   When the Trendmaps are available, the product teams indicate a first selection of trends, providing priorities per market segment.
   A decision is made which trends are most important to the market segment regarding:
   - The Strategic Plan
   - Previous Roadmaps
   - Market values
   - Competition

4. *Prioritise Trends*
   The Roadmapteam discusses the trends prepared by the product teams.
   A decision is made which trends are most important to the business, regarding:
   - Budget
   - Resource constraints
   - Opportunities
   - Risks
   - The business case (NPV, etc.)

5. *Prioritise trends per View*
   Based on the prioritised trends by the Roadmapteam, the View-teams decide which trends are most important to their View.
   They also consider the complete set of trendmaps on opportunities not selected in the previous steps, according to their knowledge and information available. If this is the case, agreement of management has to be given to spend time on the creation of roadmaps for these trends.

6. *Agree on differences?*
   If differences in priorities exist, are the additional or aberrant trends indicated by the View-teams worth spending roadmapping effort on?

7. *Develop Roadmaps per View*
   The View-teams, where needed assisted by people involved from inside and outside C/V, create roadmaps per View. These will be based on the total of knowledge existing with respect to the selected trends.

8. *Accept View-Roadmaps?*
   Does the Roadmapteam agree on the total of View-Roadmaps that arise? If negative, View-teams have to revise these roadmaps.

9. *Develop Roadmap implications*
   Based on all information from the total of accepted View-roadmaps the functional teams create roadmaps regarding their discipline. After this step, integrated application, market and technology roadmap implications exist, accompanied by the required resources and budget to realise the plans.

10. *Check with SP and Staffing Plan*
    Are the roadmap implications in line with the SP, and are the indicated resources and budget required for realising the roadmaps in agreement with the Staffing Plan? If negative, the discipline teams have to revise their roadmaps.

11. *Proposal to Roadmap consolidation*
    If the roadmap implications are agreed upon with regard to alignment to the SP and Staffing Plan, the Roadmapteam sends them with the proposal for consolidation to the MT.

12. *Consolidate the Roadmaps*
    If the MT agrees with the proposal, they will consolidate the roadmaps.

7.2.2 Parties involved and their roles and tasks

Roadmap creation is a joint effort of all relevant stakeholders. The roadmap manager is responsible for the top-level roadmap. Presumably, this will be the product manager, who also is roadmap owner at this moment.
Each roadmap has an owner in the organisation. The functional roadmaps will be owned by the leaders of the functional teams. Presumably, this will be the application manager, the product manager and a representative of the development manager. The View-roadmaps will be owned by the people responsible for the View. These presumably will be system designers, experienced in the field of the View. The exact assignment of roles has not been determined yet.

The process consists of the teams that can be seen in figure 7.1. The tasks and responsibilities of the different teams are described in Appendix 10.

7.2.3 Relation to yearly calendar

Roadmap creation is linked to the yearly calendar used by the organisation.
Minimal once a year, a new revision of the roadmap views is created. At the end of the roadmap cycle, the roadmap views are discussed, aligned and agreed upon. This results in the release of the top-level roadmap and the more detailed application, marketing and technology roadmaps.
In between two roadmap alignment meetings, the individual roadmap views evolve more or less independent.
During the next cycle, one will start from the latest version of the set of consolidated roadmaps. The individual roadmaps will be updated in parallel, to come finally, at the end of that planning cycle, to the next version of an aligned top-level roadmap.

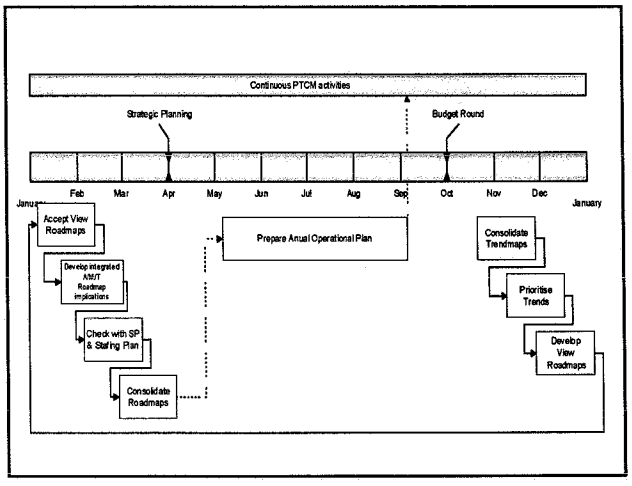

Figure 7.3: The relation of the roadmap process to the year calendar

Milestones of the process are:
- The consolidation of roadmaps before the Strategic Planning in April.
- The consolidation of Trendmaps after the Budget Round in October.

Figure 7.3 shows the relation of the roadmap process to the yearly calendar and the described milestones that should be reached.

Furthermore, the yearly returning events should be paid attention to during the execution of the roadmap process. At fairs and assemblies important issues may arise that have impact on strategic decisions making.

7.3.4 Mutual relationships

The final roadmap process contains a lot of maps and plans that should be aligned. To provide insight in the relationships, figure 7.4 provides an overview.

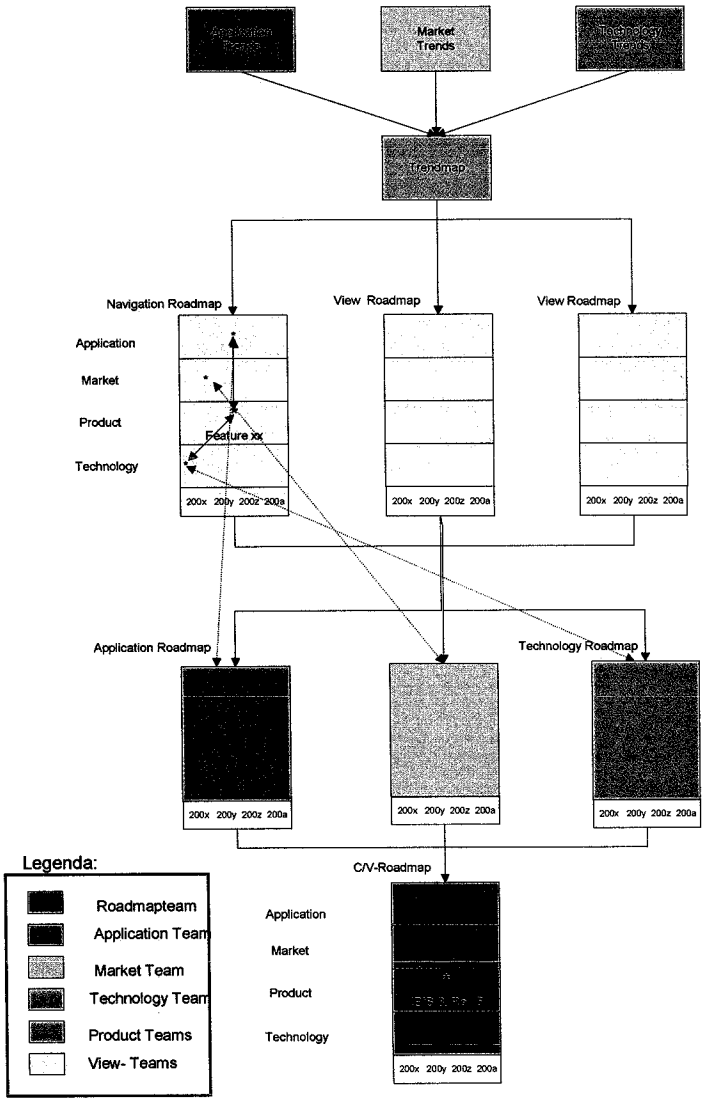

Figure 7.4: Overview of the mutual map-relationships

Application, market and technology trends together form the overall C/V Trendmap. This Trendmap (together with the KSF's), determines the Views that are important to create roadmaps for.

View-roadmaps contain the application, market, product and technology view.
In the overall View-roadmap relations are visible between a desired feature of a product, the corresponding application, the corresponding market values in time and the required technologies to realise this feature. These View-roadmaps are created for all Views selected. In figure 7.4 navigation is shown as an example of a View-roadmap.

Next, the View-roadmaps are integrated to roadmaps per discipline. All issues indicated in the View-roadmaps separately, come together in the functional roadmaps, grouped per discipline. These functional roadmaps are created for application, marketing and technology.

Finally, in the top-level C/V roadmap, the application, market, product and technology aspects, coming from the individual functional roadmaps are combined to form the overall C/V roadmap. The product view of the overall roadmap shows the planned product releases in time.

The colours of the maps in figure 7.4 correspond to the colours of the teams in the hierarchical structure, which was shown in figure 7.1.

7.3 Summary

This chapter described the final design of the roadmap process for C/V. With the design of this final process, the aim to create alignment of the C/V roadmap process and the integration of the product, application and technology roadmaps has been reached.
The hierarchical structure has been shown and the process has been described in detail. Furthermore, the process flow chart has been given, showing the steps that the different parties involved have to execute, provided with the input needed and the output the step delivers. The parties involved with their roles and responsibilities have been discussed shortly. Management still has to determine the exact appointment of roles. Also the relation to the yearly calendar has been shown, and finally the mutual relationships between the several trendmaps and roadmaps.

Chapter 8 Conclusions and Recommendations

This is the final chapter of this report. It describes the conclusions that can be drawn as a result of the research, and gives recommendations based on the conclusions and experiences during the internship. First, in section 8.1, the research questions will be reviewed and answered. Then, in section 8.2, the conclusions with regard to the research objective and conclusions beyond the scope of the research are given. Finally, section 8.3 will provide recommendations to C/V.

8.1 Research questions

The following objective gave rise to conduct this research:

- 'Align the roadmap process and integrate the product, application and technology roadmaps, which results in better alignment of the market demand and the required technologies to satisfy this demand in the future.
- Define roles and responsibilities.
- Establish the process by means of a process description.
- Set up the implementation of the roadmap process in the organisation'.

Based on the above research objective, seven research questions were formulated (see chapter 1). This section provides answers to these questions.

1. *In which way does the implementation of an aligned roadmap process influence the existing roadmap process?*
   This research question aims at the results of the improvements with respect to organisation processes as well as to the business objectives.
   The key improvements that are distinguished with respect to the business objectives are:
   - The introduction of vision and market orientation to the roadmap process results in a reduction of the time-to-market and a more customer-oriented process.
     The outside-in view contributes to the availability of better knowledge of competition and the possibility to better anticipate to their moves. This leads to the advantage that less time can be spend during the project execution phase to quickly enable market introduction of products. This time can be used during the product and definition phase, which leads to more speed and a reduction of the time-to-market.
     Furthermore, the alignment created by the roadmap process, results in common agreement and alignment of the development processes, which prevents the scattering of resources and makes the allocation more efficient. This also contributes to the reduction of the time-to-market.
   - The introduction of roadmapping based on Views results in the relation with the KSF's described in the Strategic Plan, which are derived from the core competencies of C/V. Concentration on core competencies enables, among other things, the realisation of a better product quality.
   - The existence of a criterion to select roadmap creation to. This results in an appropriate trade-off between roadmap development / update time and the advantages the roadmaps bring. It also results in a better view of the existing roadmaps.

   The key improvements that are distinguished with respect to organisation processes are:
   - The communication and information exchange between the application, marketing and technology department will increase and will be more explicit and univocal by the alignment.
   - Crossfunctional teamwork and process-oriented thinking will improve creativity and the combination of skills and know-how.
   - Management time and effort will mainly be spent on real management issues: providing directions and decision making.

2. *Which requirements and conditions should the roadmap process satisfy, according to stakeholders and literature statements?*

This research question focuses on requirements and conditions the roadmap process has to satisfy to ensure the viability of the process.
These requirements and conditions are the ten criteria that the design should meet, which have been described in section 5.1.4. The evaluation of the final roadmap process design in section 7.1.2 shows the design is evaluated positively on nine of these criteria. Two of the criteria have not completely been satisfied, but:

- Since the market segments have to be served optimally, there is no other solution than placing members of the product teams in the Roadmapteam.
- The wish to address each of the Views contributes to the existence of many teams. But since the possibility of parallel creation of View-roadmaps exists, the existence of many View-teams does not automatically stand for a longer lead-time to execute the process. Also, many teams will exist, but since the View-managers can also arrange information exchange informally, the amount of meetings people have to attend can be reduced.

3. *Which roadmaps should be created, in view of the trade-off between roadmap development / update time and the advantages the roadmaps bring?*
The introduction of roadmapping based on Views, results in an appropriate selection criterion to make an appropriate selection of roadmaps. Roadmap creation will be based on prioritised trends and KSF's, which are derived from the core competencies that are described in the Strategic Plan. This results in a proportional trade-off between roadmap development / update time and the advantages the roadmaps bring.

4. *What will be the distribution of roles and responsibilities?*
Figure 7.1 showed which teams exist and how the hierarchical structure will be. The global description of roles and skills has been given in section 7.2.2. Also, tasks and responsibilities have been described and can be found in Appendix 10. The concrete assignment of roles to people is the next step that has to be taken by management.

5. *Which processes are related to the roadmap process? Which processes influence the roadmap process and which processes does the roadmap process influence?*
The roadmap process is related to four main processes of the organisation:
   - The policy and planning process
   - The Product Creation Process
   - The people and technology management process
   - The customer oriented process

   Roadmaps give a vision on how to realise the objectives committed to in the strategic planning. The other way round, the vision of the future that roadmaps have influences the strategic planning. These processes are mutually linked and influence one another. They cover the first phase of the PCP. Because the people and technology management process delivers the people, processes and technologies that enable the PCP, these also should be part of the long-term planning with the help of roadmaps. The customer-oriented process is the customer of the PCP, which should be optimally served. This is why roadmaps should contain an outside-in vision.

6. *How should the process be initiated and introduced into the organisation?*
This research question considers the implementation of the roadmap process identified. The first steps have already been taken, as described in chapter 6. It is required to take the following additional steps:
   1) Bottom-up Trendmaps should be created by the marketing and technology departments.
   2) The application, marketing and technology manager should concretely assign roles to people.
   3) The application and marketing people involved at the cardiac workshop need to map the results of the workshops on a timeline. Meanwhile, suitable people from the technology department can start with the creation of the technology roadmap for the navigation trend, based on the technology-tree that resulted from the cardiac workshops. This has to be done just for navigation in the cardiac segment, because the goal is to create an example that shows the way of how to execute the process.
   4) Results gained need to be presented during a Roadmapteam meeting, to involve the members and show the usefulness and progress of the process.

5) The people involved of the three departments need to arrange a meeting for the final discussion and alignment of the cardiac-navigation roadmaps per discipline.
6) All relevant people of the other market segments, suitable to make the navigation roadmap for the other market segments where navigation has its influence, should see the example of the cardiac-navigation roadmap.
Then navigation roadmaps for the other market segments have to be created.
7) All navigation roadmaps, showing the product features and their meanings to application, marketing and technology, have to be presented to the Roadmapteam.
8) When the previous steps are carried out as described, and the Roadmapteam agrees with the result, a blueprint will be ready that can serve as an example for other Views. These have to be selected carefully and should be carried out step by step, starting with the ones most important to the business and most conceivable to people involved.
9) When roadmaps exist for all Views, these have to be integrated per discipline to overall application, product, marketing and technology roadmaps.
10) Finally, the roadmaps resulting from step 9 can be integrated to one overall C/V roadmap. The top-level shows the product releases in time, with related application and market issues and the required technologies to realise them.
11) All trendmaps and roadmaps have to be updated and new roadmaps have to be created for arising Views on a yearly basis, as indicated in the yearly calendar in section 7.3.3.
12) When this process is mature enough and people involved consider it as a routine, the roadmap process can be enriched with people and process views.

7. *Which characteristics of the organisation are an opportunity or threat during implementation and continuation of the process?*
An attempt to answer this research question can be based on the TPC-model of Tichy (1989), which was described in chapter 3.2.3. The model can be used to evaluate the design afterwards, by questioning if the design pays sufficient attention to the political and cultural aspects of the transformation, and does not mainly focus on the technical/economical aspects.
Indeed, much attention has been paid to the technical/economical aspect system, especially to the *strategy*, the *structure* and the *systems*.
Also, attention has been paid to the *skills* of people, mainly the skills the people responsible for the Views need. Sufficient management attention is required to this aspect.
The *staff*-element has not explicitly been discussed with the final design, although the importance of the management of people does not only hold for the roadmap process, but also for the total of innovation processes. The following statements stress this importance:
- Rubenstein (1976) argued that the innovation process is essentially a people process and that organisational structure, formal decision making processes, delegation of authority and other formal aspects of a so-called well-run company are not necessary conditions for successful technological innovation.
- Among firm-specific competencies that determine innovation, human resources are very important. It is stated in the empirical confirmation by Hall (1994) that the skills and know-how of the employees are among the most influential competencies [Sou02].

This stresses the importance of the management of people and skills for C/V, which will be discussed in the conclusions and recommendations in the next sections.
The cultural aspect system contains the elements shared values and the style.
Shared values relates to the organisation culture. Attention has been paid to this element during the creation of the final design, by taking into account the currently existing roles and teams. This has been stated as a possible roadblock; some people are afraid of losing current roles. This will impact acceptation.
Style relates to the style of management and the style of organising. With respect to the style of organising, it has been mentioned before that some people like the informal way meetings take place at this moment. About the style of management; it is important to adjust this style to the new design. Management has a role in fewer teams than before, which should mean that management interferes less with the operational side of roadmapping. Teams have more freedom and this might positively influence creativity.

8.2 Conclusions

After the research questions have been answered, conclusions with respect to the assignment can be drawn. Also some conclusions beyond the scope of the research are given. Most of the conclusions are numbered. The number of the conclusion corresponds to the number of the accompanying recommendation that will be described in the next section. The conclusions that are not numbered are equally important, but do not have an accompanying recommendation in the next section.

I. At this moment, the roadmap process does not (yet) have enough priority to be successful. Although the C/V-organisation is working very hard to complete current product development, the organisation also needs to focus on the long term. Unless sufficient time and resources are made available for long-term planning, roadmapping will not be successful.

II. The time required to realise the blueprint and the time required in the future to execute the roadmap process are likely to be underestimated.
From the experiences of the cardiac workshops, it can be concluded that a relatively long period will be required to execute the steps indicated in the answer to research question 6 in the previous section. The start of these workshops was two months ago, and the completion of the navigation roadmap will ask at least several months. The creation of the complete C/V roadmap will, with the same speed, take at least another half year to a year. If, where possible, roadmaps are created in parallel, hard work and high priority setting might lead to View-roadmaps before the strategic planning in April, but it is unlikely that this goal will be reached.

III. One of the most important aspects of roadmapping within C/V will be roadmap alignment. This applies to better mutual alignment between the departments, and to alignment between management and the members of the teams.

IV. It is important to keep people involved and informed. Attention to the people process is essential for both good execution of the roadmap process and the innovation process as a whole. This will take time and effort.
This involvement also concerns the accessibility aspect of roadmaps and the Strategic Plan. Roadmaps should be a guide for the organisation as a whole and should be based on strategic issues.

V. In practice, the establishment of roles and responsibilities takes a long time, although this is one of the first requirements to keep progress to the process. Unless people have explicit responsibilities, they will not give enough effort and priority to the roadmap process.

VI. Management wants to change the innovation process to development that is more exploratory. In view of the uncertainty map (explained in section 3.2.1), roadmapping is a tool that supports in changing from 'development engineering' to 'combining market opportunities with technical capabilities'. It does not help to realise exploratory development.

In addition to the introduction of roadmapping, attention is needed for the organisation structure, culture and management style.
'Organic', flexible organisation structures, characterised by the absence of formality and hierarchy, support innovation more effectively than do 'mechanistic' structures. An increase in the formalisation of procedures will result in a decrease in innovative activity (see appendix 4, page 16 of the appendices, among the topic 'hierarchy'). The organisation structure of C/V can be characterised as mechanistic: most of the process improvements within C/V are directed hierarchically. The long decision making procedures slow the innovation process and enlarge the chance of missing opportunities.

If management intents to change to exploratory development, it first should re-establish the optimal balance between empowerment and control.

- It is important to fit all yearly activities that influence the long-term planning in the roadmap process, like seminars, fairs, assemblies and not least important: the budget round of hospitals.

- The roadmap process will be very useful when the process is mature enough to add resource and process layers.
  For example, often a lack of resources is the reason for postponing the start of C&F studies. Starting C&F studies early improves the lead-time of product development and could even lead to more innovation.
  When the roadmap process is more mature, it will attribute to better resource planning, resulting in better management of C&F studies.

- In the process of roadmap alignment, all available information has to be expressed in terms of trends and roadmaps. During my internship, it proved difficult to express market and technology knowledge in these terms.
  The contribution made by the application department provides a good example of an attempt to consolidate knowledge in a trendmap.
  To become an extrovert, innovative organisation, this is a skill to be acquired by people in all groups of the C/V-organisation.

8.3 Recommendation

I. *C/V should make enough time and resources available for roadmapping.*
This can only be realised with full management agreement and support for long-term planning.

II. *The time needed to realise the complete C/V roadmap and the time required to keep the process on track should not be underestimated!* To accelerate the process, people should give roadmapping higher priority and processes should be executed in parallel as much as possible.

III. To create the roadmap alignment *it is recommended to spend a few days completely on roadmapping twice a year, at a location outside C/V, where no disturbances of the daily activities will interrupt the progress of the process.*
Management should set priority to full attendance during these days!!

IV. To keep involvement to the process, every department itself should determine the distribution of roles and tasks, and the communication structures.
In addition to formal aspects like delegation and authority, *it is recommended to shift the focus to the management of people and skills. Furthermore it is recommended to reconsider the accessability aspect of roadmaps and the Strategic Plan.*

V. To be able to continue roadmap creation, *it is recommended to determine soon:*
   - Which people are responsible for the Views and the composition of their teams
   - The composition of the functional teams
   - The composition of the Roadmapteam
   - The owner of the roadmap process.

VI. *It is recommended to adopt an innovation strategy that matches the C/V-culture.*
Changing to 'radical innovation' requires a major change of culture. The introduction of roadmapping to improve the development process requires far less change to the culture and therefore seems to be more feasible.

- For further alignment, when the roadmap process will be more mature, *it is recommended to integrate it as soon as possible with the roadmap processes of other PMG's like GXR, XRG, XRT and CIS.* Also, alignment is needed with external suppliers and *non X-ray groups*, when they enter the cardiovascular market (e.g. CT and MR, as indicated in the clinical trendmaps).

- *C/V should keep in mind the framework shown in section 3.2.1.* Within C/V the two factors 'understanding competition' and 'resource availability and allocation' for the formulating of strategies are not optimally developed. As mentioned before, also understanding of culture and management should deserve full attention.

- *It is recommended to keep in mind the technological lifecycle of products constantly,* to assure that products will be within their window of opportunity.

Epilogue

"If you have built castles in the air, your work need not be lost; that is where they should be. Now put the foundations under them".

-Henry David Thoreau

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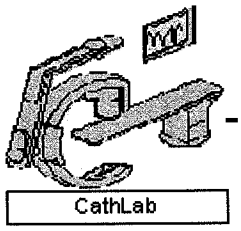
Glossary

This glossary gives an explanation of the terminology and abbreviations used in this report.

Terminology

Cardiovascular
Relating to the heart and blood vessels



Cath lab:
The room in a hospital, equipped with cardiovascular systems. An illustration is shown alongside.

Competency
The capacity of a company to act in a context; it is the combined knowledge of the employees on a certain topic.

Criterion
A fact or standard, by which you judge, decide about or deal with something [Cam02].

Effectiveness
The extent, to which the goal is achieved, 'are we doing the right things'.

Efficiency
The means required to attain the goal, 'are we doing the things right'.

Flow chart
A schematical representation of the steps that different parties involved to the process have to execute, provided with the input needed before the step can be executed and the output the step delivers.

Front-end phase
The early stages of product development.

Innovation
Combining ideas, insights and knowledge to create new knowledge and to put this new knowledge into products and solutions.

Key driver
Main conditions or antecedents, that drive the business.

Key Success Factor:
For C/V: The core competence areas, which are the business drivers for C/V [Stratplan02].
In general: The limited number of areas in which results will ensure competitive performance for the organisation if they are satisfactory [Rock79].
According to Krijnen et. al. [Krij91], they are meant to give top management specific information about aspects of the business on which they should focus their attention for the company to be successful. They are the 'Opportunities' and 'Threats' factors of the SWOT analysis.

Lead-time
The time needed to deliver the output required.

Management
- Management is the control and organisation of something [Cam02].
- The management of a company is/are the group of people responsible [Cam02].

Mission Statement
A short written description of the aims of a business, charity, government department or public organisation [Cam02].

'Outside-in' part
The part of the roadmap that is determined by factors from outside, like applications, the market, competition, suppliers and the outside developments in technology.

Product Creation Process
Process starting with the perception of the market needs and ending with the start of regular production.

Process
The combination of one or more activities to achieve a certain output.

Quality Function Deployment
A customer-oriented approach that guides product managers and design teams through the concept and idea phase of the product creation process. It helps to focus on the functional customer requirements and translates these requirements into appropriate product characteristics. It offers a reliable starting point for roadmapping and building the required cross-functional cooperation [Groen97].

Roadmap
A visualisation of the future, integrating all relevant business aspects, which leads to better coordination of organisational decisionmaking and to better communication.
Important is the alignment of application, market and technology.

Roadmapping
The process that contributes to the integration of business and technology and to the definition of the technology strategy, by the representation of the interaction between products and technologies in time [Groen97].

Roadmap consolidation
The combining of different roadmaps to one aligned and approved roadmap.

Strategy
A detailed plan for achieving success in business situations, or the skill of planning for such situations [Cam02].

Structure
The way in which the parts of a system or object are arranged, or organised or the system arranged in this way [Cam02].

Subsystem and system characteristic teams
Teams consisting of people from the development department, which concentrate on a specific subsystem (e.g. the geometry) or on a specific system characteristic (e.g. 3DRA or IQ).

Tool
Anything that helps you to do something you want to do [Cam02].

Trend
Course, direction or tendency in which the business moves in the field of marketing, application or technology.

Trendmap
The compilation of predictions of future trends that are most important to the business (for about the next 10 years), made for each discipline separately.

Aligned Trendmap
The compilation of the prediction of future trends most important to the business the next 10 years, which are tuned among the different disciplines.

View
Characteristic or feature of a system that is important to the business. It creates value to the system. These Views are derived from the trends in the Trendmap and from the KSF's indicated in the Strategic Plan.

Vision
The ability to imagine how something will develop in the future and to plan in a suitable way [Cam02].

Abbreviations

BL	Business Line
CIS	Common Imaging Subsystems
CE	Consumer Electronics
CFT	Centre for industrial Technology
CPT	Cardiac Product Team
CT	Computed Tomography
C/V	Cardiovascular
C&F	Concept and Feasibility study
GE	General Electric
IQ	Image Quality
KSF	Key Success Factor
MIMIT	Medical Imaging IT
MR	Magnetic Resonance
MT	Management Team
PCP	Product Creation Process
PMG	Program Market Group
PMS	Philips Medical Systems
PTCM	Project Team Coordination Meeting
QFD	Quality Function Deployment
RMT	RoadMapTeam
SMART	Specific, Measurable, Acceptable, Realistic and Timely
SSR	Sales and Service Region
SP	Strategic Plan
TPC	Technical system, Political system, Cultural system
TU/e	Eindhoven University of Technology
URF	Universal Radiography/Fluoroscopy
XRD	X-ray Diagnostics
VPT	Vascular Product Team
XRD	X-Ray Diagnostics
3DRA	3D Rotational Angio

Appendix

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Appendix 1 Project Plan strategic roadmap alignment

	PMG: C/V	Date:	24/05/2002
Project name:	Strategic Roadmap Alignment	Project nr.:	DPI PT ??
Project leader: ***Jacco Wesselius***	Sponsor: ***Wim Crooijmans***	Authorized (Chairman PPB): ***Wim Crooijmans***	

Business Case

The PMG wishes to develop CardioVascular systems that offer specific values to our customers. In the strategic plans, these business drivers are identified based on a vision on the development of the CV-market. To be successful in the CV-market, products have to be developed that offer:

- the right qualities,
- at the right time,
- in the right markets
- for the right price.

Because of the relatively long development cycles associated to (1) the complex type of systems being developed, and (2) the development of new technology (research and pre-development), R&D-projects have to be started timely. This means that a long-term vision on the market, on our product offerings in these markets and on the technology/resources/skills needed to develop these products is needed.
Without this vision, we run two major risks:

1. the required technology/resources/skills are not available when we need them, resulting in an unacceptable increase of time-to-market,
2. critical resources are spent on development of technology, development of skills, or acquisition of resources that will not be used in products.

Both cases result in a dramatic drop of innovation.

Opportunity statement

Problem area:
At this moment some product and technology roadmaps are available, but these are not aligned and the link to the strategic business drivers is not clear.

Present symtoms in this problem area:
When considering the available roadmaps, the following issues are apparent:

- The planning horizon of the available roadmaps is too short: product roadmaps provide information about "the next project" (i.e. Rocket).
- Product roadmaps do not address the business drives identified in the strategic plan
- Technology roadmaps are only loosely coupled to the product roadmaps
- Technology roadmaps do not address the impact of technology on the identified business drivers
- Market information is not available in compact roadmap format
- Application/clinical roadmaps are not available
- Alignment of technology roadmaps with our suppliers (e.g., CIS and MIP) is not performed routinely.

Root causes of current problem area:

1. No general agreement exists about the roadmapping approach
2. Although roadmapping activities are performed and teams are installed, no regular process exists to align the various roadmaps
3. Although responsibility for the technology roadmaps is assigned, no regular process is in place to align the roadmaps (no "heart beat"). Roadmapping is a long term issue that is often in the shadow of short term project

issues.

Opportunity:
We can improve our business planning by aligning the various types of roadmaps:
- Market and application (trend) roadmaps
- Product roadmaps
- Technology roadmaps
- Resource and Skill roadmaps
- Process roadmaps.

Furthermore, we can improve our business planning by explicitly expressing the relation between the various roadmaps and our strategic business drivers.
If we define a process and execute it for a limited set of roadmaps we can implement the process and extend it in the next iteration of the process.

Goal statement (Specific, Measurable, Ambitious, Realistic, Time phased)
1. Define a roadmapping process supported by marketing, application and development before August 2002 (the deliverable is a process description reviewed by Bert van Meurs, Eric von Reth and Wim Crooijmans) 2. Create aligned and agreed roadmaps for a selected set of business drivers and technologies (to be selected in the project) 3. Create the conditions to score "5" for element 1 ("business planning") in the PMS-PST, i.e, satisfy: • *4.2 Technology roadmaps and product roadmaps are distinguished, available and used* • *5.1 The available set of roadmaps in the organization includes application roadmaps*

Project scope
The scope of the project is limited to the IBIS-products, but the approach can also be used for the Integris products in a second iteration. The scope of the project is limited to a sub-set of components, business drivers, and technologies based on the available time and knowledge. We do not aim for completeness but for installation of the process. Completeness may be an issue for the second or third iteration. Scope of the roadmaps developed in this project: 2008. We will focus on: • Market and application (trend) roadmaps • Product roadmaps • Technology roadmaps

Time Schedule, Project Team	
Time Schedule:	
June 2002:	
Kick-off meeting with Wim, Bert and Eric (setting the scope)	
Workshop 1: market/application trends (business driver roadmaps)	[1 day]
Presentation by Maryll: roadmapping "theory" + CV-status	
July 2002:	
Workshop 2: from business drivers to product features (specs)	[1 day]
Workshop 3: from product features (specs) to technologies	[1 day]
August 2002:	
Inventory of emerging technologies by technology owners	
September 2002:	
Workshop 4: putting it all together	[1 day]

October 2002:

Creation of Process Description (Jacco + Maryll)

Review of Process Description

Principal: Wim Crooijmans.

Team-members (with resource allocation):

1.	Jacco	50%
2.	Maryll	100%
3.	Members of the technology roadmap team	4 workshops + normal work
4.	Members of the roadmap team	4 workshops + normal work

Review Proces
• Progress reporting in PPB

Risks

1. Product ownership is currently under discussion (role of competence area managers). This means that it is not completely clear who will participate in the project. (what's the status of the current technology roadmapping team?). Input from Wim Crooijmans needed.
2. Idem for "technology managers"
3. The CV-organisation is in a "survival mode". Only after IBIS3 has been completed and ROCKET has been put on track, the organisation will be ready to change its focus to the "long term" (say 2008). Without a long term focus, roadmapping will not be successful.
   It is a major challenge for this project to get people involved and committed.
4. CV only controls a small part of its key technologies. The contribution of XRT/XRG/CIS to our systems is major. This means that roadmapping without involvement of these groups is probably unwise.
   The technology managers will be responsible for supplying input from these groups or for involving people from these groups in the process.
   In our attempt to structure the roadmapping process, we will not include external suppliers. This will be addressed in a second iteration (2003).
5. Our roadmap may be coupled to the GXR-roadmap. XRD-architecture discussions are an example of this coupling.
   In our attempt to structure the roadmapping process, we will "forget" about GXR-dependencies. This will be addressed in a second iteration (2003).

Appendix 2 Statements of C/V employees

Within the C/V organisation, conversations and interviews were arranged, to gain more knowledge about the current roadmap process. A summary of these conversations and interviews is given here point by point.

- At this moment, only the product roadmap and underlying component roadmaps exist. Also a few technology roadmaps exist, but these are not sufficiently tuned to the product roadmaps.
- Currently, not everyone concerned has the roadmaps to his/her disposal. Roadmaps are confidential. Only management and the roadmapteam have accessibility.
- Most of the people involved are not accustomed to the content of the Strategic Plan.
- It is not clear for which aspects roadmaps should be created.
  Performance indicators have to be determined from the vision to the market more, so that C/V can distinguish itself from competition.
- Roadmaps are made only for the short term of 2 to 3 years and are based on reality only. They do not contain enough vision.
- Marketing only brings in a limited view of the future. It does not propagate a long-term vision.
- The absence of application roadmaps is a deficiency for the development department, because they are not informed about market trends.
- Since product roadmaps, underlying component roadmaps, and a few technology roadmaps exist, a top-level roadmap is out of the question.
- Many people do not know the exact meaning and goal of roadmapping.
- At this moment still too many roadmaps are created in isolation and roadmapping is not an interactive, cross-functional activity.
- Technology should be involved more into the roadmap process. Many teams are mainly represented by marketing people.
- At this moment a structured roadmap process does not exist and is not managed, but the intention to start this process exists. Management is involved to this intention and many people from different functional areas are already involved.
- Roadmapping within C/V is not an iterative process.
- Suppliers are not involved to the roadmap process at this moment. Important is the planning of purchasing and outsourcing.
- Also aspects from outside C/V should deserve attention, for example the way MR is going to develop the coming years.
- Roadmaps are not revised on a regular basis. Also, they are not revised simultaneously.
- A regular process to consolidate roadmaps on fixed points in time does not exist.
- Too many people make decisions just from their own perspective and advantages, not from a business perspective. More processes should be tuned to one another. For example project plans and the division of resources should be discussed more.
- Strategical roadmaps should be made with a vision of 10 to 15 years. Also operational roadmaps should be made, that are often revised and just consider the coming period.
- Plans also have to be aligned with the availability of the resources required.
- The different roadmaps and process descriptions should be kept simple. They should be kept short and readable.
- C/V is very susceptible to triggers coming from the outside, from competition. The planning is often adapted to these triggers.
- C/V does not come with a product to the market first. It usually comes later with a better quality.

Appendix 3 Statements of employees of other PMG's and divisions

During conversations and interviews with people involved to roadmapping at Semiconductors and the PMG's CIS and MR, the following aspects relevant for this research raised:

- Attention has to be paid to the chance that roadmaps become out of date. In practice this easily happens, because roadmaps concern the long term.
- Technologies are not necessarily linked to key drivers. It is also possible to develop new technologies without the initiative of a key driver.
- It is impossible to create roadmaps based *only* on key divers. Costs also play a major role. Combined action and alignment of these factors is essential.
- Many innovations within C/V are technology driven, although C/V delivers to a niche market, which enables gaining knowledge with respect to customer demand more easily.
- Roadmaps should be revised at least every year, maybe even every six months.
- Technology processes change quickly. The time-to-market is getting shorter, which makes it important to anticipate timely.
- C/V should definitely have an application roadmap, to which CIS should have access. The Roadmapteam of CIS mainly works bottom-up, because it is not involved sufficiently in market requirements and trends.
- A tool that can be used for assisting the creation of a technology roadmap is the 'technology tree'. This is a representation of a step by step more deepening specification of the required technology. Important aspects to pay attention to are the required level of detail and the relationships between the diverse technologies.
- Competencies and skills have to be aligned with the technology roadmaps.
- Key factors need to be expressed 'SMART' (Specific, Measurable, Ambitious, Realistic, Time phased) to enable all parties involved to interpret them in the same way.
- The most important parameters, like time, money and functionality need to be aligned.
- It is important to shift the attention from the individual profit margin of PMG's to the profit for PMS in general. This will lead to better alignment and better internal relationships between supplier and customer.
- The absence of a vision is strongly related to the absence of the right skills. A good combination of skills is very important.
- It is important to fit in all yearly activities that influence the long-term planning, like seminars, fairs, assemblies and very important but often not considered, the budget round of hospitals.
- Time and effort needed for setting up a structured roadmap process took MR a few men-years.

Appendix 4 Complete description of the theory (summarised in chapter 3)

This Appendix provides additional theoretical background, which has been gained during the literature study. It will describe aspects related to the development and application of technology, innovation, and organisational change and design.
First, in section A, all relevant aspects about technology will be treated. Next, section B will describe different aspects of innovation. Section C will deal with organisational change, with its complexities and aspects that deserve attention. At the end of the Appendix a summary will be given, provided with comment on how the facts learned from this theoretical framework can be used during the project.

A. Technology

1. Technology and technology management

The essence of organisation strategy and planning is the alignment of the activities and resources of the organisation to the way it creates value and competitive advantage compared to other companies. This requires tuning of the nature of changes of the organisation environment on the medium to long term (e.g. market, customer, competition and law), in terms of external opportunities and threats, together with the internal strengths and weaknesses of the organisation.
Technology can be seen as a specific type of knowledge. The characteristic that distinguishes technology from more generic knowledge types is that technology is applied, focussing on the 'know-how' of the organisation.
Treating technology as a knowledge type is useful, because knowledge management concepts can be used to manage technology more effective [Phaal01a].

Like for technology, in literature many definitions of 'technology management' exist, but, related to the subject of the project, the following definition will be applied in this research, stated by the European Institute of Technology Management (EITM):

> 'Technology management addresses the effective identification, selection, acquisition, development, exploitation and protection of technologies needed to maintain the market position and organisation performance in accordance with the company's objectives' [Phaal01a].

This definition emphasises two important aspects of technology management [Phaal01a]:

- Establishing and maintaining the linkages between technological resources and company objectives is of vital importance and represents a continuing challenge to many companies. This requires effective communication and knowledge management, supported by appropriate tools and processes. Of particular importance is the communication and understanding that needs to be established between commercial and technological functions in an organisation.
- Effective technology management requires management processes and the above mentioned definition concerns the five processes identification, selection, acquisition, exploitation and protection of technology. These processes are not always very visible in organisations, and are typically distributed within other business processes, such as strategy, innovation and operations.

Technology management addresses the processes needed to maintain a continuous flow of products and services to the market. It deals with all aspects of the integration of technological aspects into organisational decision making. It is directly relevant to a number of business processes, including strategical development, innovation and new product development and operations management. Healthy technology management requires establishing appropriate knowledge flows between commercial and technological perspectives of an organisation, to achieve a balance between market 'pull' and technology 'push'. The nature of these knowledge flows depends both on the internal and external context, including factors such as organisation aims, market dynamics, organisational culture, etc. [Phaal01a].

A framework is developed that brings together concepts, based on knowledge and resources. This framework is depicted in figure 1 and shows technology management processes (identification, selection, acquisition, exploitation and protection) and business processes (strategy, innovation and operation). It highlights the dialogue that is needed between the commercial and technological functions in the organisation to support effective technology management [Phaal01a].

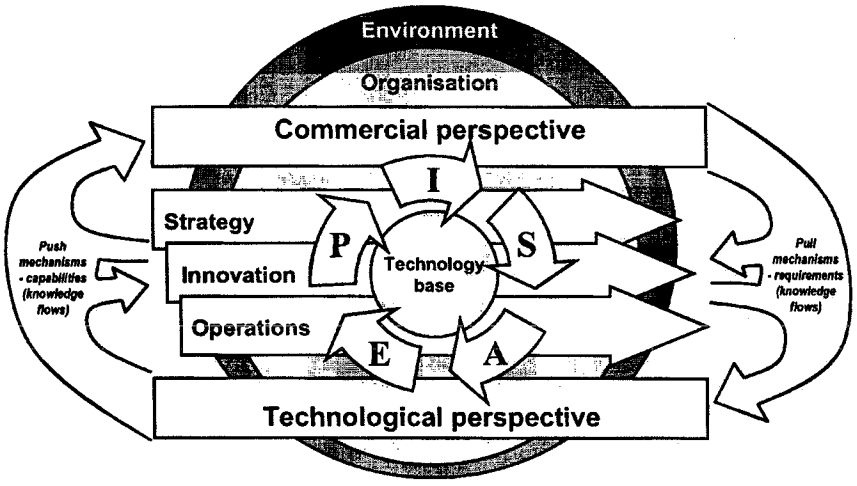


Figure 1:Technology Management framework [Phaal01a]

Furthermore, in literature a few aspects are revealed that are of great importance to management of technology in innovative organisations.
These are listed here:

- Management of technology is essential for innovative companies. It enlarges the effectivity and productivity, which improves the competitive position of the company [Khal00].
- It is important to align science and technology to remain competitive. Also of importance is keeping attention to maintain the market position of the company [Khal00].
- Market 'pull' and technology 'push' have to be tuned to one another. The technology has to be related to the market demand. For this purpose techniques exist, like the creation of roadmaps [Khal00].
- An obvious distinction has to be made between the core competencies of a company and technologies that can be farmed out to other parties [Khal00].
- It is important to integrate the technology with the organisation strategy [Burg01] [Khal00].
- The use of modular component variations may create strategical flexibility. Using the product architecture, harmony has to be created between functional, technological and physical processes [San00].
- To enlarge creativity within product development, it's wise to create cross-functional teams. The management attention to these teams is of great importance [Jas01].

2. The technological lifecycle

An organisation that is highly related to innovation will have to take care of an appropriate planning in time of which technology is important and has to be available at what moment. The performance of a technology has a pattern recognisable in time that, if understood, can bring a big advantage to the strategical planning of the company. Other processes can be adapted to this planning. This pattern in time is also called the technological lifecycle [Khal00].

The technological lifecycle and market growth

When technology develops, it grows according to the technological lifecycle. Market penetration and market growth occur, expressed in market volume.
The market growth pattern of the technological lifecycle consists of different stages. This can be shown in a graph, in which the x-axis represents the time and the y-axis gives the expected market volume during the following six technology stages:

A. The technology development stage
B. The application launch stage
C. The application growth stage
D. The mature technology stage
E. The technology substitution stage
F. The technology obsolesce stage

This technology lifecycle is depicted in figure 2.

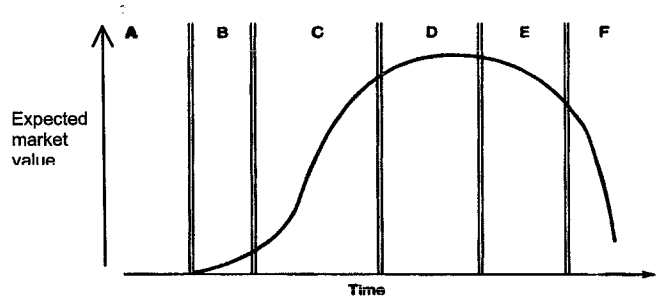


Figure 2: Technological lifecycle [Khal00]

It is important to know and to stay interested in the stage in which a technology is situated. The strategy related to investments depends on this stage. During the technology development stage for example, the market does not yet recognise the technology and not a single response happens. In fact this is an important period, during which scientists and researchers spend lots of money to develop the technology, develop prototypes and to test the new technology. Early ending of projects that seem to be unsuccessful is important. The later in development the project is ended, the higher the costs related to this.
Similar to the above mentioned stage, for all other stages strategies exist to apply investments as efficient as possible. Of course, this highly depends on the specific situation of the company.

B. Innovation

1. Innovation in general

Technology is an enabler for innovation and relates highly to the competitive advantage of the company [CE01].

Five relevant categories exist that influence the innovation strategies of a company [Burg01]:

- Resources that have to be available to enable innovative activities.
- Capacity to understand strategies of competition and the evolution of the industry, related to innovation.
- The capacity to understand technological developments, relevant to the business unit.
- Structural and cultural context of the business unit, which influence the internal entrepreneurship.
- Strategical management activities, which enable dealing with internal entrepreneurial initiatives.

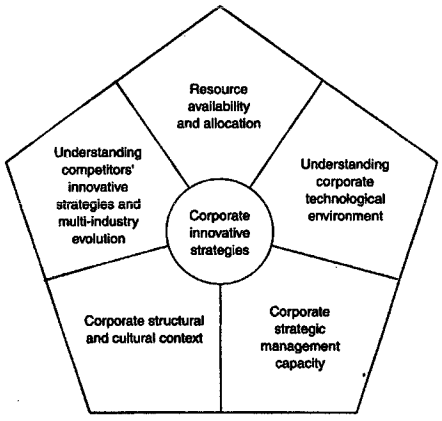


Figure 3: Innovative capabilities framework [Burg01].

Figure 3 shows the framework of these categories of innovative capacities and the way they influence innovation.

The first three categories mentioned are important input to *formulate* the innovative strategies of the business unit.
The last two are relevant input to the *implementation* of innovative strategies of the business unit.
Combination of the five categories determines the relative strength of the business unit in formulating and implementing innovative strategies [Burg01].

Among firm-specific competencies that determine innovation, human resources are very important. It is stated in the empirical confirmation by Hall (1994) that the skills and know-how of the employees are among the most influential competencies [Sou02].
Research in the Greek manufacturing industry indicated the importance of R&D and marketing activities, education, training and previous work experience of personnel, teamwork, formal internal communication, and utilisation of professional staff and shop floor employees as sources of innovative ideas [Sou02].
Rubenstein (1976) argued that the innovation process is essentially a people process and that organisational structure, formal decision making processes, delegation of authority and other formal aspects of a so-called well-run company are not necessary conditions for successful technological innovation [Trott02].

2. Managing uncertainty

Pearson's uncertainty map (Pearson, 1991) provides a framework for analysing and understanding uncertainty and the innovation process.
Pearson's framework divides uncertainty into two separate dimensions:

- Uncertainty about ends (what is the eventual target of the activity or project)
- Uncertainty about means (how to achieve this target)

Problems of managing uncertainty often concern means. Some projects are unsuccessful and decisions have to be taken regarding future funding. Decisions have to be made such as whether to cancel, continue or increase funding. In these situations, senior managers have to listen carefully to those most closely involved and those with the most information and knowledge. Further information and knowledge are usually available with the passage of time, so time is another element that needs to be considered. It is because time is limited that decisions are required. However, many decisions are made with imperfect knowledge, thus there is usually an element of judgement involved in most decisions.
Pearson's framework, shown in figure 4, addresses the nature of the uncertainty and the way it changes over time.

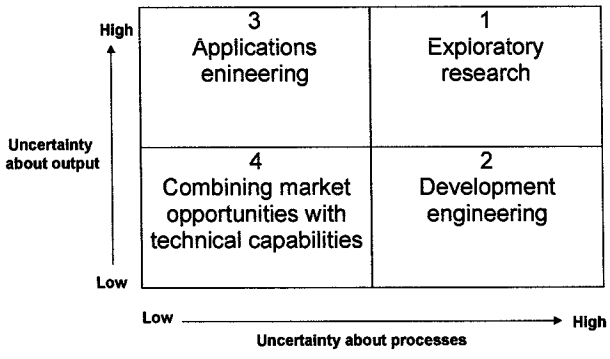


Figure 4: Pearson's uncertainty map [Trott02].

Quadrant 1
Activities involving a high degree of uncertainty about means and ends. The ultimate target is not clearly defined and how to achieve this target is also not clear. These activities often involve working with technology that is not fully understood and where potential products or markets have not been identified. Increasingly it is only supported by large organisations that have the necessary resources to fund such exploratory studies.

Quadrant 2
In this area the end or target is clear. Hence, there is uncertainty about precisely how the organisation will achieve its target.

Quadrant 3
In this area there is uncertainty regarding ends. The means to get there are clear.

Quadrant 4
Covers innovative activities where there is most certainty. Activities may be dominated by improving existing products or creating new products through the combination of a market opportunity and technical capability. With so much certainty, similar activities are likely to be undertaken by the competition. Hence, speed of development is often the key to success here. New product designs that use minimal new technology but improve, sometimes with dramatic effect and the appearance of an existing product are examples.

Management of each of the quadrants demands different approaches. The organisational structure and culture necessary for innovation is different [Trott02].

3. Organisational characteristics that facilitate the innovation process

As mentioned before it is important to view innovation within the context of the organisation. The following characteristics are continually identified in the literature as necessary for successful innovation [Trott02]:

Growth orientation
Not all companies' first and foremost objective is growth. Some companies are established merely to exploit a short-term opportunity or to maintain the company to the existing size. Companies that are innovative are those companies whose objective is to grow the business. They do not make large profits one year then huge losses the next, but they actively plan for the long term.

Vigilance
Vigilance requires continual external scanning, not just by senior management but also by all other members of the organisation.
Collecting valuable information is one thing, but relaying it to the necessary individuals and acting on it are two necessary associated requirements. An open communication system will help to facilitate this.

Commitment to technology
Most innovative companies exhibit patience in permitting ideas to germinate and develop over time. This also needs to be accompanied by a commitment to resources in terms of intellectual input from science, technology and engineering. Those ideas that look most promising will require further investment. There needs to exist a long-term approach of the company to attract good scientists and stable investment in technology development.

Acceptance of risks
This means the willingness to consider carefully risky opportunities. It includes the ability to make risk-assessment decisions, to take calculated risks and to include them in a balanced portfolio of projects.

Cross-functional cooperation
Inter-departmental conflict is a well-documented barrier to innovation. The relationship between the marketing and R&D functions has received a great deal of attention in the research literature, because the two groups often have very different interests. Research has shown that the presence of some conflict is desirable, probably acting as a motivational force (Souder, 1987). It is the ability to confront and resolve frustration and conflict that is required.

Receptivity
The capability of the organisation to be aware of, identify and take effective advantage of externally developed technology. Most technology-based innovations involve a combination of several different technologies, which should not all be developed in-house.

'Slack'
Besides the need for efficiency, there is also a need for a certain amount of 'slack' to allow individuals room to think, experiment, discuss ideas and be creative.

Adaptability
The readiness to accept change in the way the organisation manages its internal activities, as a result of disruptions to established organisational activities caused by the development of new product innovations; the ability to adapt to the changing environment.

Diverse range of skills
The ability to effectively manage the diversity of knowledge and skills required with the innovation process. A combination of specialist skills and knowledge in the form of experts is needed.

C. Organisational change and design

1. In general

During the creation of an organisation design or redesign, some general aspects are useful to consider. These are described here.

Within an organisation, the assignment of decision making responsibility and the capacity to exercise control arises from that organisation's design [Rit00].

An organisation is 'untouchable, unknowable and unmakeable', which is a characterisation that clearly sets limits to the extent to which an organisation is able to be designed effectively [Aken92].
The organisation culture has to be taken into account when changing an organisation structure [Jäg95].

The creative combination of functional requirements and design possibilities leads to a design. Realisation of the design leads to an organisational change.
The process of organisation design is a creative and iterative process. There is no straight line from the conditions and criteria to the fitting design. Sometimes it's even impossible to create a design that fits the conditions and the criteria. Then conditions and/or criteria have to be changed or a suboptimal design has to be accepted [Jäg95].

The design has to be consistent: position structure and procedural structure have to match with one another [Jäg95].

Organisation development refers to changes an organisation makes so that it can better state and achieve its strategic goals. It is a way of achieving organisational effectiveness end efficiency. It may involve a change in structure, but it usually also involves training and development programs for managers and other personnel.
As part of an organisation development program, an organisation can, and often does undertake a comprehensive study of its design to determine if the organisation can be

redesigned to find more effective and efficient processes to reach its strategic goals [Merwe02].

2. Strategy and Structure

To be able to realise a certain strategy the company involved in general needs to have an appropriate organisation structure. Therefore, a change in strategy often causes a change in structure.
The statement 'structure follows strategy' from Chandler (1962) is a famous one. However, the danger exists to approach the relation between structure and strategy from only a one-directional causality. On one hand because structure is not only the result of consciously structural action but is also the result of more or less autonomic growth processes, and on the other hand because structure and strategy mutually influence one another. It may be wise during a change in strategy to also change the structure, but during the organisation of the structure on the other hand also attention has to be paid to the strengths and weaknesses of the existing organisation, and in this way strategy follows structure. Strategy and structure are inextricably connected to one another [Aken93].

Organisation changes get started, because transformers expect material and/or immaterial advantages. Generally, transformations also cause material and immaterial costs: the transformation costs.
Furthermore, organisation changes cause risks. Sometimes changes are inevitable, but they are always accompanied by risk. Even perfectly designed and guided organisation changes mostly are not painless [Aken93].

3. The 7S-Framework

The 7S-framework of McKinsey can be used as a checklist for analysing the organisational problems. The framework can help to map the current situation of an organisation and to analyse the causes of functioning problems [Aken93]. This may support to design a new structure, which needs paying attention to the total of the seven elements.

The 7S-framework consists of [Aken93]:

- *Strategy*: The internal strategy of the company, as far as this strategy is understood and accepted and used by the members of the organisation.
- *Structure*: The internal and external structure, where the internal structure is the position structure of the organisation and the external structure contains the roles and relations with customers, competition and suppliers.
- *Systems*: The formal and informal managerial and physical procedural structure. This means the procedures and information systems used to manage the primal process as well as the primal process itself.
- *Skills*: The technology that is required to execute the primal process. This means all knowledge and skills required, the essential core competencies as well as all other know-how.
- *Staff*: The formal and informal ways according to which the personnel is educated, rewarded and motivated, but also the way the behaviour of this personnel is managed by the existing power structure.
- *Style*: The style of management and the style of organising.
- *Shared values*: The organisation culture.

Two main thoughts exist behind the 7S-framework. These are [Aken93]:

1. Besides the 'hard' Strategy, Structure and Systems, also the 'soft' Skills, Staff, Style and Shared values are of essential importance to contribute to the success of the organisation.
2. At the moment one S needs to be changed, also much attention has to be paid to the other elements; all elements are mutually interdependent. They form a balanced configuration.

One cannot assume that certain elements are more important than others, but it may happen that an organisation in a certain occasion can better work goal-oriented to improvements of one or a few of the elements.

Not every S is equally tangible. The three 'hard' elements 'Strategy', 'Structure' and 'Systems' are the most tangible and the relatively easiest to design. This doesn't always mean they are the most realisable.
For 'Skills' it is possible to inventory what is missing in the current situation and to determine the requirements for the new situation.
For changing the power structure ('Staff') modifying the current formal position structure is used.
'Style' and 'Shared values' are the least tangible and designable elements and these are the most difficult to change. Realising an actual, different organisation culture probably is not possible, or a long, consequently sustained process is required [Aken93].

4. Structure Parameters

Organisational structure determines the speed of adaptability to changing environments [Merwe02].
It's important to take into consideration structure parameters. These point out the type of organisation. Every design can be described based on certain characteristics. The choice of a characteristic is essential for the design. The choice of one characteristic can exclude another.
Three important parameters that are essential for the design of the structure are [Jäg95]:

1. Differentiation, grouping of people
2. (De)centralisation
3. Hierarchy

1. Differentiation:
This leads to more efficiency; people have collective, common aspects.
Four basic structural alternatives exist to guide the process of organisational design:

- The functional structure
- The divisional structure
- The hybrid structure
- The matrix structure

The functional structure
The functional structure groups all organisational participants into sub-units on the basis of a shared function or area of specialisation. They perform a number of closely related activities and consist of employees with similar expertise, skills, and work activities [Rit00].

Table 1: Advantages and disadvantages of the functional structure [Rit00] [Jäg95]

Advantages	Disadvantages
- Knowledge, experience, expertise on certain functional areas, can result in competitive advantage	- Communication between functional areas
- Efficient use of resources, economies of scale	- Lack of coordination across departments to respond quickly to multifunctional problems
- High level of coordination; direct communication within functional area	- Limited mobility of employees within the organisation
- Communication; common language	- Demotivation caused by monotonous work

The divisional structure
The divisional structure groups all organisational participants into sub-units on the basis of similar products, geographical locations, or customers. Within a divisional structure, each sub-unit or division is self-contained [Rit00].

Table 2: Advantages and disadvantages divisional structure [Rit00] [[J□g95]

Advantages	Disadvantages
- Close to market: fast stream of products and services, short time to market	- Inefficient use of resources, higher costs
- Fast problem solving caused by direct coordination and interaction	- Too large amount of autonomy: losing goal of organisation
- One focus results in strong customer attention	- Little development of in-depth expertise
- Broad range of skills employees	- Lack of functional coordination may create difficulties, e.g. organisation-wide marketing initiative.
- Larger engagement: higher quality	

The hybrid structure

Very few firms adopt a purely functional or divisional structure. Most firms operate a hybrid structure that incorporates elements of both divisional and functional structural designs. For example, the organisation may chose to centralise some, but not all, the divisions' functions into one or more functional sub-units. This offers a mix of the advantages and disadvantages of the functional and divisional structures. These include [Rit00]:

Table 3: Advantages and disadvantages of the hybrid structure [Rit00]

Advantages	Disadvantages
- Avoiding the duplication of some functional resources, realising economies of scale	- Conflict, caused by incompatible goals of functional and divisional sub-units
- Functional departments have organisation-wide responsibilities, adoption of organisation-wide perspective	- Slow response times; delay resolution of problems calling for decisions
- Retention of divisional structures engenders a focus on customer service	

The matrix structure

The organisation imposes a second functional structure on top of the pre-existing divisional structure so that every position and activity exists simultaneously within a divisional sub-unit and a functional sub-unit. Everyone reports to and works under a divisional manager and a functional manager [Rit00].

Table 4: Advantages and disadvantages of the matrix structure [Rit00]

Advantages	Disadvantages
- Divisional structures engender strong sense of customer service while functional structures impose a strong commitment to organisational goals	- Conflicts over the authority and responsibility of the two managers
- Functional sub-units improve functional coordination and help develop in-depth expertise while divisional sub-units retain capacity to respond quickly to multifunctional problems	- Slow decision making as cause of disagreement between functional and divisional manager
- Promotion of flexible use of human resources because functional managers can shift resources from division to division if needed	- Sheer effort needed to make a matrix structure work can result in an overemphasis on internal relations
- Avoidance of duplication of effort and realisation of economies of scale	- Two levels of authority can create excessive administrative costs

2. (De)centralisation:
Centralisation refers to the decision making activity and the location of power within an organisation. The more decentralised the organisation the fewer levels of hierarchy usually required. This tends to lead to more responsive decision making closer to the action [Trott02].
The decision for centralisation or decentralisation depends on the type of organisation, the nature of the activities, the expertise of the employees, etc.
To make this decision the following aspects are important:

- Who has the information to make a decision or to whom it is fast available?
- Who has the expertise to make a good decision?
- Do emergency decisions have to be taken on the spot to show accommodation to local circumstances?
- How important is the decision?
- Does the willingness to the development of initiative and motivation strongly improve by decentralisation?

Table 5: Advantages and disadvantages of centralisation [Rit00]

Advantages of centralisation	Advantages of decentralisation
- Unity and consistency of policy	- Exemption of the top
- Efficient allocation of resources	- More responsive decision making closer to the action
- Expertise	- Better data processing
- Control	- Motivation of employees
- Strategical manoeuvrability, if top gets all information necessary	

3. Hierarchy:
The establishment of reporting and acceptation of assignments. It concerns the composition of groups, teams and departments, manager or leadership decisions and responsibilities. 'Organic', flexible organisation structures characterised by the absence of formality and hierarchy, support innovation more effectively than do 'mechanistic' structures. The latter are characterised by long chains of command, rigid work methods, strict task differentiation, extensive procedures and a well-defined hierarchy. Many objections have been raised against this argument, but flexible rather than mechanistic organisational structures are still seen, especially within the business management literature, as necessary for successful industrial innovation. In general, an organic organisation is more adaptable, more openly communicating, more consensual and more loosely controlled. The mechanistic organisation tends to offer a less suitable environment for managing creativity and the innovation process. An increase in the formalisation of procedures will result in a decrease in innovative activity. It is unclear however, whether a decrease in procedures and rules would lead to an increase in innovation. Moreover, organisational planning and routines are necessary for achieving efficiencies [Trott02].

5. The transformation process

The TPC-model of Tichy
During the creation of the realisation process for the transformation, attention has to be paid to the fact that organisational changes most of the time do not stay restricted to the planned changes, but also may have (often unplanned) side effects.
This topic is described by the TPC-model of Tichy (1989).
It generally states that changes have their side effects in the technical/economical system (T), as well as in the political (P) and the cultural system (C) of the organisation [Aken93].

The elements from the 7S-framework can be related to Tichy's TPC-model. In the technological/economical aspect system strategy, (position)structure, systems and technology (skills) play a role.
Position structure also plays a role in the political aspect system. Also staff is important in the political system, relating to the evaluation and rewarding system. The style of organising and managing and the organisation culture play a role in the cultural aspect system.
These relations are shown in figure 5.

The TPC-model of Tichy can also be used to evaluate a realisation design afterwards, especially by questioning if the design pays sufficient attention to the political and cultural aspects of the transformation, and doesn't mainly focus to the technical/economical aspects.

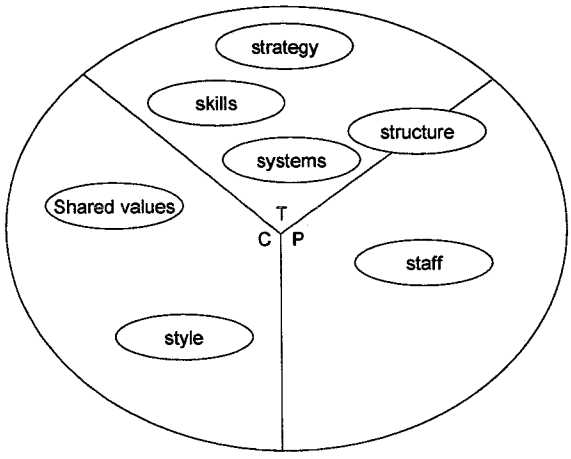


Figure 5: The seven elements of the 7S-framework and the TPC-model of Tichy.
T: Technical/economical aspect system
P: Political aspect system
C: Cultural aspect system

Resistance towards change
Behaviour arises from the net effect of driving forces and restraining forces. During the changing of the patterns of behaviour on one side, the driving forces have to be mobilised and on the other hand, the restraining forces towards the change have to be adapted. Sources of resistance towards organisational change may be diverse. A few of these are [Aken93]:

- Incomprehension and distrust.
- Divergent perceptions: people involved may honestly have a different view.
- Low inclination to change: the fear to be unable to function in the new situation, fear for the unknown.
- Local self-interest: the change is of interest for the organisation as a whole, but doesn't contribute to a specific department or certain persons.
- During the transformation process and the choice of interventions to use, the nature of the resistance expected plays a role.

D. Summary & Utilisation

Technology
Technology and the management of technology are very important for an innovative company like C/V to create value and competitive advantage compared to other companies.
Technology can be seen as a specific type of knowledge, focussing on the 'know-how' of the organisation. Effective communication and knowledge management, establishing the link between technological resources and company objectives is of vital importance, as well as appropriate knowledge flows between commercial and technological perspectives of an organisation to achieve a balance between market 'pull' and technology 'push'.
Within C/V these knowledge flows are not managed optimally at the start of the research. An aligned roadmap process can align technological resources and company objectives, and commercial and technological perspectives.
To be able to integrate the development of technology in accordance with the organisational strategy in the right way, it is very important to understand the performance of a technology in time: the technological lifecycle. In this way, early ending of projects that seem to be unviable can be accomplished.

Innovation
Technology is an enabler for innovation and relates highly to the competitive advantage of the company. Five categories of innovative capacities were described (see figure 3.3). The skills and know-how of employees are among the most influential competencies that determine innovation. When C/V realises an aligned roadmap process, it has the ability to manage human resources and skills according to the needs.

The management of uncertainty is an important aspect of the innovation process. Uncertainty often concerns means; decisions about projects that are unviable have to be taken regarding future funding. Also time is an element that needs to be considered, because time is limited. Many decisions are made with imperfect knowledge.
The nature of uncertainty has been shown in Pearson's uncertainty map in section B.2. The innovation process of C/V can be situated in the second quadrant, development engineering: the end is clear, product releases are planned in time, but there is uncertainty about precisely how the organisation will achieve this target. It also occurs that the target is not achieved in time. For the organisation it is important to create a mechanism that enables to control the uncertainty of means and delay.

Organisational characteristics were described that are necessary for successful innovation. These can be used to do a pronunciation upon the way the roadmap process will be successfully implemented and applied in the future. The absence of some of these characteristics will make it difficult for the roadmap process to be successful.

Organisational change and design
To create a roadmap process that fits the organisation, organisational change is inevitable. It is important to consider the costs and risks it will bring.

The organisational problems of the current situation and the design of a new structure can be analysed by paying attention to the seven elements of the 7S-framework. Important aspects to consider from this framework are:

- the fact that besides the hard skills also the soft skills are essential to contribute to the success of the organisation, and
- the fact that all elements of the framework are mutually interdependent.

Three important parameters that are essential for the design of the organisation structure are differentiation, (de)centralisation and hierarchy. How the alignment of the roadmap process has to be organised with respect to the differentiation aspect is important, just like the hierarchical structure and issues concerning the centralisation of decision making. These issues are dealt with in chapters 5,6 and 7 of the report.

Furthermore, with the change of the roadmap process structure, side effects should be considered. Changes have their side effects in the technical/economical system, as well as in the political and the cultural system of the organisation. The design should pay sufficient attention to each of the three systems.

Finally, an organisational change may cause resistance. Sources may be diverse and some of these are mentioned. The nature of the resistance plays a role during the transformation process and the choice of interventions to use.

Appendix 5 Complete description of roadmapping Theory (summarised in chapter 3)

In this Appendix, the theoretical perspective on roadmapping and the current roadmapping situation within C/V will be evaluated and described in detail.
In section A, literature about roadmapping, roadmap aspects and the relation with other processes will be treated to gain more understanding. The expertise that has been passed on by experts of other Philips divisions will be treated in section B.

A. Roadmapping theory

1. Definition

Technology roadmapping is a needs-driven technology planning process to help identify, select, and develop technology alternatives to satisfy a set of product needs. It brings together a team of experts to develop a framework for organising and presenting the critical technology-planning information to make the appropriate technology investment decisions and to leverage those investments.

Given a set of needs, the technology roadmapping process provides a way to develop, organise, and present information about the critical system requirements and performance targets that must be achieved in a certain time frame. It also identifies technologies that need to be developed to meet those targets. Finally, it provides the information needed to make trade-offs among different technology alternatives [Gar98].

2. Roadmap Creation

An efficient way to create roadmaps is to fully concentrate on this subject a couple of days. Expert teams are the input of these days. They concentrate on the market, product and technology segments of the roadmap [Mul01].

Figure 7 shows the typical content of a roadmap.

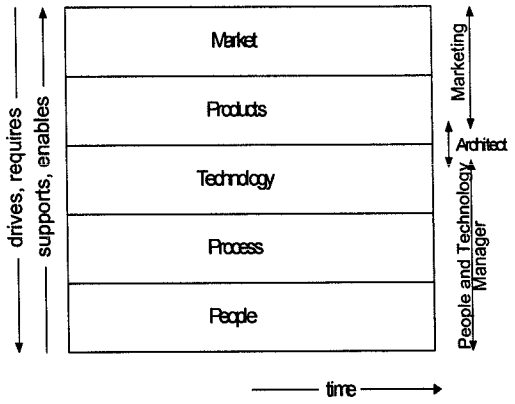


Figure 7: Typical content of a roadmap [Mul01]

At the right hand side the owner of the view is shown, while the left hand side shows the asymmetry of the views: the market is driving, while technology, people and process are enabling.
Key to a good roadmap is the skill of showing the important, relevant issues. The roadmap should provide immediate insight in the most relevant developments from the five mentioned points of view. These issues are primarily related by the dimension of time.
The product roadmap should be coupled to the technology, people and process roadmap. The technological chances have to be discussed before the product section of the roadmap is detailed.

One can often start by establishing a small project team in which (strategic) marketing, product management, research, development and engineering participate. The team addresses a leader who preferably should be responsible for the maintenance of the roadmap. The team activities preferably should be followed by workshops to assure integral engagement and input of the organisation. The project team uses the results of the workshops to develop draft roadmaps, or parts of these [Groen97].

The most essential art of making a roadmap is the selection of the most relevant issues. A technology roadmap per key driver is an explicit way to visualise the relation between the market in terms of key drivers and the technology. At the marketing side, the trend in these key drivers must be visible in the roadmap.
If possible, facts should be used as input for roadmap creation: market analysis reports, installed base, manufacturing, suppliers and internal reports.
The top-level roadmap should fit on a single sheet of paper. This is a challenge, because it should contain the information entirely, to enable everyone to see the broader perspective and to see the many underlying relationships.
Supporting roadmaps can concentrate on specific relations, for instance between key driver and a required technology. These supporting roadmaps should be linked to the highest level roadmap by the time axis and a small set of recognisable landmarks, for instance quantified key drivers and the main products. [Mul01].

An example of the creation of a roadmap process is given by the lecture 'T-Plan, Fast Start Technology Roadmapping' of the University of Cambridge [Phaal01b]. This lecture consists of four sessions, of which the content per session is described next.

Workshop 1: The market
This workshop aims to establish a set of prioritised market and business drivers for the future, reflecting external and internal factors. First a set of 'performance dimensions' should be defined. These are aspects of product performance that are (or might be) important to the customer, and that technology can enable. This is practical, because these are related directly to the product and most of the time can be identified fast.
Product performance is a fundamental factor that can be used to relate market drivers to technological capacity.
After determining performance dimensions the 'market / business drivers' should be determined. These are the external market and internal organisation drivers, which reflect the underlying customer and organisation motivation, needs and advantages.

Workshop 2: The product
This workshop aims to establish a set of 'product feature concepts' which could satisfy the drivers identified in workshop 1. The market / business drivers and product feature concepts together define a simple grid which can be used to investigate the relationship between features and drivers. These grids can be seen in figure 8.

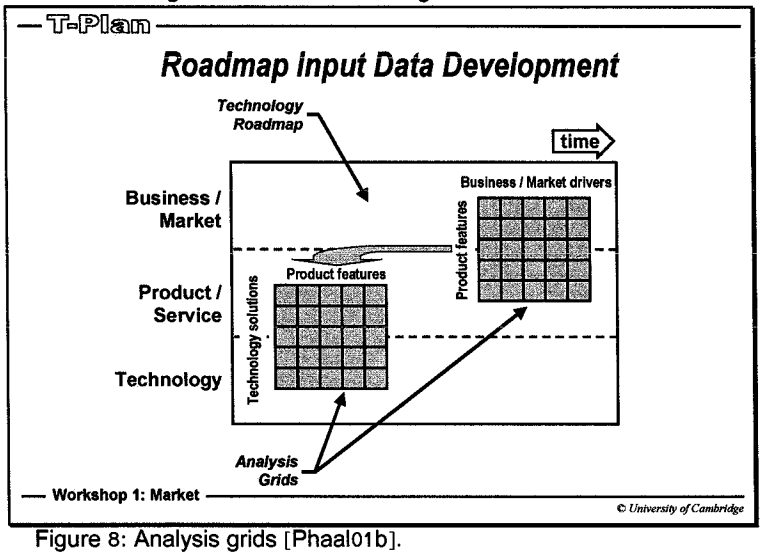


Figure 8: Analysis grids [Phaal01b].

The product feature concepts are grouped and their impact ranked for each market and business driver, and alternative product strategies considered (in combinations of market and business drivers).

Workshop 3: Technology

This workshop aims to identify possible technological solutions that could deliver the desired product features. These solutions are grouped into technical areas (or 'routes'), which taken with the product features defined in Workshop 2, define a second analysis grid. This is shown in figure 8. This grid links directly to the market-product grid. The impact of the technology areas on the desired product features is then ranked. The two analysis grids link together, and provide a means of relating the impact of technology to product features and market / business drivers, connecting various levels of the roadmap.

Workshop 4: Roadmapping

Workshops 1-3 enable a simple framework for linking the three levels of the roadmap to be developed, together with a 'language' for supporting the construction of the roadmap. Workshop 4 draws the marketing and technology strands together to produce the first roadmap. The format of the technology roadmap is defined, in terms of time scales, levels, and product strategy (e.g. platforms). Key milestones are identified, product evolution plotted, and technological programs identified, together with linkages between the roadmap levels, bearing in mind the prioritised market drivers, high impact product features, and most attractive technological solutions.

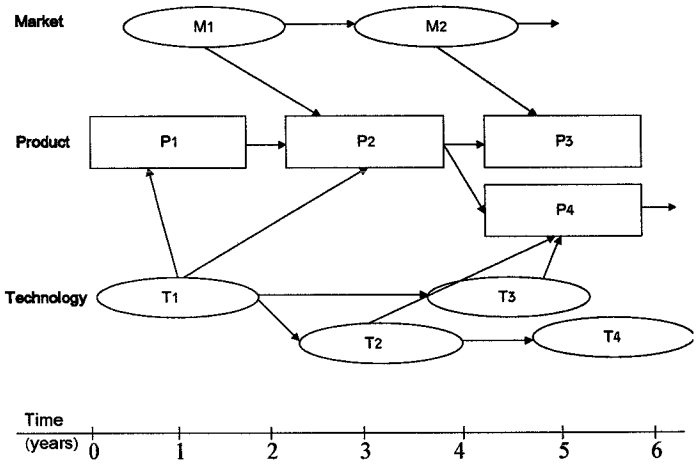


Figure 9: Generic overall roadmap, showing nodes and links

The final roadmaps that result from the workshops should be a draft of the product roadmap, which shows product releases in time, key milestones and the linkages between the products and the market and technology roadmaps. The market roadmap shows the market drivers plotted in time and the technology roadmap shows the technological solutions to realise the product indicated in the product roadmap. An attempt should be made to put the three roadmaps on one sheet of paper. The result will be an overall roadmap, which will look like the roadmap shown in figure 9. The market, product and technology roadmaps that result from workshop 4 will not be complete, because roadmapping is an iterative process that needs to be carried out several times to move to completion. The roadmaps can be completed to the level of detail desired. This depends on the amount of time and effort the company reserves to spend on roadmapping.

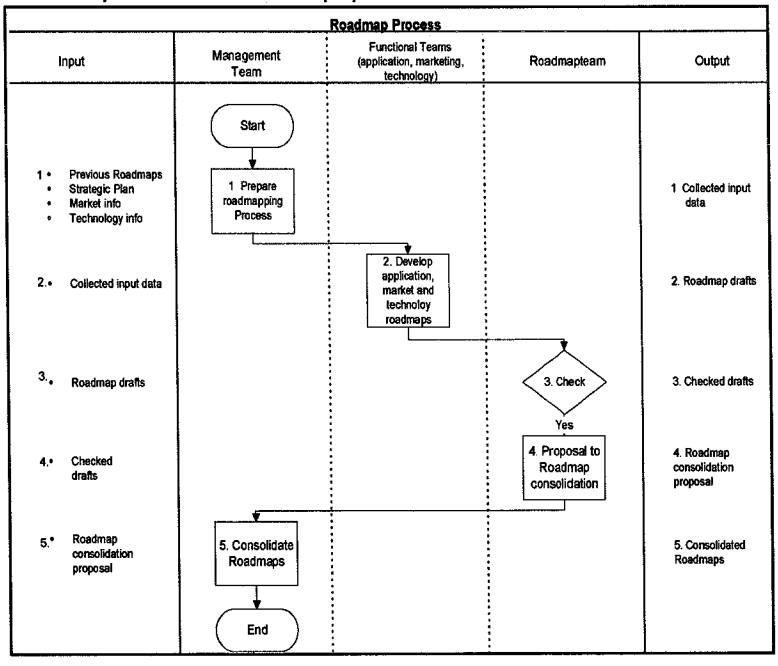


Figure 10: Global process flow of roadmap creation

The process of roadmap creation is shown at a very high level of aggregation in figure 10.

3. Advantages

Literature describes many advantages roadmapping can have for the organisation. The most important advantages from literature are listed here:

- One of the biggest advantages of technology roadmapping is that it provides information, which enables better decision making concerning investments [Kost01].
- An advantage of roadmapping is the improvement of the time-to-market and time-to-money which results in an improvement of the competitive position [Groen97].
- A good organised roadmap process enables better identifying, evaluating and selection of strategic alternatives [Kost01].
- One of the advantages of roadmapping is the creation of a connected approach for long term product and technology planning and the building of a vision [Groen97].
- An observed effect of not applying roadmapping is a late start of activities with a long lead-time. Roadmaps have the value of anticipation, which is especially important to projects with a long lead-time [CE01] [CE02] [Mul01].
- Besides the technology needed, properly aligned roadmaps enable early determination of skills and resources required, and the alignment with other projects [Kap01] [CE01].

4. Organisational aspects of interest

Besides advantages, literature appoints aspects that deserve special attention when the intention exists to set up a roadmap process. The most important organisational points of interest are:

- Technology roadmapping has to be driven by a need, not by a predefined solution [Gar98].
- An important aspect of the roadmapping technique is the multidiscipline, crossfunctional working. Teamwork, integral engagement to the organisation and good communication are characteristics of vital importance to the process [Kost01].
- Management has to be involved to the process [Kost01] [Mul01] [Groen97] [CE01] [CE02] [Mor00] [Gar98] [Phaal01b].
- Roadmap creation is a common effort of all stakeholders [CE01] [Mul01].
- Roadmaps need to be a guide for the organisation as a whole [Kost01].
- Roles of roadmap managers and teams have to be defined unambiguously and have to be common knowledge of all parties concerned [Kost01] [Mul01].
- Roadmaps need to have a sufficiently flexible structure to contain dynamic changes. They need to be revised on a regular basis [Kost01] [Mul01].
- Attention should be paid to the fact that roadmapping is not a 'black box' methodology. Each practice is a learning experience. A flexible approach, adapted to the specific circumstances has to be adopted [Phaal01a].
- Roadmapping needs to be integrated with other decision processes and tools within the organisation [Kost01].
- The standardisation of roadmaps is essential to create improved communication and better recognition of technology synergies [Groen97].
- Roadmaps per key driver are an explicit way to structure roadmaps [Mul01].
- Scope, borders, requirements and conditions need to be defined in advance [Mul01] [Groen97].
- Many relations exist between technology and application. These are not necessarily linear or unidirectional [Kost01].
- Necessarily, roadmapping is an iterative process [Kost01].
- Do not underestimate the amount of time and concentration required to continuously change the content and to optimise the use of roadmaps [Groen97].
- The timespan of a roadmap depends on the business cycle. When the innovation cycle is short, the timespan of a roadmap is also short. These two aspects are strongly related [CE01].
- At least twice a year new visions/ roadmap versions should be consolidated [Mul01].

- Factors that should be considered before roadmapping can be started [Phaal01b]:
  -Identification of the appropriate participants
  -Required resources and scheduling of workshops
  -Identification of available information
  -Definition of the unit of analysis
  -Clear articulation of company objectives for the process

5. Relation between roadmapping and the PCP

Developing a technology is a very time consuming process. Also, predicting this process is difficult [Burg01]. This is why a timely start of a technology project is important.
As is depicted in section 2.4 that describes the front-end phase of product development, the resource and the overall company situation need to be considered in the early phases of product development. To realise this, front end routes should be identified, visualised and communicated to the company community. Elements of a front-end route would include front-end activities, priorities, sequences and staffing. The decided routes are then to be communicated to top management, involved persons and to the interfacing or linked projects. To perform this process in the future, roadmaps are a very useful tool. They enable to determine the appropriate technologies, resources and processes needed to meet the market demand and to realise the market requirements.

The roadmap process is related to four main processes of the organisation. The context of these processes, their mutual relations and the role roadmaps play related to the main processes are shown in figure 11 [Mul01]. The Policy and Planning Process, in which the future policy and planning for the organisation are determined, establishes the framework in which the PCP operates. The People and Technology Management Process delivers the people, processes and technologies that enable the PCP. The customer-oriented process is the customer of the PCP [Mul01].

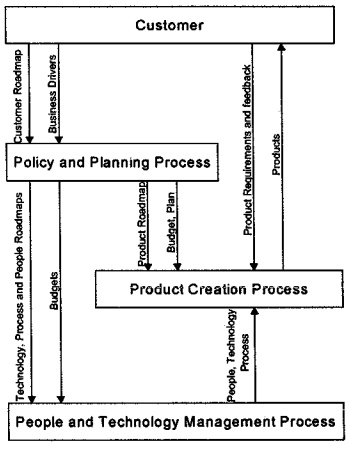


Figure 11: Context of the four main processes [Mul01]

Goals
With the help of an aligned roadmap process improvements in the predictability and the reliability of the Product Creation Process can be realised [Ce01].
This can be expressed in:

- Time to market, which can be shortened by the ability to respond to the market demand faster, by better predictions of the market demand and the project course and duration.
- The integral costs; by better predictability and reliability less projects have to be ended halfway, which saves a lot of money.
- Quality of products and processes; by roadmapping better communication and as a result more awareness and coordination arise [Kost01]. Also better recognition of technology synergies arises [Groen97], which helps in the better alignment of these technologies.
- Optimisation of effectivity and efficiency of product creation, by better communication and alignment of technologies, market, application, resources and processes.
- Adoption of shared terminology in product creation. This results in standardisation en communication improvement.

B. Roadmapping experiences

To gain insight in the field of roadmapping in practice, interviews have been conducted with roadmap experts within other divisions of Philips; the Centre for industrial Technology (CFT), the Natlab, and Consumer Electronics (CE). These experts also wrote articles and some of them give lectures about roadmapping. Goal of these interviews was learning from the experiences of experts, who already applied roadmapping activities in practice. This knowledge approximately provides the same value as professional literature for this research.

Relevant aspects in the field of roadmapping that were pointed out during these interviews are:

- A roadmap has to be alive!
- Roadmaps are a communication tool. They visualise, communicate and change things.
- To serve the total view a top-level roadmap has to be created that fits a single sheet of paper.
- Roadmapping is an iterative process.
- Many companies and business units do not have continuous roadmapping activities or do just have limited roadmapping activities. For example, they just have a product roadmap.
- Important aspects from the Strategic Plan need to be the basis and steering force of roadmaps.
- Someone involved and passionate has to be responsible for a roadmap. This role has to be determined for each roadmap separately.
- Limiting conditions of the organisation play an important role and have to be reviewed. These conditions depend on the market segment in which the organisation operates.
- All parties participating in the chain have to be involved in the roadmap process. Suppliers, customers and other parties contracted need to be included. This also concerns internal suppliers, like CIS and Hamburg!
- In the determination of key drivers an answer should be found to the question what the essence is of a certain key driver for the customer.
- In a roadmap, technologies have to be separated from key drivers, because technologies may also be renewed unrelated to the key drivers.
- Roadmaps do not have to be uniform. Every roadmap responsible has to feel connected to his/her roadmap and roadmap style, which results in better carrying out the roadmap to others.
- The timespan of a roadmap depends on the organisation. When the business cycle is short, the timespan of a roadmap should also be short.
- The timespan for the market roadmap may be larger, because the market is more predictable in time than the technology.
- Performance indicators may differ for the different market segments Cardiac, Vascular and Neurology.
- The fast disposal of a tool is not important. Often a tool works adverse in view of the commitment of the person responsible and the spread to other parts of the organisation, because the roadmap has to be adjusted to the tool.
- Besides application, also marketing people need to be involved in the roadmap teams. Application tends to look to the customer requirements too much, because they have contact with the customer daily. Marketing should be able to think more customer independent.

Appendix 6 Description of the current C/V roadmap process according to the user's manual

The current process structure is described in the C/V user's manual, in the chapter considering the business processes [handboek_C/V99].

The process gets started by input to the C/V Product Teams. These are the Cardiac Product Team (CPT) and the Vascular Product Team (VPT). They get miscellaneous input from the subsystem and system characteristic teams. Based on this information the Product Teams analyse their market segment and draw a Product Policy. This policy includes an analysis of the market and clinical trends.
From this Product Policy and the supplier roadmaps, a Concept Product Roadmap is derived, which indicates the required availability of future products, the current products and products from committed projects.

Because of budget constraints, capacity limitations and marketing consistency, the roadmaps need to be aligned. This is done by the Roadmapteam, and results in the aligned C/V product roadmap. This internal C/V product roadmap is reviewed and approved by the C/V Management Team (MT).

To start a project, the relevant product team presents a project proposal to the Roadmapteam, with accompanying Concept Project Brief.
Next, the PTCM checks the business case of the Project Brief, and when the Roadmapteam and the PTCM have accepted the proposal, the time is right and the resources are available, a Concept and Feasibility (C&F) Study is started by the PTCM. Based on the results of this study and the approved C/V Project Brief, the project can be started.

The structure of this process is shown in figure 12.

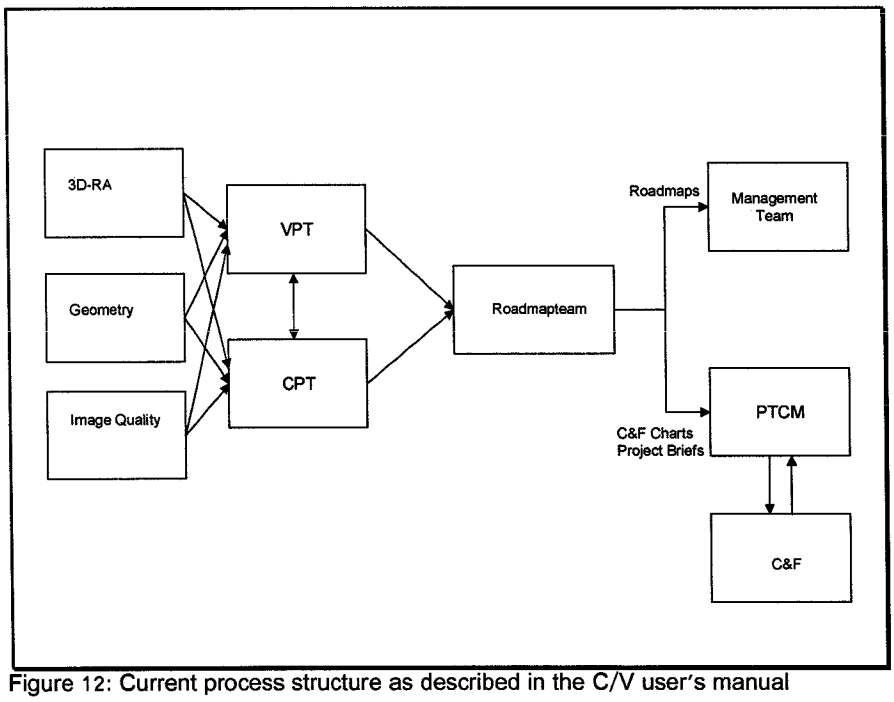
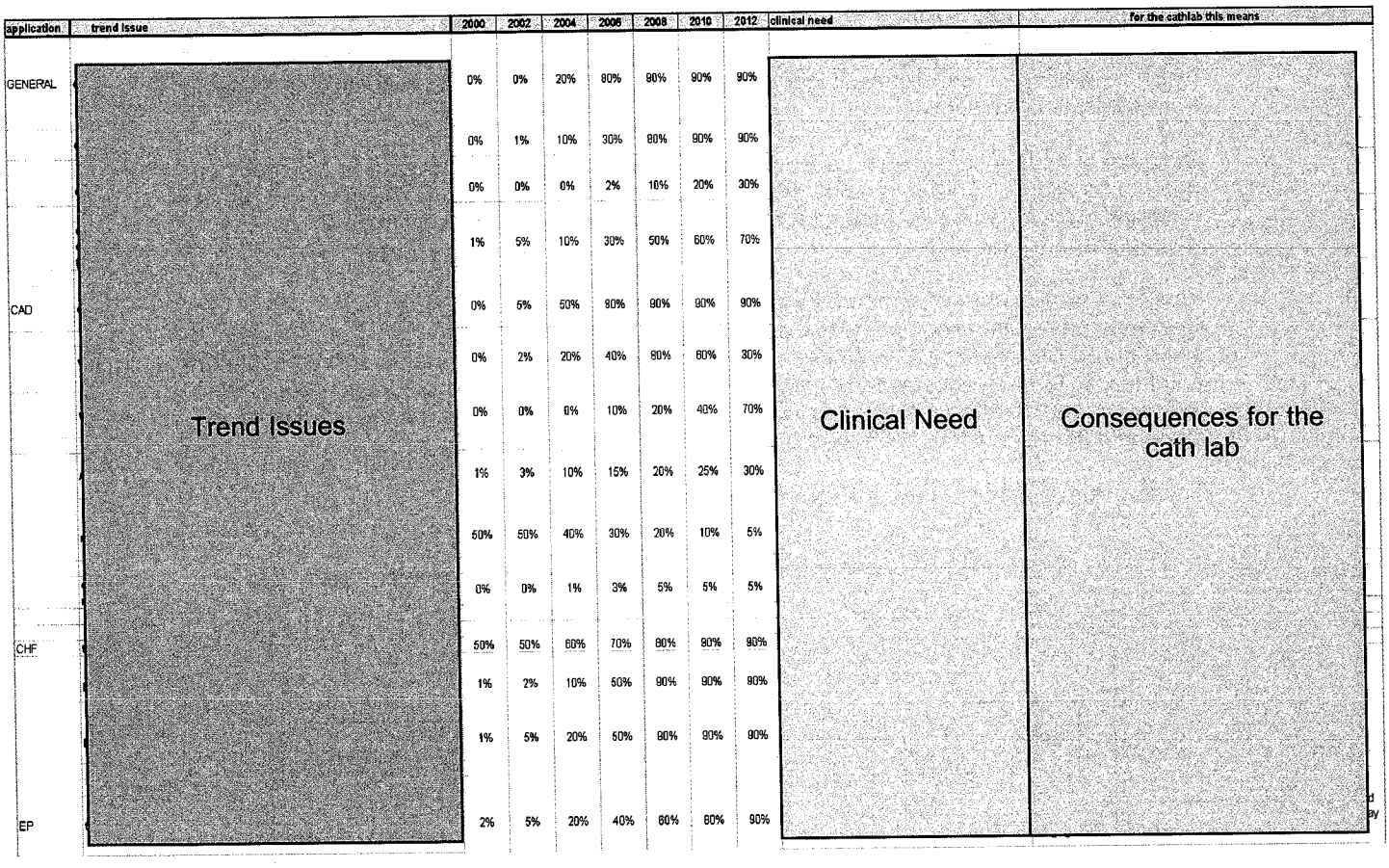
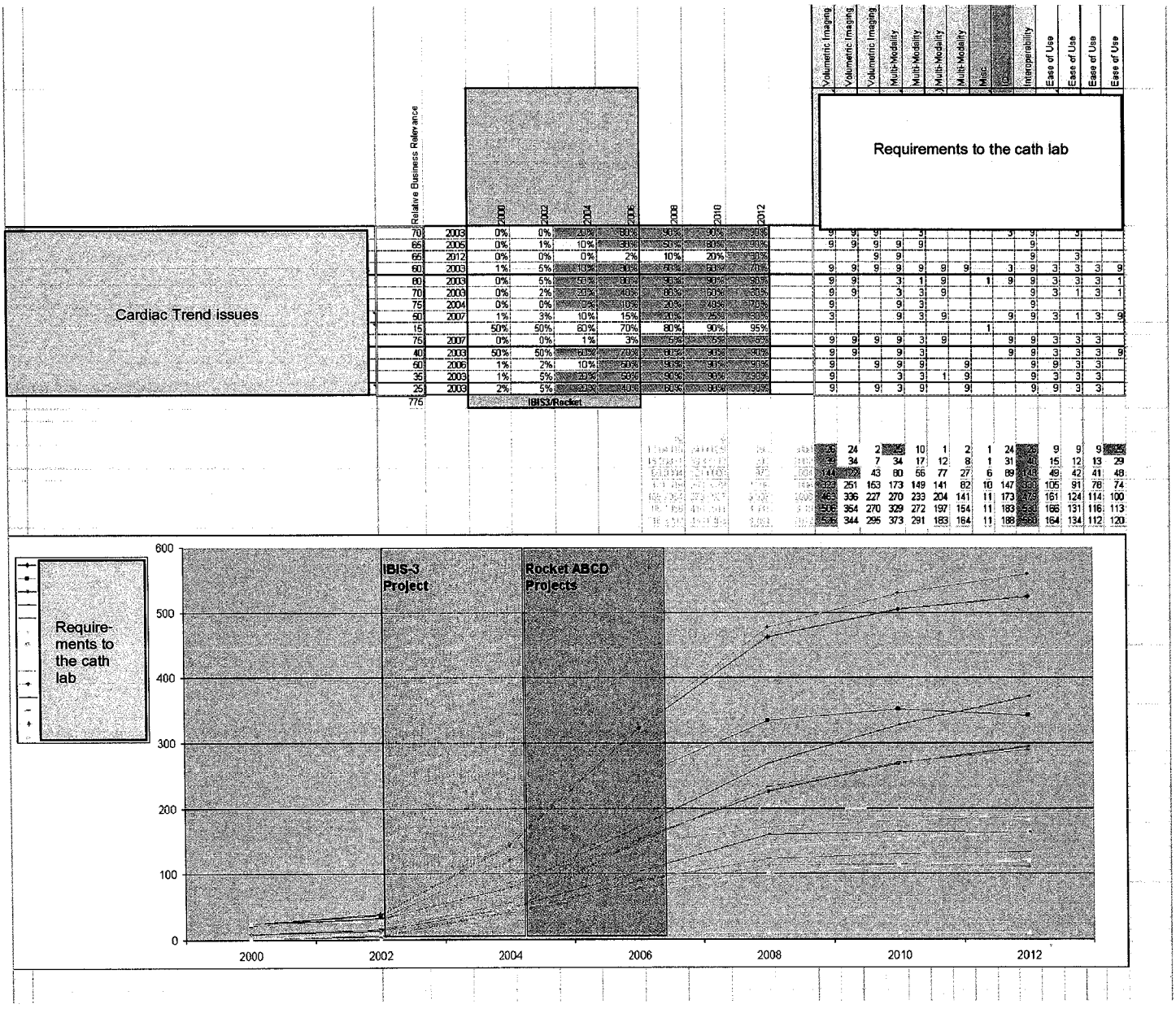


Figure 12: Current process structure as described in the C/V user's manual

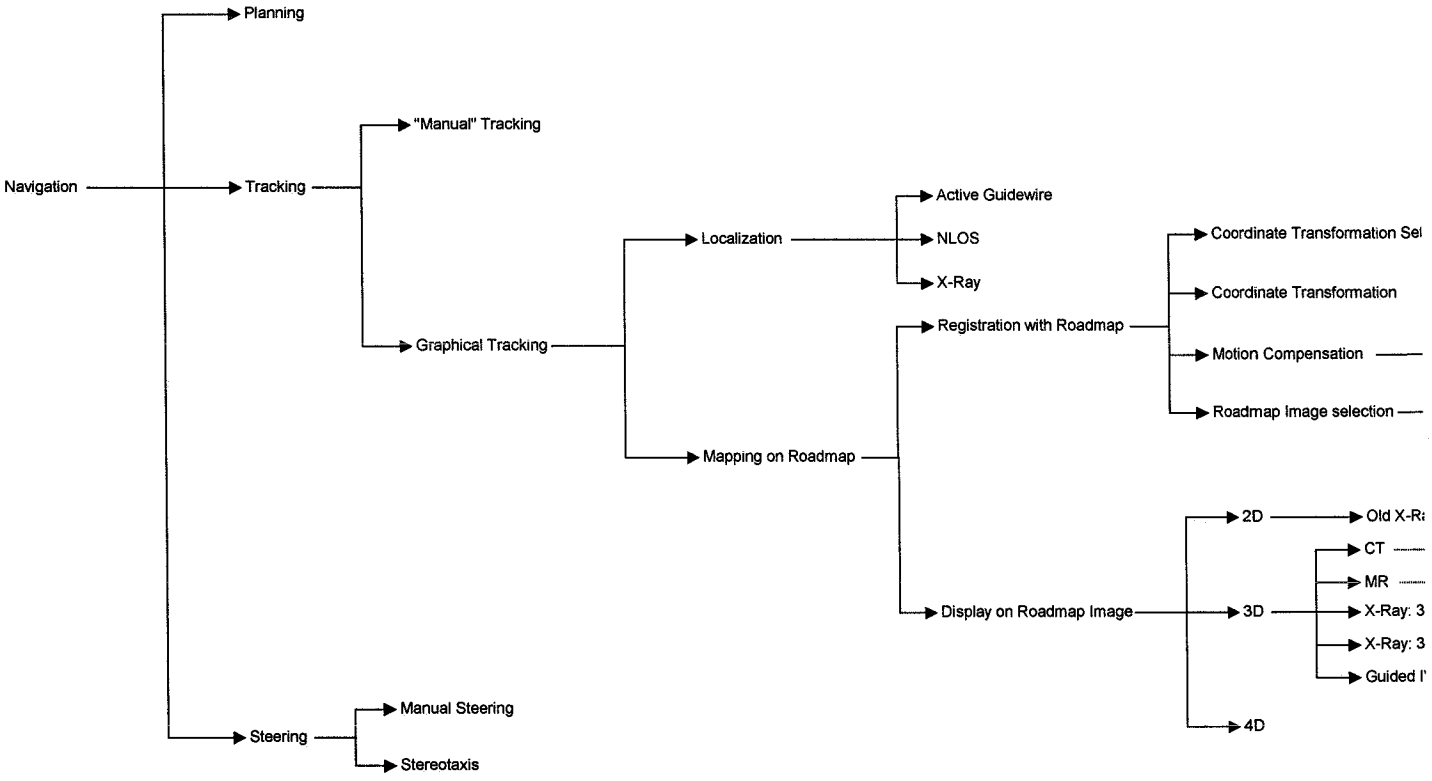
Appendix 7 Trendmap example: the cardiac application Trendmap

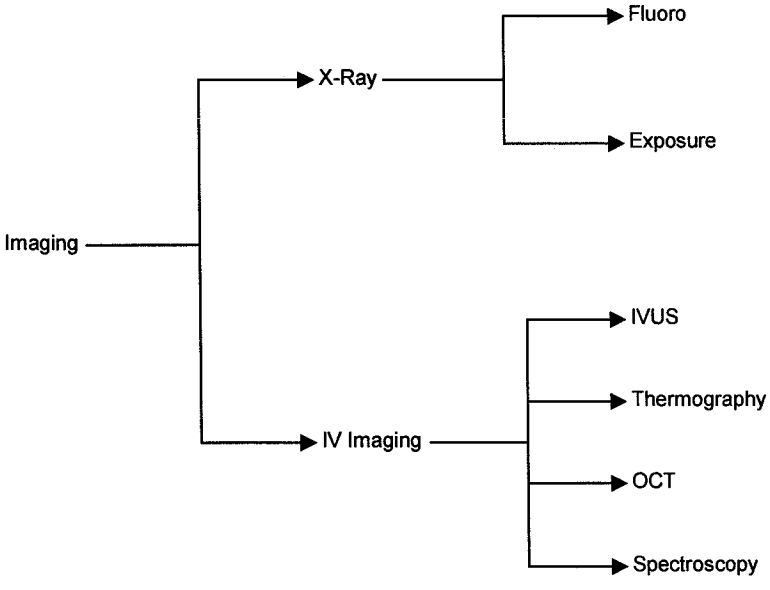


Appendix 8 The results of the cardiac workshops



Appendix 9 Technology Trees





Appendix 10 Tasks and responsibilities of teams in the roadmap process

MT (Management Team)

- Consolidation of roadmaps submitted by the RMT.
- Brainstorm about vision, which results in (adaptations to) the Mission and Vision of CV. This is done once a year, chaired by the PMG-director.
- Business strategy and planning.
- Taking care of the disposal of the Strategic Plan to the necessary teams.
- Decision making about problems and possibilities.
- Initiation and managing of C/V improvement programs.

RMT (RoadMap Team):

- Prioritising trends from the trendmaps, after the preparation of the trends by the Product Teams. If these differ from trends prioritised by the View-teams, (dis)approving these trends.
- Acceptation of Roadmaps per View.
- Checking of roadmap implications per discipline to the Strategic Plan and the Staffing Plan.
- Do the proposal to roadmap consolidation and submit roadmaps for consolidation to MT.

Product Teams:

- Preparing priorities per market segment of trends in the Trendmap.

Functional Teams:

- Determining customer needs and analysing market, clinical and technology trends within the functional domains and mutual communication and information exchange concerning these trends.
- Developing trendmaps timely.
- Developing roadmap implications per discipline, based on accepted View-roadmaps.
- Final responsibility of the roadmaps per discipline.

Besides these common tasks and responsibilities, the different functional teams have their own tasks and responsibilities:

Application Team:

- Appointing responsibilities within the application department concerning the roadmap process.

Market Team:

- Managing the Product Teams and appointment of responsibilities within the marketing department concerning the roadmap process.

Technology Team:

- Managing and starting up View-teams
- Appointing responsibilities within the application department concerning the roadmap process.

View-Team

- Prioritise trends from trendmaps and compare them to prioritised trends by the roadmapteam. If these are aberrant, asking for approval to involve these trends.
- Combining all existing knowledge to develop roadmaps per View.
- Arranging the necessary contacts, inside and outside of C/V.

Person responisble for the View

- Final responsibility of the View-roadmap.
- Exchanging information and roadmaps to functional teams.