Keeping on track!

A study of disturbance factors within Sensata Global New Product Development projects, by using the World Cafe method

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v. 1.0
August 24, 2015

Sensata Technologies

UNIVERSITY OF TWENTE.

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Contents

Page

List of Figures vii

List of Tables ix

List of Abbreviations xi

1 Sensata's current situation and challenges for Global New Product Development 1

1.1 Day to day business at Sensata, developing sensors and controls for the automotive industry by New Product Development Projects 1

1.2 Deviating from the project budget, how can this be solved? 3

2 Setting up the study: Structure and approach 7

2.1 Relating the deviation from the project forecast to disturbance factors by using a conceptual model 7

2.2 Identify the causes resulting in the deviation from the project budget within Sensata and investigate possible soltuions based on the studied literature 9

2.3 Finding deviation factors by interviewing project managers and generating solutions with a World Cafe 10

3 Getting it wrong by doing it right; an overview of New Product Development literature 13

3.1 New Product Development as driver for organizational growth, understanding its problems by learning from the past 13

3.2 The importance of NPD; Using best practices and finding success factors to become the best 20

3.3 The difference between success and fail factors, the importance of preventing failure . . . 22
3.4 Preventing glitches in cross-functional teams by organizational integration and shared knowledge . . . 27
3.5 Combining the literature in a theoretical framework to discuss relations and solutions . . . 29

4 Investigating the current situation at Sensata 33
4.1 Reviewing the issues at hand by analyzing financial reports of the projects 33
4.2 The deviations of the project are made insightful by comparing them in a table . . . 34
4.3 An average deviation of -39.6 per cent and a maximum of 150.3 per cent 36
4.4 Interviewing the Project Managers to find deviations based on the financial reports . . . 36
4.5 Twentythree unique Deviation Factors grouped according to Actuals, Budget and Construction . . . 37
4.6 Comparing the found deviation factors with the literature, being to specific or general. . . . 43

5 Using the World Cafe to bring together stakeholders to get usable results for practice and science 47
5.1 Prioritize the deviation factors and generating solutions by using the World Cafe method . . . 47
5.2 The results of the NPD Café: deviation factors and their solutions . . . 49
5.3 Solving practical problems by linking the practical solutions to the theoretical solutions . . . 53

6 Limitation, recommendations and conclusions 57
6.1 Limitations as a result of organizational specific findings and missing data 57
6.2 Recommendations for Sensata based on practical problems and theoretical solutions . . . 58
6.3 summarizing the study approach and answering the research goal . . . 59

Bibliography 61

Appendix A. Interview Guide A.1
1 Dutch version . . . A.1

2 English version A.2

Appendix B. World Cafe **B.1**

1 Table host instructions B.1

2 table cloths B.3

Appendix C. Tool **C.1**

1 Tool construction C.1

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List of Figures

1.1 The structure of project teams. 2
1.2 The GNPD process. 4

2.1 The research model. 7
2.2 The global conceptual model with dimensions and variables. 8
2.3 The specific conceptual model. 9
2.4 The complete specific conceptual model. 10

3.1 Ansoff's Matrix 15
3.2 New Product Development strategies Matrix 16
3.3 Tree swing cartoon by S. Høgh 18
3.4 Schematic overview of the theoretical framework 32

4.1 Deviation Factor mind map, constructed with XMind 2013. Data as collected from the interviews, some DFs in Dutch. 39
4.2 Graph displaying the Deviation Factors and their occurrence, constructed in Excel 2013 41

5.1 The amount of stickers are called the priority rating, in this graph they are grouped by theme and sorted from high to low. 51
5.2 Deviation Factors with # mentioned and priority rating expressed in % of total. 53

B-1 The tablecloth of the Actuals table. B.3
B-2 The tablecloth of the Budget table. B.4
B-3 The tablecloth of the Construction table. B.5
C-1 Imput field of the ABC-Top Tool C.2
C-2 Overview graph of the ABC-Top Tool C.3

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List of Tables

1.1 Determining the scope of a project, criteria for A or B-list projects. . . . 3

3.1 Classification of newness, based on Booz et al. 1982 17
3.2 Success rates of products introduced in the last five years, the best vs. the rest. Barczak et al. (2009) and Markham and Lee (2013) 20
3.3 How to ensure a project's failure. Pinto and Kharbanda (1996) 23
3.4 Percentage of failed projects per failure factor from Cerpa and Verner (2009) 26

4.1 Deviation from budget, TOP projects. 35
4.2 Deviation from budget, before and after omitting incomplete months. *=after correction 42

5.1 Results from the NPD Café 52

C-1 How to ensure a project's failure C.2

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List of Abbreviations

GNPD Global New Product Development.

DE Design Engineer(ing)

PMT Product Management Team.

PM Project Manager.

ASIC Application Specific Integrated Circuit.

ISO International Organization for Standardization.

M&A Merger & Acquisition.

GNDP Global New Product Development.

NPV Net Present Value.

UB Universiteits Bibliotheek Twente = University Library Twente.

DFM Design For Manufacturing.

TTM Time To Market.

GPD Global Product Development.

PDMA Product Development and Management Association.

DF Deviation Factor.

COE Centre of Excellence.

RP Request for Purchase.

NPI Net Product Investment.

KPI Key Performance Indicator.

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1 Sensata's current situation and challenges for Global New Product Development

1.1 Day to day business at Sensata, developing sensors and controls for the automotive industry by New Product Development Projects

SENSATA Technologies is a public traded, American owned organization. It originated as the sensors and control division of Texas Instruments, until it was bought by Bain Capital in 2006. Since then it became an independent organization under the name Sensata Technologies. Sensata has multiple offices and production facilities around the world and employs over 17.000 people worldwide. This study takes place at Sensata Technologies Holland B.V. located in Almelo. This location operates as a business center for Europe that focuses on the sales and development of sensors. Over 600 people are working here on the development and sales of sensors. Sensata Almelo features a facility for testing and producing small batches, but in general finished products will be produced at specialized factories in low income countries.

Sensata's primary activities are development and manufacturing of sensors and controls. Their biggest customers are automotive manufactures for which specific products are developed through projects. These projects are divided into two categories; change and new. Change projects consist of changes to existing products, this is either customer driven or results from a change to the production method to reduce costs or following legislation. These projects are mostly handled by the Product Management Team (PMT). New projects are covered by the Design Engineering (DE) department and coordinated by a Project Manager (PM). The DE department is grouped based on a core technology, these groups are parallel to each other and set-up vertically in the organization. Because

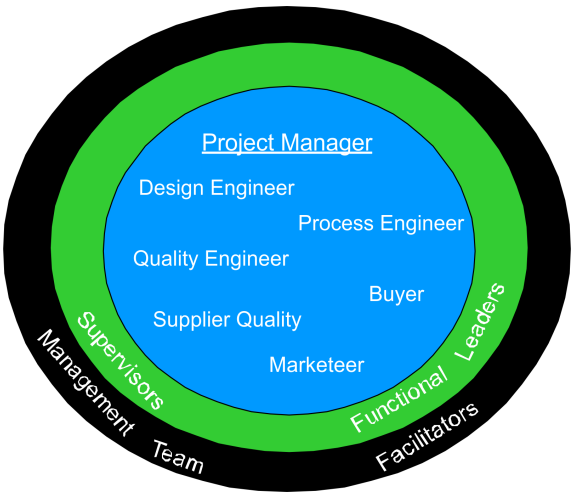

Figure 1.1: The structure of project teams.

projects often require various specialized knowledge, multi-disciplinary teams are put together. These teams are setup across the organization and have a more horizontal setup. In figure 1.1 the structure of a GNPD team is shown. The inner circle represents the actual project team consisting of various team members and lead by a PM. The middle circle represents the supervisors that act as functional leaders, guarding the progress and outcome of the project. The outer circle represents the management team that acts as a facilitator. They provide the necessary resources for a project. They also decide if a project is accepted or not; do the costs weigh up to the potential gains and risk.

Depending on the scope of the project a distinction is made between A-list and B-list projects. Generally A-lists are the bigger, more important projects, while B-list projects are often derivatives. When a project meets one of the criteria in table 1.1, it is considered an A-list project.

To get from business closure to production start, projects within Sensata are executed using their Global New Product Development (GNPD) method. This method is used by the project teams to structure and streamline the development process. The GNPD process consists of five phases and five milestones, see figure 1.2. Although each phase is closed with an exit review, the process is not sequential but has an overlapping structure. In the concept phase the feasibility is established with a “business plan”, this plan consists a financial forecast and a schedule. During the exit reviews the current progress is compared to the initial estimations. Deviations need to be explained and actions have to be taken to get back on track. In exceptional cases the goals had to be adjusted or projects abandoned. However in the situation that a project is customer driven, there are

	Criteria:
(a)	Is there a technical risk? (non-derivative or derivative product)
(b)	Is a new core sensing technology used?
(c)	Is a new Application-Specific Integrated Circuit (ASIC) used?
(d)	Is the net revenue impact >$xxx (confidential)?
(e)	Is the new product or technology of strategic importance?
(f)	Is the customer new or of strategical importance? (guidance: Top 20 revenue customer by region)
(g)	Is the capital budget >$xxx (confidential)?
(h)	Is the product used in a safety application? (guidance: Severity 9 or 10)
(i)	Is ISO 26262 (Functional safety standards road vehicles) required in the program?
(j)	Is the project based on a acquired product? (Merger & Acquisition)
(k)	Does the project involve a significant warranty or liability risk
(l)	Management decision

Table 1.1: Determining the scope of a project, criteria for A or B-list projects.

predetermined specifications that have to be met. In practice this results in very little leeway regarding product specifications and delivery time, meaning that when a project is running behind on schedule or there are difficulty in meeting the specifications more resources are allocated to the project. During the duration of the project the project is tracked by using the GNPD checklist. This tool is developed based on best practices learned from succesful projects and the incorporates standards from the automotive industry, it serves as guideline and helps in preventing common mistakes.

1.2 Deviating from the project budget, how can this be solved?

In the automotive industry it is common practice that a contract can be won by placing a bid on it. This means that the manufacturer that requires certain parts states the required specifications and deadlines. Suppliers can then place a bid on this, offering to supply/produce/develop the product for a certain price.

As a supplier Sensata analyses these business opportunities and evaluates if it is a profitable project. Important is that a competitive price can be offered while still maintaining a reasonable profit margin. If such a contract is won, this results in a new project. Although every project is carefully scheduled and financially forecasted,

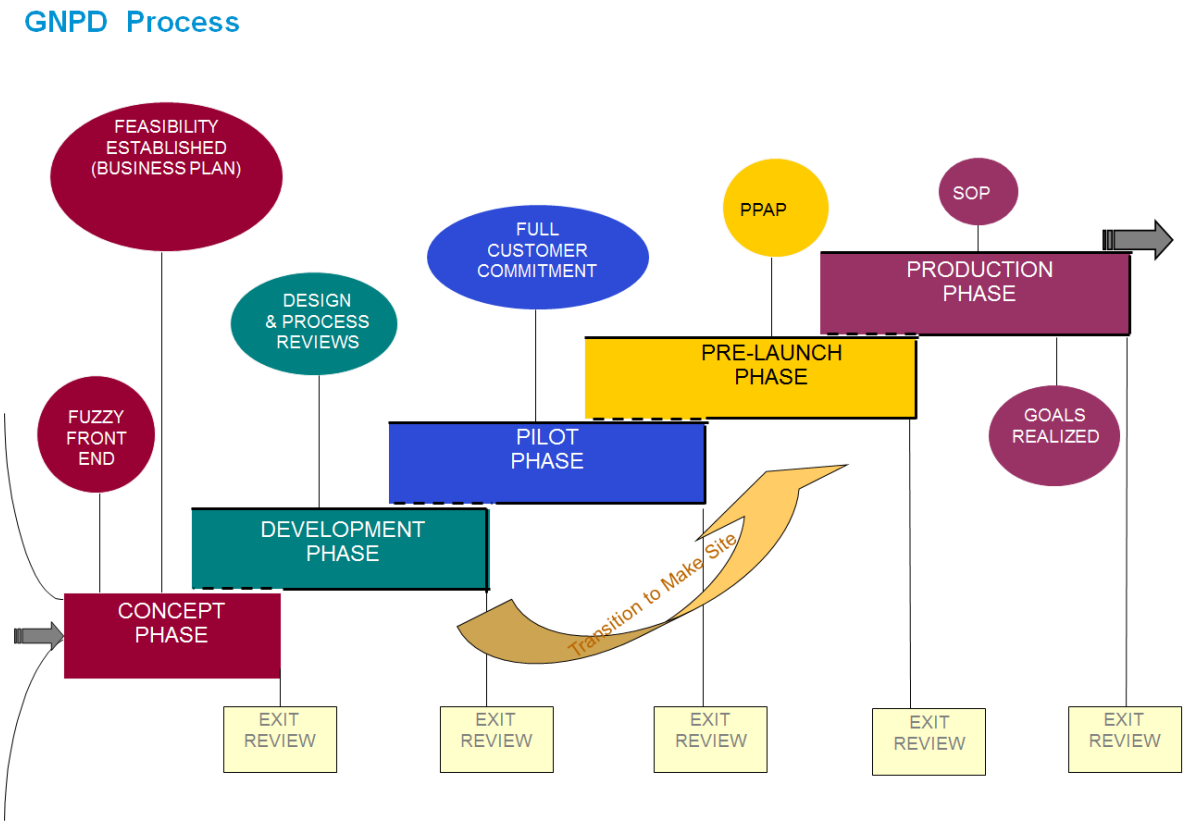

Figure 1.2: The GNPD process.

deviations from the original budget are all to common. Not only exceeding the budget, but also falling below it, happens. In some cases deviations up to 50% occur. While not meeting the budget seems not as bad as exceeding it, both cause an incorrect allocation of resources. An incorrect allocation of resources may, for example, result in projects not getting enough engineering capacity or lab-time resulting in a high workload and cutting corners. This influence the capacity of Sensata to successfully complete as many, profitable, projects as possible.

This is the problem that lies at the basis for this study. The goal is to identify the causes resulting in the deviation from the project budget within Sensata and investigate possible solution based on the studied literature.

Now the existing situation and problems have been described and a research goal is formulated it is important to elaborate this into more specific research questions. This will be structurally done in the following chapter according to the method described by

Verschuren and Doorewaard (2007). Together the answers of the research questions will help finding an answer to the research goal.

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2 Setting up the study: Structure and approach

2.1 Relating the deviation from the project forecast to disturbance factors by using a conceptual model

The structure of this study is developed based on the method described by Verschuren and Doorewaard (2007); a research model is constructed based on the research goal, followed by a conceptual model. The research model shows in a general way which steps will be taken in the study and which information sources are used. The research model as can be seen in figure 2.1 was constructed for this study.

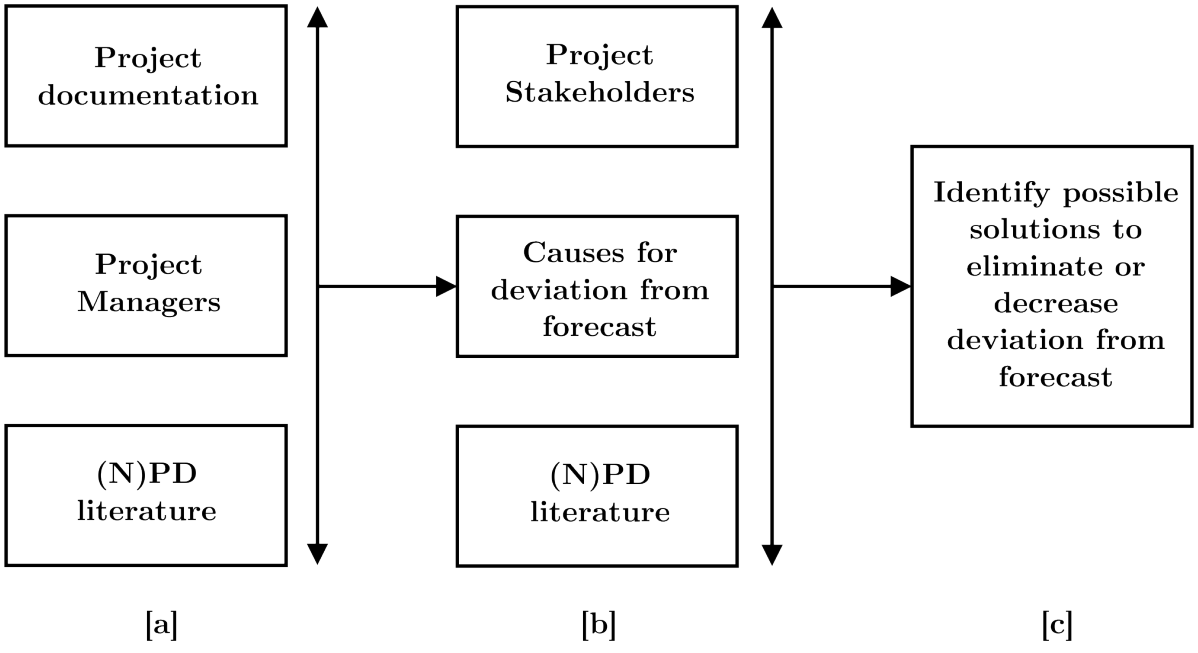

Figure 2.1: The research model.

This study is of a diagnostic nature and to make clear which concepts are studied and which dimensions and variables are known or unknown a global conceptual model (figure 2.2) is produced. A global conceptual model is the first step in making schematically clear what the relevant dimensions and variables are and how they relate to each other. The independent variable is "disturbance factors", these yet unknown variables are all the factors that disturb the project as it was planned. The dependent variable is "forecast deviations" with the dimensions *cost*, *time* and *quality*. The reason these dimensions are chosen is because this "iron triangle" it still the most used criteria to assess project success or failure.[1]

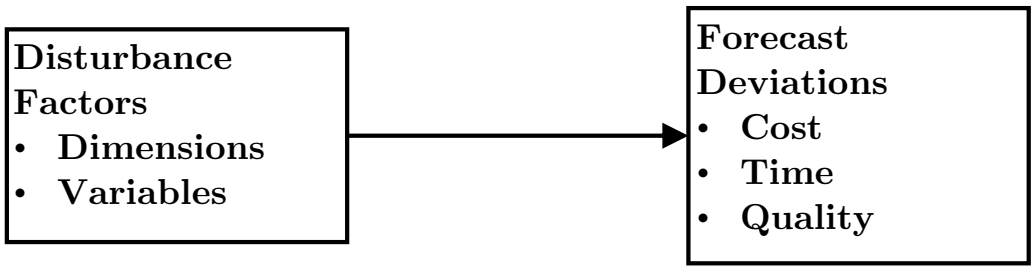

Figure 2.2: The global conceptual model with dimensions and variables.

Atkinson goes to great lengths to discuss why other criteria could be better and while he certainly has a valid point, in this case, cost, quality and time are the obvious criteria to choose. This is because Sensata already works with these criteria and has records of them. Based on the specifications and quality the customer wants a forecast is made regarding the cost and time evolved. The quality and time parameters are thoroughly specified by the customer at the beginning of a project. Not meeting the requirements will result in huge fines and charges because of malfunctioning products or product lines that are put on hold. The result of this is, that when it is looking that a project will not make its schedule or the quality is lacking, additional resources are made available to get the project back on track. The bottom line of this is that cost is the single most important dimension to track the project, as deviations regarding the time or quality dimension all lead to extra costs, either because the set requirements regarding time or quality are exceeded or extra effort is expended to not exceed them. With this conclusion the step to a specific conceptual model can be made (figure 2.3).

[1]See Atkinson 1999, pp. 337-338.

Figure 2.3 does not yet describe the whole problem, following from the problem description an interacting variable is suspected. The scope of a project and its subsequent classification as an A-list or B-list project may well be an influence on the relationship between disturbance factors and forecast deviation. Because A-list projects require more checks and thus get more attention it is hypothesized that in general A-list projects deviate less from the forecast than B-list projects. One more attribute needs to be included and that is the direction of the relation between the independent and dependent variable. As one may expect the relation between disturbance factors and deviation from forecast is positive; More or higher disturbances result in a larger deviation from the initial forecast. This leads to the final conceptual model (figure 2.4) were XYZ represent the different unknown disturbance factors.

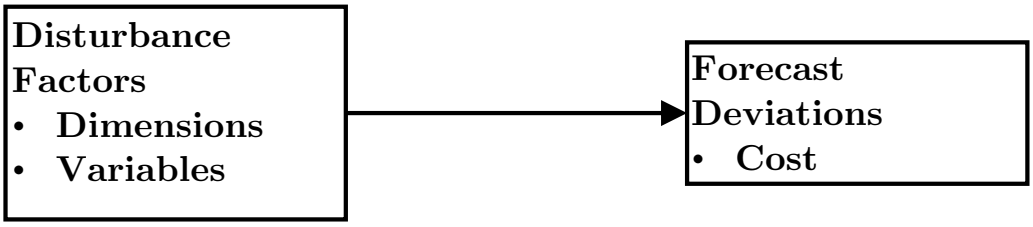

Figure 2.3: The specific conceptual model.

2.2 Identify the causes resulting in the deviation from the project budget within Sensata and investigate possible soltuions based on the studied literature

Now the external goal and structure of the study are clear, the internal goal or research questions can be defined. Based on the goal and elaboration of the conceptual model the following Research Questions are defined:

RQ1: What is the current deviation from the budget?

RQ2: Which deviation factors are relevant in the projects?

RQ3: What are possible solutions to reduce or eliminate deviations?

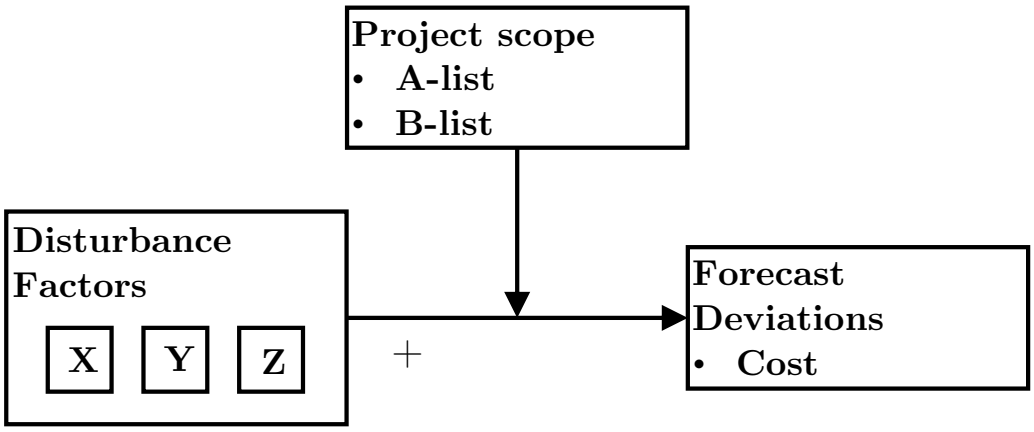

Figure 2.4: The complete specific conceptual model.

The first question RQ1 is used to asses the current situation. This is necessary because there are deviations up 50% of the budget. It is however not clear if this is a single exceptional case or that most projects fall in this range. To answer RQ2 it is necessary to identify which deviation factors play a role at Sensata. The results of RQ1 will be used to identify when and where deviations occur. Depending on the results of RQ2, possible solutions will be generated to reduce or eliminate deviations and answer RQ3

2.3 Finding deviation factors by interviewing project managers and generating solutions with a World Cafe

Now the research model and conceptual model are clear it is necessary to outline how the study will be conducted in order to obtain the necessary data for answering the research questions. The three research questions each require a different approach, but they do build on each other; The results for RQ 1 are the starting point for the results for RQ 2 and these results are then used as a starting point for RQ 3.

The subject of this study are the TOP-projects, these projects are chosen by Sensata out of all the running projects. These TOP-projects are tracked in more detail then

regular projects in an effort to make the deviations insightful. At the beginning of this study nine TOP-projects were in progress, they were all still running and spread through the GNDP process phases (figure 1.2). To get as much data as possible all nine TOP-projects were included in the study.

The study is set up in two parts; The first part is about mapping the current situation and answering RQ 1: What is the current deviation from the budget? and RQ 2: Which deviation factors are relevant in the projects? It revolves about integrating the information collected from the project documentation, project managers and NPD literature, as can be seen in phase [a] from the research model (figure 2.1) This is done in chapter 4. The second part of this study is about RQ 3: What are possible solutions to reduce or eliminate deviations? To find possible solutions the found disturbance factors are taken up with the project Stakeholders to find relevant solutions which are then analyzed based on the NPD literature, as can be seen in phase [b] from the research model (figure 2.1). This is discussed in chapter 5.

To start off and find an answer to RQ 1 the project documentation will be analyzed to get an overview of the current situation and detect any notable deviations in a project. The project documentation is the explicit or "written" information that is available on the projects, it consists of the financial reports of the project that is made up of an excel workbook with multiple sheets that track the monthly financial progress in comparison to the forecast. The data of the different projects were collected and put together in an excel file to get an overview of how the projects compare to each other. In chapter 4 this is discussed in more detail.

The results of RQ 1 are then used as starting point for RQ 2. These results are discussed with the PM of each project so they can fill in or explain the deviations found in the project documentation. This is done during a semi structured interview, because semi interviews provide much and rich information and offer the possibility to go more in-depth on certain topics if necessary[2] while standardizing the meaning of the input.[3] This results in a list with causes for deviation from forecast which will be compared with the found deviations in the literature. This is further discussed in chapter 4.

To answer RQ 3 solutions to the deviation factors of RQ 2 need to be found. The possible solutions found in the literate will be discussed along with possible solutions that ore suggested from Sensata. To generate solutions from Sensata a World Café is organized. The World Café is a very flexible and time-efficient method that can be

[2]Creswell 2003, p. 17; and Bernard 1988, p. 117.
[3]Barriball and While 1994, pp. 332-334.

adapted to various situations and needs.[4] The World Café method is gaining popularity and has found application in diverse settings. It is being used to bring together diverse stakeholders[5] and create conversations in the work environment,[6] all while ensuring a high level of academic rigor and generating relevant findings for both academics and practitioners.[7] Further elaboration regarding the World Café method and application is discussed in chapter 5.

Finally in chapter 6 the answers to the research questions are combined to answer the research goal while discussing the recommendations and limitations.

[4]Brown and Isaacs 2005, pp. 15-16.
[5]Steier et al. 2008, pp. 167-180; and Tan and Brown 2005, p. 83.
[6]Hess et al. 2006, p. 132.
[7]Schiele et al. 2014, p. 17.

3 Getting it wrong by doing it right; an overview of New Product Development literature

3.1 New Product Development as driver for organizational growth, understanding its problems by learning from the past

This chapter gives an overview of the literature used in this study. It starts with a general description of what New Product Development is, the development of NPD through history and why it is important for organizations to be good at it. This information is important to be able to put NPD and its problems in the right perspective. This is followed by the discussion why failing at NPD is not simply the reversed of being good at it. Several reasons for failing, or fail factors, are being discussed with some special attention being given to glitches. This information is of importance for RQ2: Which deviation factors are relevant in the projects? The final section of the chapter integrates the theory discussed and gives an overview of the theoretical framework used and discusses the possible solutions the theory offers to remedy project failure. This is used to evaluate possible solutions in the discussion of RQ3: What are possible solutions to reduce or eliminate deviations?

To develop a relevant and recent overview of literature regarding disturbances in projects a first search was conducted using the popular Scopus and Web of Science databases. The main keywords used were project, disturbance and/or deviation and/or fail. Additional filters were used to select highly cited articles as a starting point. This resulted in a few works on the topic of NPD that helped to get a good basic understanding of the topic and provided starting grounds to further explore the literature in search of relevant articles. After some inital exploration of the research field it was found that the

problems that Sensata struggles with are common in NPD projects. Because of this the NPD research field was chosen as focus for the literature study. The next step was to look for "highly" cited, recent review articles to get an overview of the current situation of the research field. Again Scopus and Web of Science were used as a starting point to find the most cited review articles in the last five years that match the criteria "New Product Development" disturbance and/or deviation and/or fail. Additional literature was found by searching among the backward and forward citations of the found review articles.

New Product Development can be defined as the transformation of a market opportunity into a product available for sale.[8] It is important because it is a source of growth[9] for organization and over 25% of sales is generated by products of five years or newer.[10]

To understand current approach of NPD and its problems it is important to understand how the current practices are come to be and on which foundation they are based. To understand this, the history of NPD is discussed along with the problems that are overcome. When looking for solutions to existing problems it is important to not recreate old problems.

Research into NPD goes back about 40 years, interest in this topic has been growing ever since. Getting an overview of NPD literature can be considered a daunting task, the field is broad and fragmented and even review articles that try to tie this together are forced to focus on a certain stream or a confined group of models.[11] This uncoordinated proliferation of articles results in an unclear field where a lot of exploratory research takes place, while the field would benefit from more in depth studies.[12]

The actual development of new products is the process of transforming business opportunities into tangible products.[13] The main driver in this process is growth, either by expanding the product or market scope. This results in two dimensions: First is the newness of the product or technology and second is newness of the market. These two dimension are often expanded into a matrix. Two well known examples are the matrices of Ansoff and Johnson and Jones.[14] Ansoff's Matrix (figure 3.1) consists of four quadrants containing strategies for market growth, depending on the newness of the market and products. The Market penetration strategy is aimed at the opportunities that exist

[8]Krishnan and Ulrich 2001.
[9]Shenglan 2010, p.605.
[10]Takeuchi and Nonaka 1986, p. 137; and Barczak et al. 2009, p. 6.
[11]Brown and Eisenhardt 1995, p. 344; Ernst 2002, p. 2; and Montoya-Weiss and Calantone 1994, p. 397.
[12]Brown and Eisenhardt 1995, pp. 343-378.
[13]Trott 2012, p. 418.
[14]Ansoff 1965, p. 81; and Johnson and Jones 1957, pp. 50-53.

for the current product in the current market in order to increase market share. The Market development strategy is appropriate when existing products are introduced in new markets, for example new market segments or other geographical markets. The product development strategy and diversification strategy are relevant when new products are introduced in current markets or new markets. Respectively these strategies result in NPD and either aim to introduce a new or improved product in the existing market or introduce a new product in a market that is new for the business. When a business develops a new product this does not mean that is has to be completely new or different from existing products, many companies try to utilize their existing technical and/or commercial knowledge base, this is one of the reasons that sometimes it is difficult to establish if a product is new or improved.

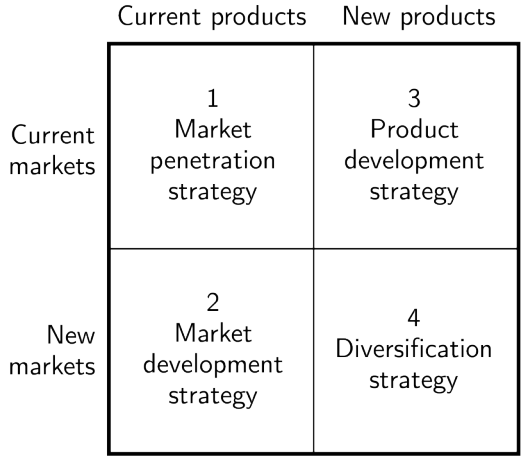

Figure 3.1: Ansoff's Matrix

A development of Ansoff's matrix is Johnsen and Jones's matrix for product development strategies (figure 3.2). The product variable in this matrix is replaced by technology and the matrix is expanded to sixteen sections. This matrix offers further clarification of the options available to businesses for product development. Interesting is that the use of technology as a variable better illustrates some considerations a business needs to make; for example the possibility of acquiring new technology or improving existing.

A commonly accepted categorization of NPD is developed by Booz, Allen & Hamilton[15] (table 3.1). This differentiation can also be seen within Sensata when looking at the difference between A and B-list projects. Among others technology and market newness are translated into the criteria (table 1.1) used to categories a project. An important

[15]See Booz et al. 1982, pp. 6-8.

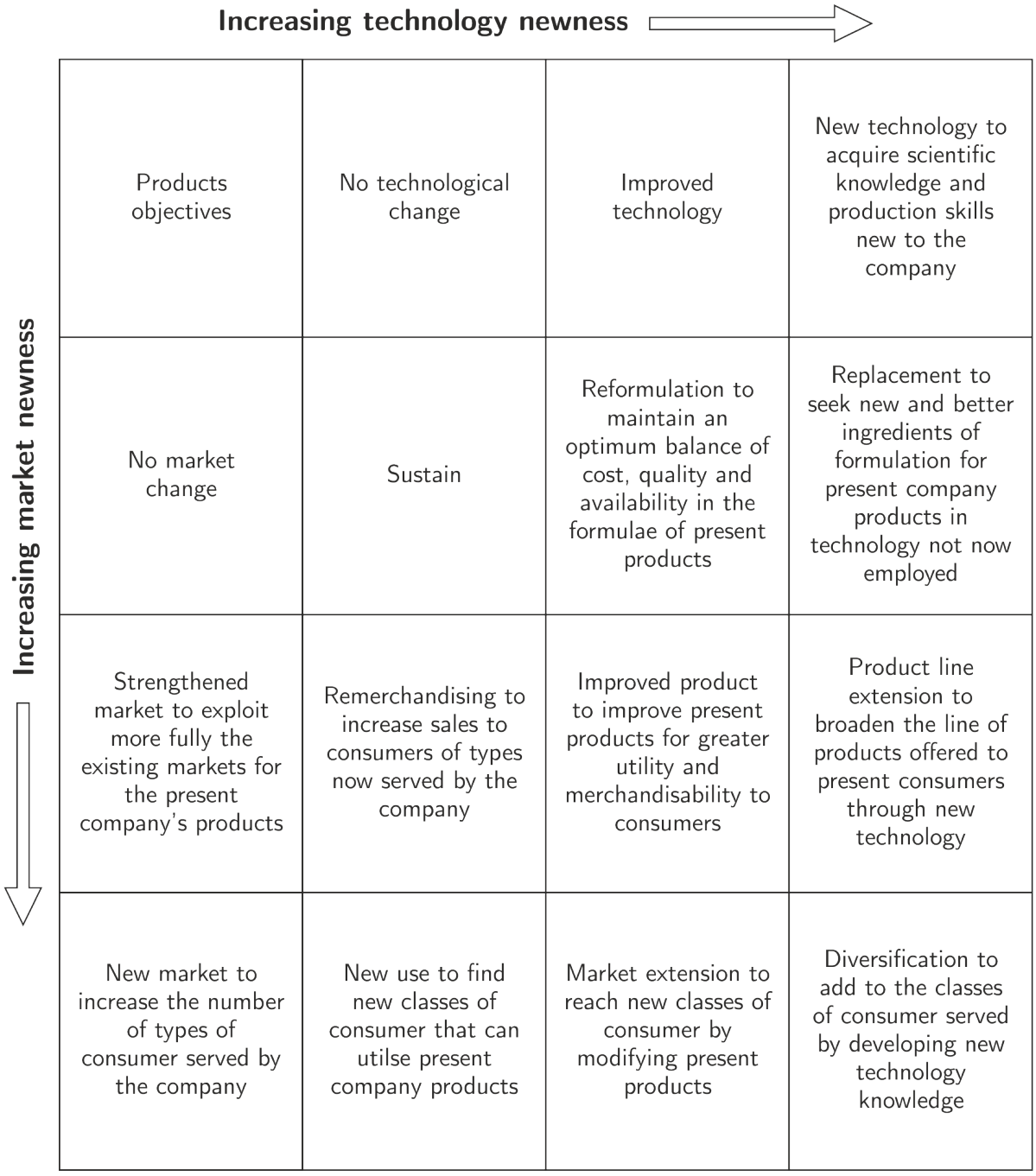

Figure 3.2: New Product Development strategies Matrix

distinction between NPD as seen by most organizations and NPD at Sensata is that NPD can be considered a core business at Sensata. Rarely they sell standard products from a catalogue or off the shelf. Most customers require products with specific specifications

New-to-the-world products	These represent a small proportion of alll new products introduced. They are the first of their kind and create a new market
New product lines	Although not new to the marketplace, these products are new to the particular company. They provide an opportunity for the company to enter an established market for the first time
Additions to existing product lines	This category is a subset of new product lines. The distinction is that while the company already has a line of products in this market, the product is significantly different from the present product offering but not so different that it is a new line.
Improvement and revisions of existing products	These new products are replacements of existing products in a firm's product line
Repositioning	These new products are essentially the discovery of new applications for existing products
Cost reductions	This category of products may not be viewed as new from a marketing perspective. From the firm's perspective, however, they may be very significant. The ability to offer similar performance while reducing production costs provides enormous added-value potential

Table 3.1: Classification of newness, based on Booz et al. 1982

that are produced only for them. This is possible because of the quantities involved in the automotive industry. Even though the newness of the product varies, each project can be considered NPD and is approached this way by Sensata.

NPD is an overarching activity and concerns the management of the multiple disciplines involved in the development of new products. These disciplines have developed their own perspectives on the subjects of NPD. These are largely based on their experiences of involvement in the process.[16] This means that theories and models are not sufficient to guide the actual development of new products. As with any internal organizational process, it needs to be managed by people. The concepts of strategy, marketing and technology all have to be coördinated and managed effectively. Inevitably, this raises issues in such areas as internal communications, procedures and systems.[17]

[16]Trott 2012, p. 418.
[17]Trott 2012, pp. 555-556.

A good example of these issues can be recognized when looking at the departmental-stage model, an early form of a NPD-model. The NPD process is divided among the different departments of an organization and when a department is done with "their part" they throw it over "the wall" to the next department, these models are also called "over-the-wall" models. The problems occurring in such a model are captured in the classic tree swing cartoons[18] (figure 3.3)

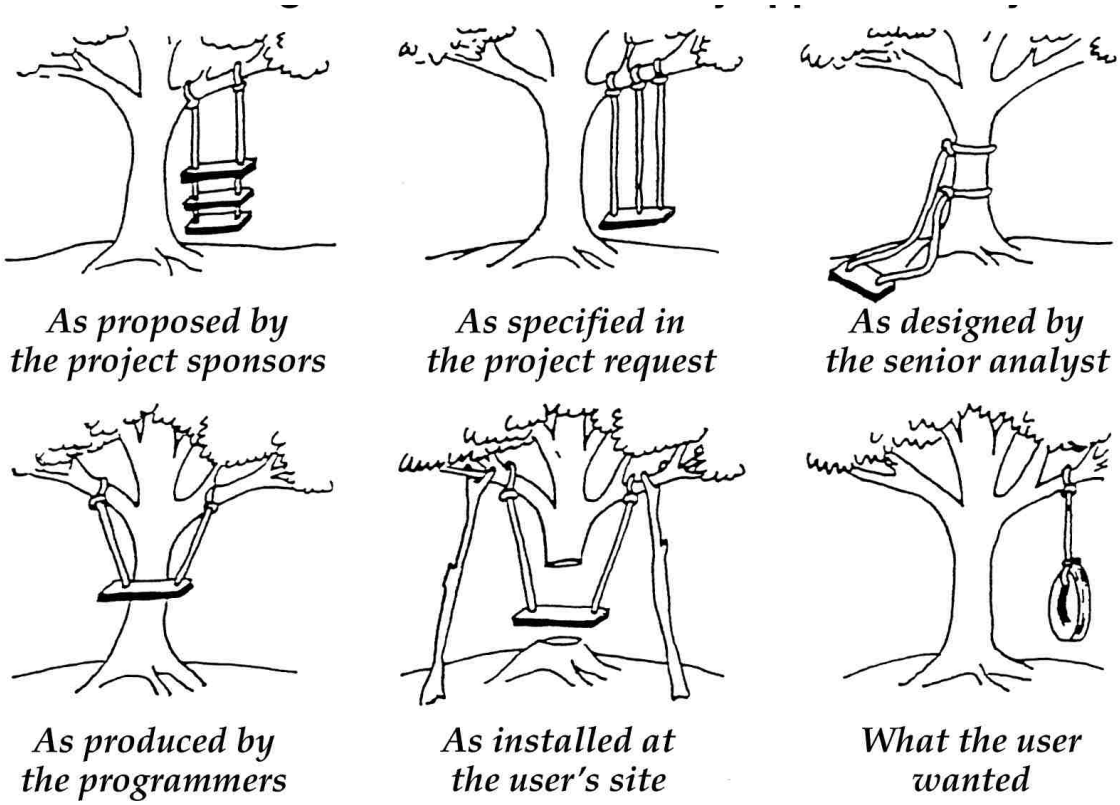

Figure 3.3: Tree swing cartoon by S. Høgh

In the late 1980s, many manufactures attempted to address some of the problems occurring with "over-the-wall" practices by adopting "concurrent" engineering. Concurrent means simultaneously and the practice of concurrent engineering focuses on the project as a whole instead of the individual stages. By taking into account the up and down stream stages of the project and simultaneous involving multiple stages, cross-functional interaction is improved. This should lead to less mistakes, hold-ups and quicker iterations. This approach is more difficult to manage and introduces the need for project teams.[19]

[18] Chapman 2014.
[19] Trott 2012, p. 440.

When looking back to Sensatas GNPD process (figure 1.2) the properties of concurrent engineering are evident, and the cross-functional composition or the project teams is now also clear (figure 1.1).

Lessons learned from the NPD best practices developed in the 1980s and 1990s, such as design for manufacturing (DFM) and time to market (TTM) were widely accepted by 2000. The co-location of cross-functional teams, especially design and manufacturing engineers, led to highly effective product development.[20] The growing trend of "globalization" however became more and more important to NPD. Globalization is characterised by increased international competition, but also by increased international opportunities. In order to make use of these opportunities, organisations adjusted their NPD strategies to a global scope. One of the challenges of GPD is that it makes managing the organisation more complex, needing resources and capabilities to tackle the specific challenges and opportunities associated with an international environment where people need to collaborate.[21]

Eppinger and Chitkara (2009) discuss four reasons for GPD:

1. Lower cost

2. Improved Process

3. Global growth

4. Technology access

But they remark: "Although cost remains the primary reason that many companies initially consider GPD, it is technology, process innovation or revenue growth that drives a GPD strategy. This move from cost to growth and innovation has been a major shift in stated GPD objectives over the past two to three years."[22] This development also takes place at Sensata. Production sites are mainly offshore in low or medium-cost locations. However the importance of co-locating design and production engineers is also recognised and design engineers are now hired to work at the production site.

[20] Eppinger and Chitkara 2009, pp. 1-3.
[21] See Kleinschmidt 2007, p. 420; and Salomo et al. 2010, pp. 957-958.
[22] Eppinger and Chitkara 2009, p. 4.

3.2 The importance of NPD; Using best practices and finding success factors to become the best

Now the basics of NPD has been discussed, the focus will shift to the factors important for this study: What makes or breaks NPD? Results from the Product Development and Management Association's (PDMA) Comparative Performance Assessment Studies show that over 30% of sales and profits derive from new products.[23] NPD does not only influence financial performance but is also an important driver for the growth and diversification of an organisation.[24] The influence of NPD and its key role in business planning has been documented well in the scholarly literature.[25]

	2012		2004	
	The Best	The Rest	The Best	The rest
Number of firms	88 (24,6%)	270 (75,4%)	96 (24,1%)	303 (75,9%)
Successes (commercialized) (%)	82,2	52,9	75,5	53,8
Success-profits (%)	78,2	47,9	72,4	47,9
Sales from new products (%)	47,9	25,4	47,6	21,4
Profits from new products (%)	48,5	25,0	49,1	21,2
Number of ideas for one success	4,5	11,4	4,0	9,2

Table 3.2: Success rates of products introduced in the last five years, the best vs. the rest. Barczak et al. (2009) and Markham and Lee (2013)

As may be clear, a lot depends on NPD, especially for the organisation that invests its resources in it. Because resources are in general limited, it is important that these resources are utilised as efficiently as possible. In other words: Maximise the results and minimize the effort. The importance of doing NPD as good as possible also becomes clear when looking at the numerous articles about this topic. Each conceivable aspect of NPD is being studied, resulting in a very broad research field. Different frameworks and models,[26] but especially success factors[27] and best practices[28] are being studied.

[23] Barczak et al. 2009, p.6; and Markham and Lee 2013, p.411.
[24] Shenglan 2010, p.605.
[25] See Booz et al. 1982, pp. 4-8; Urban 1993, pp. 19-83; Cooper 2001, pp. 26-85; Crawford and Benedetto 2008, pp. 307-367; and Ulrich 2012, pp. 379-404.
[26] See Kleinschmidt 2007, pp. 419-422; Brentani et al. 2010, pp. 144-146; and Bhuiyan 2011, pp. 745-751.
[27] See Cooper and Kleinschmidt 1995, pp. 374-390; Ernst 2002, pp. 1-35; Evanschitzky et al. 2012, pp. 21-30; and Ismail 2012, pp. 9442-9451.
[28] See Cooper and Kleinschmidt 1994, pp. 383-385; Griffin 1997, pp. 429-454; Barczak et al. 2009, pp. 3-23; and Eppinger and Chitkara 2009, pp. 1-11.

The drive for doing great NPD becomes clear when "the best" is compared with "the rest", as has been done in the PDMA studies,[29] see table 3.2. When looking at this data it is clear that there is a sizeable difference between the top 25% organizationist and the other 75%. The influence of NPD is so important that it can be considered a potential source of competitive advantage for organizations who do it well.[30]

A shortcoming of the NPD literature however is that much of it is of a prescriptive nature, a "manual" on how to do better NPD based on what others applied successful, hence the best practices. The problem of this kind of research is that often one of its conclusions is that better project management leads to better projects, unfortunately it appears to be very difficult to differentiate between organizational structures used by the best and those by the rest.[31] The actual process of product development is still largely a "black box".[32] Nevertheless when looking at practices that are statistically more highly associated with the best:[33]

- The use of formal NPD processes.
- Having a specific NPD strategy.
- Measuring NPD outcomes and expecting more out of NPD efforts.
- Using cross-functional development teams.
- Using multiple different types of qualitative market research, including voice of the customer, customer visit, and beta-testing techniques.
- Using engineering design tools such as computer-aided design (CAD) and computer simulations.
- Closing NPD projects with completion dinners.

Most of these practices are implemented in Sensata's GNPD process, so they certainly seem to have everything in place for successfully NPD. However, doing all the right things does not guarantee success. Even if all the right practices are implemented, does this not guarantee that the execution of a project is flawless.

[29]Barczak et al. 2009, p.15; and Markham and Lee 2013, p.412.
[30]Brown and Eisenhardt 1995, p.344.
[31]Barczak et al. 2009, p.22.
[32]Brown and Eisenhardt 1995, p.375.
[33]Barczak et al. 2009, p.4.

3.3 The difference between success and fail factors, the importance of preventing failure

That success and fail factors are two different things was already concluded by Link in 1987, in his conclusion he mentions two important findings:[34]

1. Perceived reasons for success differ from perceived reasons for failure.

2. Success and failure determinants are highly situation specific.

These two findings are of importance, because it highlights the difference between factors that lead to success and those that lead to failure. Additionally it also highlights the need for a qualitative case study because of the dependency of the firm specific situation.

Research into fail factors is probably as old as is research into success factors. In the 1980's Cooper extensively studied the field of industrial product innovation, including barriers to success. His research, partly based on the problems highlighted by Booz et al. (1968), showed that many new product fail after market introduction, resulting from lagging sales.[35] In later studies Cooper recognized different dimensions and factors that are key or barrier for success.[36]

Link (1987) came to the same conclusion as Cooper (1979) did eight years earlier: "Overriding all of these is the basic issue: is there really an answer to what makes a new product a success? Perhaps the problem is so complex, and each case so unique, that attempts to develop generalized solutions are in vain."[37] An important limitation in the applicability of the findings of Cooper (1979) and Link (1987) are that it also includes the marketing of the product and that many product failed because of wrong market orientation and market success. This is beyond the scope of this study because Sensata works mainly on a project basis, meaning that there is no project if there is no customer. In essence, the product is already sold before the project is started. During the project goals regarding cost, time and quality need to be met, as described by the iron triangle.[38]

When looking more specific at projects and how and why they fail, it is important to define what is considered success or failure. Pinto and Mantel (1990) use how failure is

[34]Link 1987, p.116.
[35]Cooper 1975, p.325.
[36]Cooper 1979, p.101.
[37]Cooper 1979, p.102.
[38]See Atkinson 1999, pp. 337-338.

defined together with the type of project and the stage of the project in its life cycle as contingency variables. These contingencies determine the difference between the set of managerially controllable factors associated with project failure.[39] The focus of Pinto and Mantel (1990) is on factors over which management exerts (some) control, however there are important causes of project failure that are beyond the control of management, such as: Environmental factors, unforeseen economic downturns, development of a superior technical alternative, or changes in governmental regulations and many others.[40]

Belassi and Tukel (1996) confirmed the complexity in determining if a project is a success or a failure. Even if delays and increased project costs occur, the project may still be considered successful, although this view may differ between the PM and the client,[41] for example: The client recieves the requested functionality at the agreed time and for the agreed price and considers the project succesful, however it took the organization more effort then expected, losing money on it, the project is considered a failure. Belassi and Tukel (1996) also recognize that success factors are usually listed as either very general factors or very specific factors affecting only a particular project. However lacking a comprehensive list makes it difficult not only for project managers but also for researchers to evaluate projects based on these factors.[42] This is even more the case regarding fail factors; there are hardly any lists and the applicability of those that do exist can be questioned.

(1)	Ignore the project environment (including stakeholders).
(2)	Push a new technology to market too quickly.
(3)	Don't bother building in fallback options.
(4)	When problems occur, shoot the one most visible.
(5)	Let new ideas starve to death from inertia.
(6)	Don't bother conducting feasibility studies.
(7)	Never admit a project is a failure.
(8)	Over-mange project managers and their teams.
(9)	Never, *never* conduct post failure reviews.
(10)	Never bother to understand project trade-offs.
(11)	Allow political expediency and infighting to dictate crucial project decisions.
(l2)	Make sure the project is run by a weak leader.

Table 3.3: How to ensure a project's failure. Pinto and Kharbanda (1996)

[39] Pinto and Mantel 1990, p.269.
[40] Pinto and Mantel 1990, p.274-275.
[41] Belassi and Tukel 1996, p.141.
[42] Belassi and Tukel 1996, p.141.

Pinto and Kharbanda (1996) however, constructed a list with methods to ensure a project's failure: See table 3.3[43] In this very clear and practical list, several items are comparable to the Sensata scope checklist. Likewise, attributes can be recognized that are similar to the findings of authors discussed above. The key lessons that can be learnt from these guidelines are that failure is often a by-product of projects that involve untested or new technologies and processes and that failure should not discourage future efforts. Learning from our mistakes is very important, putting them aside without any concern is just as harmful as becoming too afraid to act, resulting in paralyzing the organization.[44]

Defining when a project has failed or is successful is tricky, determining to terminate a project is even more so. Some critical fail factors can be objectively measured, others are more subjective and depend on the job or role of the stakeholder. This dilemma has been the foundation for the work of Dilts and Pence (2006), that brings some interesting findings. They report that on most objective measures, executives and PMs hold very similar views of importance. They have the same idea of the importance of the four underlying critical termination factors discovered, namely: political/commitment, need, resource gap, and expectation gap. The political/commitment factor combines the various elements of commitment, including funding, champion and politics. The need factor unites the items under a specific construct of degree of need for the project by the user and the organization. The expectation gap factor is by far the strongest factor relating to perceptions of project failure. Not surprisingly, a project that has had a major change in initial expectations is one most likely to be at risk of termination. The last factor is the resource gap factor. This factor would seem to be concerned with the new resources required when a project runs into technical difficulty.

Executives and PMs however, do not agree on all factors. PMs perceive change in project complexity and a change in overall completion time as much more important than executives do. An explanation for this could be that PMs are more focused on the day-to-day tasks of a project and feel the pressure to successfully complete the project. Any change in project complexity, either because of initial misspecification of the project or due to requirement creep, is viewed by PMs as yet another threat to achieving the goal of satisfying the user on-time and in-budget.[45] Another finding related to cost and schedule growth is that this primarily occurs when unrealistically high levels of performance are required and little flexibility is provided to degrade performance during

[43]See Pinto and Kharbanda 1996, p. 46.
[44]Pinto and Kharbanda 1996, p.52-53.
[45]Dilts and Pence 2006, p.393.

the course of the program. This gap stands out as a major factor of all the critical project items. Setting these expectations can be a time consuming, arduous, and politically delicate task.[46] Setting these expectations is essentially done when the project is planned. How can the promised quality be delivered in an acceptable time frame and for a price that the customer wants to buy it and leaves a margin for the organization?

Traditional project planning carries three serious risks:[47]

1. White space: Planners leave gaps in the project plan by failing to anticipate all the project's required activities and work streams.

2. Execution: Project team members fail to carry out designated activities properly.

3. Integration: Team members execute all tasks flawlessly - on time and within budget - but don't knit all the project pieces together at the end. The project doesn't deliver the intended results.

Project planning and budgeting is even more challenging for NPD projects, simply because it concerns new technology or processes. Planning or budgeting something that has never been done before is inherently difficult. This is analogue to many IT projects, where often new and unique configurations need to be created, and are known for overshooting there budget and planning. A study of IT-projects shows more or less the same problems that are discussed here. About 20% of the projects fail and 50% of the projects are challenged, experiencing cost and schedule overruns or significantly reduced functionality.[48] Fail factors include both technical as managerial factors and in some organizations there was a political climate such that no PMer could admit to a failed project, even if the team members did not believe in it anymore. This is one reason for the lack of post mortem reviews[49] were is discussed why a project failed. All the fail factors found by Cerpa and Verner (2009) can been seen in table 3.4. As can be observed, many factors are comparable to those in table 3.3 and other factors discussed above.

[46] Dilts and Pence 2006, p.395.
[47] Matta and Ashkenas 2003, p.1.
[48] Cerpa and Verner 2009, p.130.
[49] Cerpa and Verner 2009, p.131.

Software project failure factors	Percentage of projects (%)		
	In-house	Outsourced	Overall
Delivery date impacted the development process	93.9	90.5	92.9
Project under-estimated	83.7	76.2	81.4
Risks were not re-assessed, controlled, or managed through the project	73.4	80.9	75.7
Staff were not rewarded for working long hours	81.6	57.1	74.3
Delivery decision made without adequate requirements information	83.7	47.6	72.9
Staff had an unpleasant experience working on the project	83.7	47.6	72.9
Customers/Users not involved in making schedule estimates	69.4	76.2	71.4
Risk not incorporated into the project plan	65.3	80.9	70.0
Change control not monitored, nor dealt with effectively	63.3	85.7	70.0
Customer/User had unrealistic expectations	69.4	66.7	68.6
Process did not have reviews at the end of each phase	75.5	47.6	67.1
Development Methodology was inappropriate for the project	71.4	52.4	65.7
Aggressive schedule affected team motivation	69.4	57.1	65.7
Scope changed during the project	67.3	57.1	64.3
Schedule had a negative effect on team member's life	71.4	42.9	62.9
Project had inadequate staff to meet the schedule	63.3	57.1	61.4
Staff added late to meet an aggressive schedule	61.2	61.9	61.4
Customers/Users did not make adequate time available for requirements gathering	61.2	57.1	60.0

Table 3.4: Percentage of failed projects per failure factor from Cerpa and Verner (2009)

When looking at all the fail factors and drivers behind them it is clear that there are many reasons and causes why projects can fail. Still when an project fails, often the investigation is focused on the technical reason's and engineering behind it, while in reality the root cause of the failure often is not technical but managerial.[50] This misconception results in a lost chance to learn from the past mistakes. It is also made clear by different authors that success and fail factors are very case specific and contingent,[51] or as said by Sauser et al. (2009): "...this study provided another demonstration that 'one size does not fit all.' In studying project success or failure we need not just asking, 'was it good or bad management,' but 'was it the right management to the situation, the task and the environment.' "

It is regrettable that, while much research has been devoted to critical success factors, not many studies have been focused finding alternative frameworks that allow us to understand why projects fail and what can be done about it.[52] A possible explanation for the lack of research into failure is that studying project failure demands much more research than studying successes. This is partly because failure is an emotion-laden term, striking a nerve with many respondents (from the studied organizations) but also academic researchers.[53] It is clear that failure has two sides, at one side is that every failure is a good learning opportunity, but on the other side every failure can have hefty consequences in practice.

3.4 Preventing glitches in cross-functional teams by organizational integration and shared knowledge

During the study into fail factors regarding product development performance, an interesting concept was encountered that needed further consideration because it is very appropriate for this study. The concept of "glitch" as developed by Hoopes and Postrel (1999) and applied by among others Rauniar, Doll, et al. (2008) is defined as follows: "Glitches are defined as costly mistakes that could have been avoided if some of the parties involved had understood things that were known by other participants".[54]

[50] See Pinto and Kharbanda 1996, pp. 52-53; Dilts and Pence 2006, pp. 390-395; Cerpa and Verner 2009, pp. 130-134; and Sauser et al. 2009, pp. 676-677.
[51] See Link 1987, pp. 109-117; Belassi and Tukel 1996, pp. 141-151; Pinto and Kharbanda 1996, pp. 45-46; and Sauser et al. 2009, pp. 676-677.
[52] Sauser et al. 2009, p.676-677.
[53] Dilts and Pence 2006, p.394-395.
[54] Hoopes and Postrel 1999, p.838.

As stated before, how firms get their work done and how well is a matter of intense interest. What internal firm level factors drive competitive success, but also failure is of great interest to management scholars and practitioners. Very interesting is that Hoopes and Postrel (1999) discusses glitches and how to prevent them with aid of the concepts of organizational integration and shared knowledge. Shared knowledge refers to the facts, concepts and propositions which are understood simultaneously by multiple agents.[55] By definition shared knowledge is important to reduce glitches as it provides a basis for communication and understanding. Hoopes and Postrel (1999) argues that shared knowledge is to be achieved by organizational integration across functional and disciplinary specialties. It appears that it drives superior firm capacities and current managerial practices such as flatter hierarchies, cross-functional teams and electronic group-ware all aim to improve communication among agents.[56]

It may be clear that organizational integration exactly is what happened in the product development field. As product development became increasingly complex and needed more participants with more specialised skills the need for organizational integration and shared knowledge is evident. With the introduction of concurrent engineering and (international) project teams with a cross-functional composition, it became necessary for the team members to have a basis of shared knowledge to interact effectively with each other. A lack of shared knowledge in the team can lead to conflicting and inconsistent decisions, resulting in the occurrences of glitches. This can lead to a design and development of a product that is plagued with problems such as re-work, scrap, poor resource utilization, cost-overruns, poor quality of design, poor quality of conformance or in general a waste of valuable resources..[57] When the cross-functional teams has a shared understanding about customers, suppliers, and their own cross-functional capabilities, project processes can be planned that effectively integrates the inter-dependent team knowledge.[58] In the literature on product development it stands out that interdepartmental and inter-functional communication has been identified a factor that distinguishes successful from unsuccessful projects, or as stated by Rothwell et al. (1974): “Failure to communicate successfully between organizational units was the hallmark of failure”[59]

In section 3.3 the difference between factors that lead to success or failure are different, this is also he case with glitches. It is very difficult to reconstruct which knowledge was

[55]Hoopes and Postrel 1999, p.838.
[56]Hoopes and Postrel 1999, p.837.
[57]Rauniar, Doll, et al. 2008, p.733; and Rauniar and Rawski 2012, p.940.
[58]Rauniar, Doll, et al. 2008, p.724.
[59]Rothwell et al. 1974, p.283.

involved in the processes that prevented a glitch, those involved are generally not aware of what knowledge they use in problem solving. Only in the less frequent occasions when a glitch does occurs, individuals are able to reconstruct and isolate what key pieces of knowledge they where missing.[60] This leaves the question, how glitches are to be prevented, from the studied literature it seems more than plausible that organizational integration practices increase the degree of shared knowledge, thereby reducing glitches and improving performance of product development projects. "Glitches are interesting precisely because they appear, on the surface at least, to be easily remediable errors just waiting to be polished off by that great panacea of our times, better communication".[61] Unfortunately it is never as simple as that, because knowledge sharing itself has its costs. Depending on how complex or specialized knowledge is, it can be very costly to prevent or remedy glitches. In principal there is a optimal level of glitches, at some point the cost of preventing glitches by investing in organizational integration and shared knowledge will be higher than the glitch cost.[62] Continuing this reasoning to fail factors, it can be concluded that it is not possible or even desirable to eliminate all failures. Not only will the associated costs with this be out of proportion with the cost of the failures but also every failure is an opportunity to learn.

3.5 Combining the literature in a theoretical framework to discuss relations and solutions

Now the several theoretical aspects that are of importance are discussed, the question remains how does it all come together? For this, figure 3.4 is constructed. Figure 3.4 offers an overview of the theoretical framework used in this study. The central element are the fail factors (Glitches) as described by several authors. The performance of a project is determined by measuring its results against its own predictions.[63] These fail factors are the explanation for the gap between the project expectations and results.[64] As can be concluded from the goal of this study, these fail factors are unwanted and solutions are needed to eliminate them.

To do this it is necessary to understand fail factors, what are they, what causes them and of course what are possible solutions? The literature explains that fail factors can

[60]Hoopes and Postrel 1999, p.861.
[61]Hoopes and Postrel 1999, p.861-862.
[62]Hoopes and Postrel 1999, p.862; and Rauniar, Doll, et al. 2008, p.385.
[63]House and Price 1991, p. 64.
[64]Dilts and Pence 2006, p. 389.

be very specific to an organization or even a project,[65] in addition what is defined as a failure depends on who your ask.[66]

Three types of fail factors are described in the literature: Failure due to the technical nature,[67] failure due to managerial errors[68] and unforseen / environmental.[69] Failures of a technical nature are for example technical difficulties during development or production. Failure due ot managerial errors include issues regarding sheduling and the overall functioning of the team. Unforseen / environmental failures are for example changes to legislation or natural disasters. Although failures are to be expected in projects concerning new and risky ventures[70] it is important to accept that failures may occur and that can be learned from them.[71] Unfortunately two types of behavior often occur when looking for solutions to project failure; The past failures are simply "forgotten", often because the corporate culture shuns the discussion of failure. On the other side there is to much focus on past failure, because of the fear of recurrence.[72] Both behaviors are counterproductive, forgetting past failures eliminates the possibility to understand failures and learn from them, while focussing to much on past failures may paralyze an organization in taking the necessary actions.

Although there are some challenges to overcome before failures can be tackled successfully, several possible solution paths are discussed in the literature. In most situations the goal is a structural lasting soliton to reduce failure and increase performance. However there is an alternative, one that is used widely in practice. Instead of implementing structural solutions there is always the option of ad hoc solutions. Fire fighting or trouble shooting is something that will always be necessary as not all problems can be predicted, some organization even have become very good at it and for them it is an important factor for success,[73] still one may wonder if it is desirable over a structural solution.

When a structural solution is desired the studied literature offers three possible solutions:

[65] See Link 1987, pp. 109-117; Belassi and Tukel 1996, pp. 141-151; Pinto and Kharbanda 1996, pp. 45-46; and Sauser et al. 2009, pp. 676-677.
[66] Pinto and Mantel 1990, p.274.
[67] Dilts and Pence 2006, p. 393; Cerpa and Verner 2009, p. 130; Sauser et al. 2009, pp. 676-677, See.
[68] Pinto and Kharbanda 1996, pp. 52-53; Dilts and Pence 2006, p. 393; Cerpa and Verner 2009, p. 130; and Sauser et al. 2009, pp. 676-677, See.
[69] Pinto and Mantel 1990.
[70] Pinto and Kharbanda 1996.
[71] Pinto and Kharbanda 1996, p. 53; Dilts and Pence 2006, p. 395; and Cerpa and Verner 2009, pp. 133-134, See.
[72] Pinto and Kharbanda 1996, pp. 52-53.
[73] Belout and Gauvreau 2004, pp. 5-6.

- Rapid result initiatives are in essence miniature projects. This approach was developed with mega-projects in mind, where multiple teams work on a single project. The goals of the rapid result initiatives was to do a small fast project to find any issues so that they can be ironed out early-on. Rapid-result-teams serve as a model for the other project teams.[74]

- Multiple authors found that many project fail due to managerial reasons, unfortunately not many solutions are offered. Sauser et al. (2009) actually describes several contingency theory frameworks to analyses why projects fail due to managerial reasons. His conclusion is: "...'one size does not fit all.' In studying project success or failure we need not just asking, 'was it good or bad management,'but 'was it the right management to the situation, the task and the environment.' ".

- Shared knowledge is discussed as the method to reduce glitches and can be achieved by organizational integration across functional and disciplinary specialties. A key element is improving the communication among different individuals and departments, several practices to achieve this are discussed: Flatter hierarchies, cross-functional teams, electronic groupware,[75] but also encouraging knowledge sharing by stimulating trust, power and rewards.[76]

When looking at these solutions there are a few more things to consider. First, often there is no one problem. Projects do not suffer from just a single fail factor, often multiple related fail factors are present.[77] In addition it is not desirable to solve all the fail factors (glitches) because solving them has its own costs. As mentioned before in essence there is an optimal level of glitches or fail factors.

One final point that needs to be addressed again is that fail factors and glitches tend to be very specific to the organization or even the project.[78] The result of this is that the empirical part of this study is started from the practice. The fail factors present at Sensata are examined and afterwards compared to the fail factors found in the literature. Next, the possible solutions found in the literature will be examined and if and how they are applicable to Sensata.

[74]Matta and Ashkenas 2003, p. 1.
[75]Hoopes and Postrel 1999.
[76]Rauniar, Doll, et al. 2008.
[77]Sauser et al. 2009, p. 131.
[78]See Link 1987, pp. 109-117; Belassi and Tukel 1996, pp. 141-151; Pinto and Kharbanda 1996, pp. 45-46; Sauser et al. 2009, pp. 676-677; and Rauniar and Rawski 2012, p. 949.

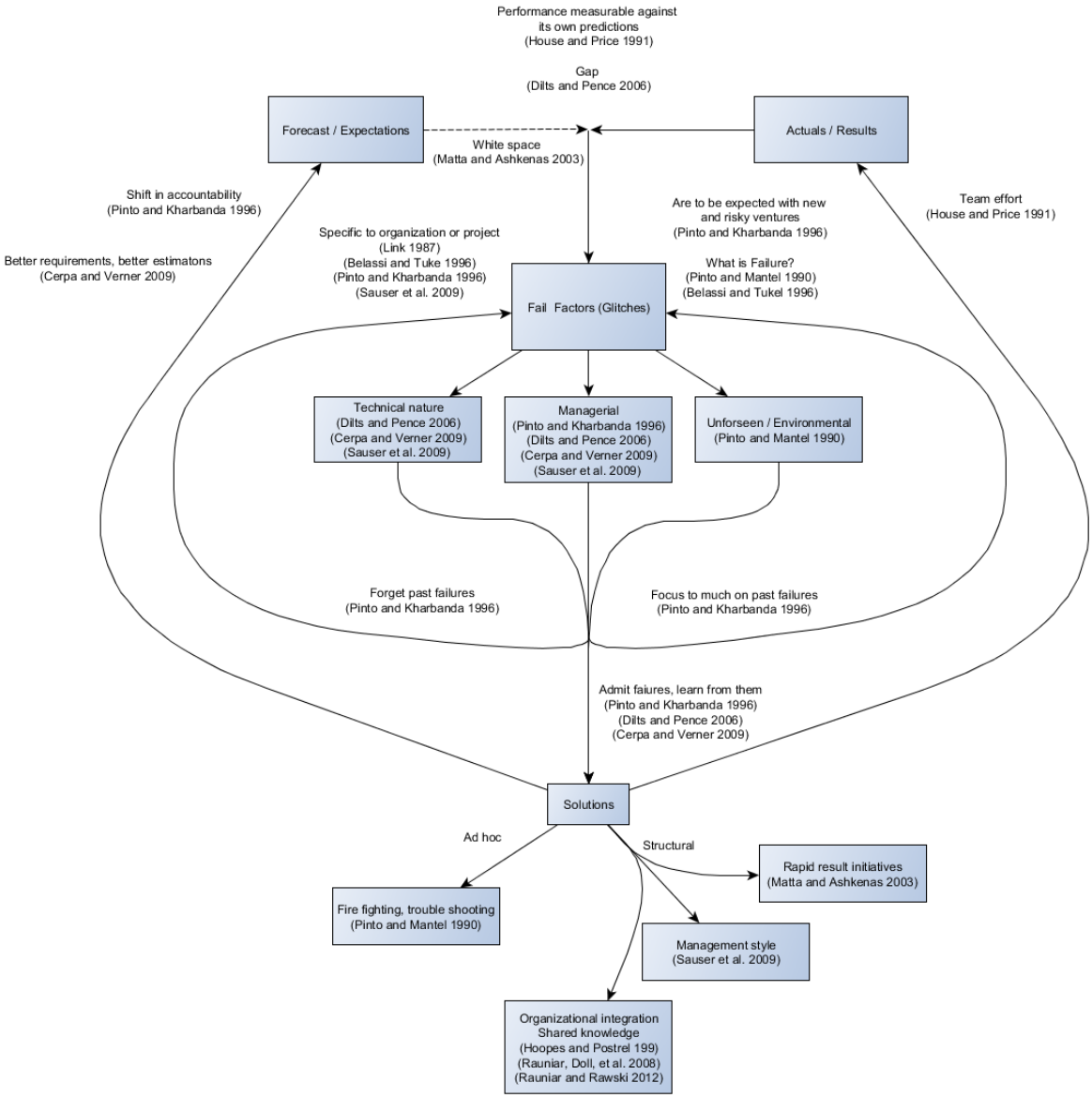

Figure 3.4: Schematic overview of the theoretical framework

4 Investigating the current situation at Sensata

4.1 Reviewing the issues at hand by analyzing financial reports of the projects

The first step in the research will be to take a closer look at the current situation. For this RQ1: What is the current deviation from the budget? and RQ2: Which deviation factors are relevant in the projects? are discussed consecutive in this chapter. Both research questions are discussed followed by their results and analysis.

At Sensata it is recognized that there are deviations from the project budget, but the size and direction is not exactly known. To gain a better understanding of budgets, forecasts and actuals of projects, Sensata started at the beginning of 2012 with a TOP-list project program. TOP-list projects are projects where special attention is paid on the making, recording and tracking of the budget forecast and the actuals. This is done by assigning an specific cost center to the project and recording the actuals alongside the forecast. Using an excel workbook that contains several sheets on which data is recorded, several overviews are generated i.e. a quarterly/monthly overview of the actuals vs. the budget. The information in these files is updated every quartile with the recent actuals and using this information alongside the current developments, the forecast can be adjusted if necessary.

To answer RQ1 it is necessary to extract and combine this financial data to compare and analyses it. The source for this data are the nine TOP projects that are available. The necessary information was found on the *Overview Actuals - Budgeted* sheet of the financial report of each TOP project. Additional information from the *1. Actual Direct Project* sheet was used to specify the budget items further. For most projects data was available from 2012 and 2013, in some cases only information from 2013 was available because the project had not started in 2012. Only if no forecast *and* actual data was

available the months were excluded, this was the case at the beginning or end for a few projects. The data of the different projects were collected and put together in an excel file to get an overview of the deviation of each project and how the projects compare to each other. This was done for the total of each project but also for the different accounts making up the project.

4.2 The deviations of the project are made insightful by comparing them in a table

Using the financial data of the nine TOP projects as described in the previous yielded the data in table 4.1. The number of each project is in the header, underneath follow the deviations of each consecutive account, concluding with the net costs. The accounts represent the following costs:

Total headcount Contains the total expenditure of manhours.

- **DE+PM** Spent manhours of the Design Engineering and Project Management department.
- **PMT** Spent manhours of the Product Management Team.

Development costs Direct and indirect development costs e.g. material costs, text equipment, lab-time, external expertise.

Make & COE Cost spent at the Make site (production location) and Centre Of Excellence (internal experts of Sensata)

Total Costs The sum of all above costs.

Project Revenue Revenue generate in the project, primarily as a result of the sale of sample batches.

Net Costs Total costs minus the project revenue.

Coming up with these numbers proofed harder than expected because the source files are Excel workbooks that imports external data and contains numerous cross references and interactive elements. After copying all the necessary data to a new file it was much more practical to do the calculations. The results of this can be found in table 4.1 and are discussed in the next section.

Budget deviation (%)	1500	1501	1502	1503	1505	1506	1507	1550	1674	**Average**
Total Headcount	-47,8	-57,4	-34,4	-5,0	-50,4	2,1	-46,2	-30,9	-39,2	**-34,4**
DE + PM	-49,8	-58,6	-29,5	-9,0	-50,4	8,5	-37,1	-26,4	-39,2	**-32,4**
PMT	-42,4	-55,2	-58,4	42,4		-14,9	-88,2	-52,2		**-38,4**
Development costs	-12,7	-62,7	-23,5	-18,5	-52,3	-69,9	-21,6	-24,6	-44,0	**-36,6**
Make & COE	35,3	-81,9	-70,9	-37,5	-100,0	-100,0	-100,0	-100,0	-15,0	**-63,3**
Total Costs	**-36,0**	**-60,3**	**-37,0**	**-8,9**	**-52,2**	**-25,5**	**-40,7**	**-33,5**	**-38,4**	**-36,9**
Project Revenue	-9,8		-72,3	150,3	-12,8	-31,1	-100,0	-64,3	59,7	**-10,0**
Net Costs	**-38,8**	**-60,3**	**-36,0**	**-26,0**	**-53,8**	**-25,0**	**-39,1**	**-32,8**	**-44,9**	**-39,6**

Table 4.1: Deviation from budget, TOP projects.

4.3 An average deviation of -39.6 per cent and a maximum of 150.3 per cent

What stands out table 4.1 is that every single project is under budget, with the smallest deviation being -25.0% and the largest -60.3%. On average the projects are 39.6% under budget. Only a few items are over budget, with the biggest deviation in the project revenues of project 1503 that is 150.3% over the budget. Of the 42 budgeted accounts only three accounts are within 10% from the budget.

The data from table 4.1 gives an overview of the current deviations and thus awners RQ1. It is used as a starting point for RQ2.

4.4 Interviewing the Project Managers to find deviations based on the financial reports

This and the following sections concern the discussion and results of RQ2: Which deviation factors are relevant in the projects? As a starting point the results of RQ1 are used and discussed with the PM of each project. An overview of the results is given followed by a discussion of these results in relation with the literature.

In order to obtain the empirical information needed for RQ2 and find deviation factors relevant for Sensata, information will be gathered through semi-structured interviews with the five PM's This is the most suitable form of data collection for this case.because semi interviews provide much and rich information and offer the possibility to go more in-depth on certain topics if necessary[79] while standardizing the meaning of the input.[80] This approach was chosen because financial reports only tends to show that there is a deviation but they do not include what the reason for this deviation is. The choice for semi-structured interviews was made because the nature of the deviations can be very broad and it is important to keep the option open to elaborate on certain aspects. Very specific, in depth, information is needed because every case is different.[81]

To guide the interviews and to make sure that all the relevant aspects of the project are discussed an interview guide was developed. One in Dutch and one in English because two of the five interviews were held in English, the other three in Dutch. The interview

[79] Creswell 2003, p. 17; and Bernard 1988, p. 117.
[80] Barriball and While 1994, pp. 332-334.
[81] See Link 1987, pp. 109-117; Belassi and Tukel 1996, pp. 141-151; Pinto and Kharbanda 1996, pp. 45-46; and Sauser et al. 2009, pp. 676-677.

guide can be found in appendix A. Because of the "sensitivity" of the term fail factors, the term *Deviation Factor* (DF) is used during the interviews. This has a less negative feeling but does cover the subject. In addition two graphs were constructed for each project to make deviations more insightful. The first graph shows the forecasted and actual *net project costs* and the cumulative deviation from the forecast. The second graph shows the progress of the cumulative deviation of each budget item. This representation was chosen so the different items can be easily represented in one overview, which otherwise would be difficult because of the great difference in absolute values. This representation should also help to make trends more insightful and not focus to much on monthly differences. The graphs constructed were used during the interview as a guide to discuss notable deviations from the budget. The first two interviewees indicated that additional graphs for each budget item separate would be helpful. For the remaining three interviews graphs containing the absolute monthly values of the budget and actuals for each budget item were added.

In preparation of the interview the PM's were sent an invitation disclosing the goal of the study and reason for the interview. A list of deviation factors was kept during the interview and these findings were fed back at the end of the interview for confirmation. All interviews were conducted at Sensata in Almelo and took about one hour when a single project was discussed and about one and a half hour if two projects were discussed. The interviews were conducted in Dutch or English or a combination of both. After the interviews the participants received an e-mail with the deviation factors discussed to check if everything was understood correctly and if not what should be corrected. Two PMs made use of this opportunity and a few factors were clarified. Within the nine TOP projects available it occurred twice that two projects are managed by the same PM. In addition two PM's recently left and those projects where transferred to a PM not available on site, leaving seven projects with five PM's.

4.5 Twentythree unique Deviation Factors grouped according to Actuals, Budget and Construction

In total 86 deviation were mentioned during the interviews. After grouping them a list of 23 unique deviations factors was found. The occurrence of these factors varied from one to five. Further aggregation resulted in six groups (and some independent DFs) of related deviation factors. During the sorting process three *themes* were recognized, all the DF were related to problems regarding to the project *Actuals*, the project *Budget* (forecast /

expectations) or the project *Construction* (execution of the project). The division into the themes was done based on were in the process the DF was most relevant. If the deviation affected the composition or reliability of the actuals it was put in the Actuals theme, if it affected the budgeting it was put in the Budget theme. The Construction theme covers the execution of the project and everything that can go wrong during this. The sorting and grouping was done with a mind mapping tool that made it easy to adjust the groups and generate different overviews. One such overview with the Themes, Groups and DFs can be seen on figure 4.1

For further use the DFs were properly translated into english and elaborated with a short description, this resulted in the following list of 23 Deviation Factors:

Actuals:

Monitoring worked hours: *PM cannot see all worked hours on their project, deviations do not show up.*

Lacking overview of cost and capital: *Not all budgeted costs can be tracked. Limited possibility to track what is paid and when.*

Make site & COE costs: *Costs are not booked (at the right cost centre). Low control on how much time is spent.*

Wrong cost centre: *Hours, Expenses, revenues and RP are not booked on the right cost centre.*

Positive Development costs: *Positive development costs are booked, revenues, returned costs or supplier development?*

Lacking administrations: *Missing actuals, unable to book costs because cost centre does not exist yet.*

Project phase opening and closing: *Project (phase) budget is not closed, residual costs and expenses that are not budgeted.*

Budgeted or allocated hours are not fully spent on the project: *Not staffed as budgeted, under-staffing.*

DE team reinforced because of technical challenges: *Additional engineers allocated to project.*

Budget:

Difficulty in estimating budget: *Forecast is best guess, there are no guidelines.*

Ask more than is necessary: *Budget has buffer, ask for more so you get what you need.*

Number of samples and sample revenues are unknown: *Unclear how much samples the customer will order.*

Fixed costs: *Make and COE costs are fixed.*

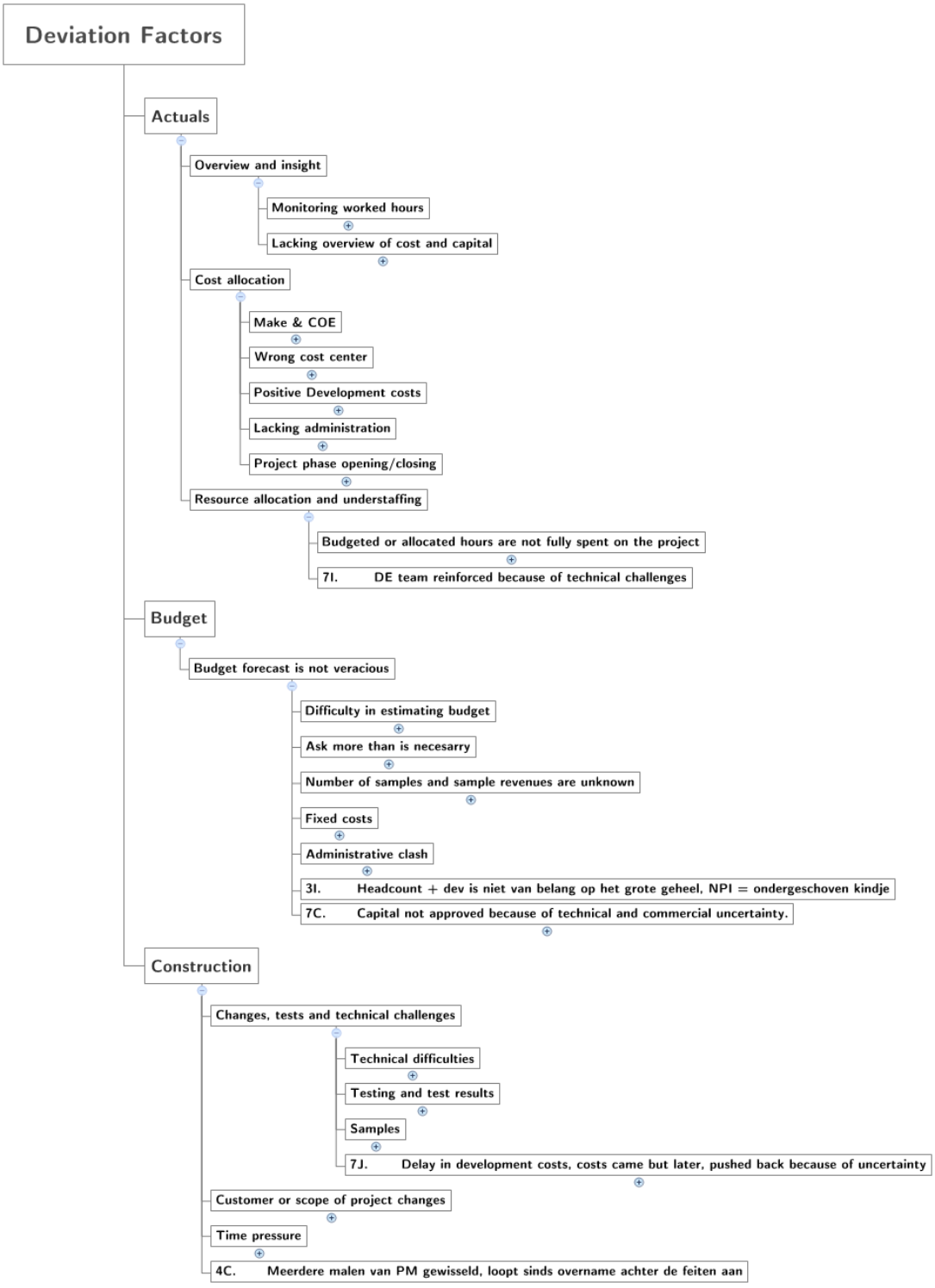

Figure 4.1: Deviation Factor mind map, constructed with XMind 2013. Data as collected from the interviews, some DFs in Dutch.

Administrative clash: *There are different files with sometimes conflicting budgets.*

Headcount and development costs are unimportant: *These costs are low and unimportant in general picture.*

Capital not approved because of technical or commercial uncertainty: *No capital available, need for other solutions.*

Construction:

Technical difficulties: *New technology not ready, difficulty in process, unforeseen challenges.*

Testing and test results: *Discussion about spec. Tests led to more tests, internal capacity is limited.*

Samples and sample delivery: *More development needed than expected, delivery was late because of delays.*

Delay in development costs: *Cost came but later, pushed back because of uncertainty.*

Customer or scope of the project changed: *Customer added or leaves, project becomes bigger than expected or is stopped.*

Time pressure: *Not enough time for proper development, a lot is developed parallel.*

PM Change: *The project is handed over to another PM.*

Figure 4.2 was constructed to give an overview of the DFs and how often they occurred.

During the interviews it became clear that there are deviations because of issues with the actuals. However all PM were surprised by the large deviations and pointed out on more then one occasion that the deviation was because of missing or incomplete information. In an attempt to correct for this all the questionable incomplete months are omitted from the data, significant different results appear, as shown in table 4.2. Initially it was assumed that if a month was budgeted but showed zero actuals, there were no expenses regarding the project. It seems however very unlikely that a project is just (temporarily) stopped and started again and does not make any costs in between. What makes this even more questionable is that the budget ought to be updated every three months when new quartile figures come in and the estimations for the next quartile need to be made. So if a hiatus is expected, why was it not budgeted this way? After rigorously omitting more months than initially, the deviation on almost all items decrease. The average net costs go from -36.6% to -27.2%, an improvement of 9.4%. Nevertheless it appears that the actuals are incomplete, severely limiting the reliability and usability of the financial reports.

Figure 4.2: Graph displaying the Deviation Factors and their occurrence, constructed in Excel 2013

Deviation from budget (%)	Total Headcount	DE + PM	PMT	Dev. costs	Make & COE	Total Costs	Project Revenue	Net Costs
1500	-47,8	-49,8	-42,4	-12,7	35,3	-36,0	-9,8	-38,8
1500*	-28,3	-30,9	-20,8	10,0	102,9	-13,9	8,2	-16,6
1501	-57,4	-58,6	-55,2	-62,7	-81,9	-60,3		-60,3
1501*	-43,3	-45,2	-40,0	-68,9	-76,4	-52,8		-52,8
1502	-34,4	-29,5	-58,4	-23,5	-70,9	-37,0	-72,3	-36,0
1502 *	0,9	9,2	-39,0	-32,7	-56,2	-15,3	-71,3	-12,6
1503	-5,0	-9,0	42,4	-18,5	-37,5	-8,9	150,3	-26,0
1503*	-5,0	-9,0	42,4	-18,5	-37,5	-8,9	150,3	-26,0
1505	-50,4	-50,4		-52,3	-100,0	-52,2	-12,8	-53,8
1505*	-18,2	-18,2		-44,7	-100,0	-26,5	14,4	-28,5
1506	2,1	8,5	-14,9	-69,9	-100,0	-25,5	-31,1	-25,0
1506 *	25,2	27,0	21,1	-40,6	-100,0	-0,2	39,9	-2,1
1507	-46,2	-37,1	-88,2	-21,6	-100,0	-40,7	-100,0	-39,1
1507*	-48,9	-41,6	-82,8	-91,2	-100,0	-60,7	-100,0	-59,1
1550	-30,9	-26,4	-52,2	-24,6	-100,0	-33,5	-64,3	-32,8
1550*	-11,6	-4,3	-41,0	-26,1	-100,0	-20,9	-91,5	-19,0
1674	-39,2	-39,2		-44,0	-15,0	-38,4	59,7	-44,9
1674*	-18,2	-18,2		-39,4	-1,7	-21,4	57,5	-28,3
Average	**-34,4**	**-32,4**	**-38,4**	**-36,6**	**-63,3**	**-36,9**	**-10,0**	**-39,6**
Average*	**-16,4**	**-14,6**	**-22,9**	**-39,1**	**-52,1**	**-24,5**	**0,9**	**-27,2**

Table 4.2: Deviation from budget, before and after omitting incomplete months. *=after correction

4.6 Comparing the found deviation factors with the literature, being to specific or general.

So what can we learn from these results? First of all it should not be surprising that the Deviation Factors could be easily divided in the themes Actuals, Budget and Construction. The studied literature indicated that the performance (Actuals) of a project is often measured against its own forecast (Budget) and this is also the case at Sensata. That leaves the theme Construction that covers the problems that occur during the actual execution of the project.

Secondly the found DF range from very specific to very general, also not unexpected based on the studied literature. The problem with the very specific DF is that they are more or less unique to Sensata, making it hard if not impossible to find comparable DV in the literature. However, because multiple DF are related to each other and grouped together it is possible to generalize them and discuss them as a group, the following groups were defined:

- Overview and insight.
- Cost allocation.
- Resource allocation and understaffing.
- Budget forecast is not veracious.
- Changes, tests and technical challenges.
- Customer or scope of project changes.
- Time pressure.
- PM change

Overview and insight, cost allocation and resource allocation and understaffing are three groups that belong to the Actuals theme because the directly influence the actuals and prevent the PM in getting a good and realistic few of the current state of the project. Overview and insight and cost allocation both fall in the category of fail factors as a result of managerial issues as they are not a result of technical issues or environmental issues, they can directly be influenced by management. It is important to remark here that managerial errors are not only errors made by the PM but management in general. These

two groups are not directly mentioned in the literature as fail factors. Resource allocation and understaffing is the result of managerial and technical issues because the project team is reinforced because of technical issues, on the other hand it is a managerial issue when not all allocated hours are actually spent on the project. This group is actually mentioned in the literature by Cerpa and Verner (2009).

Budget forecast is not veracious is the only group of the Budget theme, all deviation factors found in this group result in problems for making a reliable budget. Clearly a managerial issue as the budget is set up by managers. This problem is actually discussed by multiple authors. Matta and Ashkenas (2003) mention white space what is clearly mentioned by PMs who build a buffer in their budget by asking more then they expect is necessary.

The construction theme consists of four groups: Changes, tests and technical challenges, customer or scope of project changes, time pressure and PM change. Changes, tests and technical challenges is the result of technical issues, either directly concerning the product, its testing equipment of issues regarding samples. As can be expected there are no DF found in the literature that directly mention technical difficulties as multiple researchers report that the cause for failure is often managerial rather then technical.[82] Customer or scope of project changes is a managerial issue and also found by Cerpa and Verner (2009). Time pressure is hard to categorize and maybe falls in all three fail factor categories as it can be the result of technical issues, management errors or environmental issues. It is also not surprising that this DF that is very broad is mentioned by Pinto and Kharbanda (1996) and multiple times by Cerpa and Verner (2009). Finally change of PM can be categorized as an unexpected DF as a PM leaving is probably not planned at the beginning of a project. It is not mentioned directly in the literature but Pinto and Kharbanda (1996) do mention weak leadership.

What stands out is that the found Deviation Factors are not found a lot in the studied literature. One reason for this is already mentioned and that is that DF are very specific, but also described very specific making it hard to relate different finding with each other. The other side of this issue is that many DF are related to each other and belong to a group, either based on their origin: Technical, managerial or environmental. Or based on the project phase were they occur: During Budgeting, collecting Actuals or Construction.

What however is clear is that there is an issue regarding the actual data of the financial reports. This was found as DV in this study but is also recognized in the literature.

[82] See Pinto and Kharbanda 1996, pp. 52-53; Dilts and Pence 2006, pp. 390-395; Cerpa and Verner 2009, pp. 130-134; and Sauser et al. 2009, pp. 676-677.

An attempt to correct for this immediatly yielded better results, but the reliability and usability for this study and project manager can be questioned.

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5 Using the World Cafe to bring together stakeholders to get usable results for practice and science

5.1 Prioritize the deviation factors and generating solutions by using the World Cafe method

The purpose of this chapter is to find possible solutions to reduce or eliminate deviations and answer RQ3. This is done by setting up a World Café, why and how this is done is first discussed, followed by its results. This chapter concludes with the discussion of the found solutions and if and how they relate to solutions found in the literature.

To identify possible solutions to decrease or eliminate the found deviation factors. Based on the found themes a *World Café* will be organized to discuss the deviation factors and develop solutions. A World Café is a structured conversational workshop in which small groups of people discuss a topic at several tables. By periodically switching tables participants can add to the existing findings of a discussion and learn what previous participants have expressed. The World Café is a very flexible method that can be adapted to various situations and needs. The World Café originated from need, because of bad weather, at the house of Brown and Isaacs in 1995.[83] Proving to be an unexpected successful approach they identified seven key World Café design principles by research and experimentation.

This is an overview of the seven World Café design principles, in the book of Brown and Isaac a complete elaboration of the principles and the World Café in general can be found.[84]

[83]Brown and Isaacs 2005, pp. 15-16.
[84]Brown and Isaacs 2005, pp. 42-153.

Set the context:

Clarify the purpose and broad parameters within which the dialogue will unfold.

Create hospitable space:

Ensure the welcoming environment and psychological safety that nurtures personal comfort and mutual respect.

Explore questions that matter:

Focus collective attention on powerful questions that attract collaborative engagement.

Encourage everyone's contribution:

Enliven the relationship between the "me" and the "we" by inviting full participation and mutual giving.

Cross-pollinate and connect diverse perspectives:

Use the living-system dynamics of emergence through intentionally increasing the diversity and density of connections among perspectives while retaining a common focus on core questions.

Listen together for patterns, insights, and deeper questions:

Focus shared attention in ways that nurture coherence of thought without losing individual contributions.

Harvest and share collective discoveries:

Make collective knowledge and insight visible and actionable.

When these simple principles are used in combination, they provide useful guidance for anyone seeking creative ways to stimulate dialogue in which the goal is thinking together and creating actionable knowledge.[85]

The World Café method is a form of participatory research, that is starting to draw interest from diverse sectors in recent years.[86] The principle of participatory research is planning and conducting the research process with the people whose life-world and actions are under study. This large group method is a way of achieving whole-system change[87] by bringing together diverse stakeholders.[88] The aim of the method is to benefit from two

[85]Brown and Isaacs 2005, p. 40.
[86]Aldred 2009, p.59.
[87]Jorgenson and Steier 2013, p. 388.
[88]Steier et al. 2008, pp. 167-180; and Tan and Brown 2005, p. 83.

perspectives; science and practice,[89] so that both sides benefit from the research process.[90] Currently, literature on World Café remains fragmented, keeping to dedicated websites and sub-fields of organizational development and community development studies.[91] However the World Café method is gaining popularity and has found application in diverse settings, including the work environment.[92]

There may not be an abundance of studies based on World Cafés, however there is enough material to get a good idea of the method. Fouche and Light (2010) write that "the World Café offers promising options of collective discoveries and collaborative learning. It will also resonate well as a powerful method of data collection with qualitative researchers promoting the focus group context as an advantage."[93] The World Café also proved to be an good method to engage and include stakeholders in the process, it encourages contributions to topics that one might not feel confident in contributing to in a big group discussion.[94] It was found that using World Café method generated useful recommendations and led to a representable outcome.[95]

5.2 The results of the NPD Café: deviation factors and their solutions

In section 5.1 it is discussed why the World Café is a suitable method to find possible solutions regarding the found DFs. The World Café at Sensata was named the NPD Café to empathise the topic. The central question that was asked at the beginning was: *What would it take to decrease the deviation from the project budget?* The goal of the event was to answer this question and find actionable, practical solutions; What can we do tomorrow to solve this problem?

Important for a successful World Café is that a good mix of stakeholders participate to contribute to the event. After deliberation it was decided to invite all the PMs, the group managers (managers of the technological groups), two people from finance and the PM manager. Unfortunately it proofed difficult to find a suitable date at which it was likely that enough stakeholders could participate. Eventually it was decided to hold

[89] Schiele et al. 2014, p. 17.
[90] See Aldred 2009, pp. 57-58; and Bergold and Thomas 2012, p. 2.
[91] Aldred 2009, p.57.
[92] Hess et al. 2006, p. 132.
[93] Fouche and Light 2010, p.46.
[94] Fuller et al. 2013, p.304; and Broom et al. 2013, p.257.
[95] Jorgenson and Steier 2013, p.400-402; and Broom et al. 2013, p.257.

the event during an one hour lunch break, this way the participants could enjoy a (free) lunch and partake in the event. In the end 23 people were invited of which 11 confirmed there attendance, two of them were unexpectedly occupied the day of the event, leaving 9 participants.

For the NPD Café a conference room was booked. To create a hospitable area, a group of three tables were put together close to the window to make the most of the natural light and view. In the room there were no round tables available so the trapezium tables had to do. The tables were the right size, usable for four to five people. Each table got a flip-chart as table cloth and enough pens, markers and sticky-notes. Because the event was during the lunch, a cold buffet was set up along the tables. Combining a World Café with a lunch seems a good way to set a relaxed informal atmosphere.[96]

A limited turnout was somewhat expected and therefore fixed table hosts were used, this way all the guest were free to move around. One of the hosts was the researcher of this study and two additional hosts were found in two other graduating students at Sensata. As instruction and aid for the discussions a *table host instruction* was prepared, see Appendix 2, section 1.

As a result from the limited time available, only short rounds were possible, while one and half to two hours is recommended[97] for a World Café. To make the most of the time available and focus on the question that matter, all the DFs were laid out along the tables and all the participants were asked to start by reading them and putting one, two or three stickers on the DF that they thought were most important. There was no limit on how much DFs they could mark, but everyone was asked to use at least six stickers. This resulted in a ranking of the DFs and a starting point and focus for the discussion. The outcome of this process can be found in figure 5.1 These results of the stickering are then combined with the results of RQ 2. The results are normalized by expressing the # mentioned and priority rating in their respective percentage of the total # mentioned and the total amount of stickers used, this results in figure 5.2.

When the stickering was done everyone was asked to find a place at a table and start the discussion. The three tables each focused on a different Theme of DFs: Actuals, Budget and Construction. Ghe discussion was started with the DFs that had the most stickers. The rounds were 15 minutes what is quite short, but not much shorter than the 20 minutes rounds that are used frequently.[98] The World Café workshops from UNICA

[96]Thunberg 2011, p.323; and Broom et al. 2013, p.255.
[97]Brown and Isaacs 2005, p.163.
[98]See Fouche and Light 2010, p. 40; Kanie and Betsill 2012, p. 295; Broom et al. 2013, p. 255; and Fuller et al. 2013, p. 302.

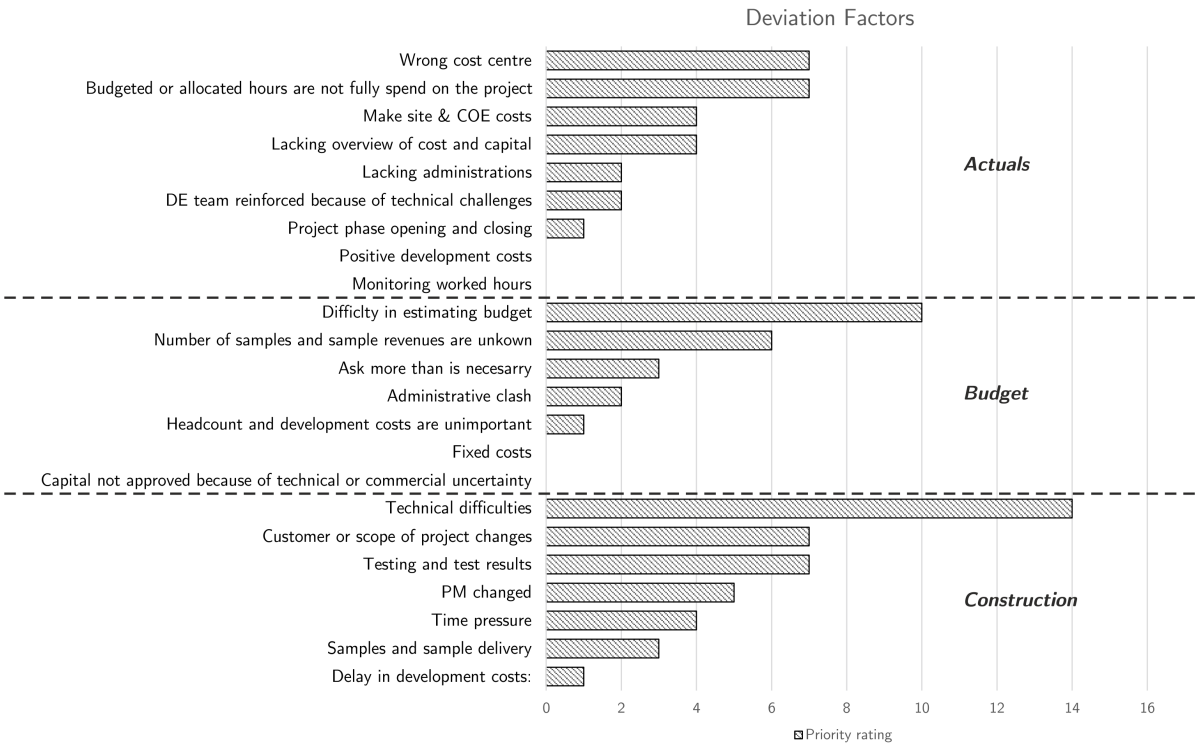

Figure 5.1: The amount of stickers are called the priority rating, in this graph they are grouped by theme and sorted from high to low.

even have rounds that only take 10 minutes.[99] After each round the participants could freely choose any other table, but they had to move from the one they were sitting at. After round two they were free to go back to their first table if they wanted. To ensure an even distribution of guests, each table had to have a minimum of three guests.

The table hosts encouraged everyone to contribute and make use of the table cloth to visualize problems and connections. The results of these scribblings can be found in appendix 2, section 2. At the beginning of round two and three the table hosts summarised what was discussed in the previous round and asked if and how this related to what the new group had discussed. At the end of round three the table hosts asked their guests to write on a sticky note a single solution, question, problem of finding that they discovered or found most important during the discussions. All these sticky notes were then put on the "Wall of knowledge". This resulted in the following list as can bee seen in table 5.1.

[99]UNICA n.d.

Wall of Knowledge

- Consolidate knowledge on tools and guidelines.
  - Relation technical challenge / expected cost.
  - Risk vs. cost expectations.
  - Quality technical review.
- More focus on technical assessment.
- DE technical assessment should be:
  - Thorough.
  - Leading for planning and budget.
  - Should improve.
- To opportunistic marketing. Need better risk management. Engineering is to lean. More details on samples from customers needed .
- Project tool: Real-time actuals vs. budget.
- Take NPI estimation more seriously. Discuss assumptions with other PMs or supervisor.
- Allocated resources should "feel" assigned to the project and have discipline to work on it. Not on other projects.
- Create time for technical assessment (now 3 weeks in quote phase).
- Make sure "technical challenges" are clear before offering.
  - Pre-development.
- Project definition.
  - Technical assessment vs. scope and planning
- Resource allocation.
  - Actuals vs. Budget(=flat file)
- Tool for making a budget.
  - "standardizing"

Table 5.1: Results from the NPD Café

Figure 5.2: Deviation Factors with # mentioned and priority rating expressed in % of total.

In the end the NPD Café was a pleasant experience. It was expected that it would be hard to get the discussions started, but that was not the case. All the guests contributed to the discussion and most even made use of the table cloths. Afterwards guests remarked that they found it a fresh and new way to brain-storm and discuss about issues that matter. In retrospect however it would have been better if the rounds were longer so there is more time for elaboration and working on new solutions together.

5.3 Solving practical problems by linking the practical solutions to the theoretical solutions

To find solutions to the Deviation Factors found at Sensata first it is important to understand the problems and which problems are most pressing to solve. For this the stickering was done during the World Café.Two things stand out when looking at figure 5.2. First the trend that DFs that were mentioned more often tend to have a higher

priority rating. Secondly some items that were mentioned during the interview received no stickers during the NPD Café, meaning that they are responsible for some deviation but are not considered a major problem.

Keeping in line with the lean six sigma methodology Sensata is familiar with. Focus on the big problems first, would be a good approach. A solution that targets one or more big problems will improve the situation significant. So what are the "big fish" that need to be targeted first? When running the numbers on the DFs, it becomes clear that the top 10 DFs account for 70% of the combined # mentioned and priority rating. This means that the DFs above the line in figure 5.2 are the most relevant DFs in the projects.

So what about the solutions gathered on the wall of knowledge? Well in general it are very specific solutions to very specific Deviation Factors. However when looking to the top 10 DF and the solutions on the wall of knowledge, they both revolve around the uncertainty of technological development; How much work is it, how long does it take and what are the risks? The DF Technical difficulties, difficulty in estimating budget, (customer or) scope of project changes, testing and test results and ask more than is necessary all contribute to the inherent risk of New Product Development. On the opposite there are the suggestions on the wall of knowledge to make the risk more insightful; Consolidate knowledge on tools and guideline, more focus on technical assessment, DE technical assessment should be thorough and leading for planning and budget, need for better risk management, take NPI estimation more seriously, discuss assumptions with other PM's or supervisor, create time for technical assessment, make sure technical challenges are clear before offering and technical assessment vs. scope and planning. In conclusion there is a need to do a better technical assessment to make risks more insightful what should lead to less failure due to technical difficulties and better budgets. Unfortunately the wall of knowledge does not provide in the actionable solutions that were hoped for, it does give us a direction for what needs to be improved for decreasing the deviations.

What remains are the possible solutions suggested by the literature, especially the structural solutions mentioned: Rapid result initiatives, Fitting management style and organizational integration and shared knowledge. In which way can these quite general solutions contribute to a solution for Sensata? A rapid result initiative would mean a quite short project that is used as a study case to find issues and make sure that they will not happen at larger projects. However this is actually already happening in the form of the TOP-projects, with the exemption that normal projects are used. For that matter rapid results initiatives are a succesful method as problems actually are found

with the TOP-projects, solving them remains the issue. An alternative approach to the existing TOP-projects could be to put together a TOP-team. This team would not only work on a project but is stimulated to evaluate the existing frameworks and tools and if necessary use or develop new ones. By recording and structuring the approach of this team, consolidated guidelines could be made. The best-practices of this TOP-team will propagate through the organization because members of the original TOP-team will also take part in other teams and share there approach and experiences.

This leaves us management style and organizational integration / shared knowledge. The literature suggests that the right management style should be chosen for the right projects. Of course this is quite broad and does not only included how the project is managed by the PM but also how the PM is managed and project in general. Unfortunately this is beyond the scope of this study, no research had be done regarding the current management style and what other possible management styles could be, however this is a very interesting point for future research.

The literature about organizational integration and shared knowledge suggest that glitches (deviation factors) can be prevented by improving the shared knowledge by organizational integration. In essence this is an issue of communication and a direct result of the need for several specialists resulting in multi-disciplinary teams. This is also a good starting point for further research, how is the current communication in the project teams? what goes wrong? what are the possibilities?

One more remarkable points need to be discussed that is recognized in multiple deviation factors and on the wall of knowledge. This is the issue regarding problems in the budget and actuals information. It was already discussed in the previous chapter that it seemed that a lot of information was missing or contained errors. This does not help in getting a good picture of the current situation and is a problem for the TOP-projects. The real issues may be concealed because of this or an attempt is made to remedy Deviation Factors that are not actually an issue. This is certainly a point for improvement and among the suggestions on the wall of knowledge were: A lack of standardization, guidelines and tools that are not consolidated. A clear hierarchy or relation between the available tools seems to be missing. In order to meet this whish for a tool, a small side step was made to look into the development of such a tool. Unfortunately there are not much scientific publications on tools in regard to budgeting NPD projects. If there is a lack on such research or if it is simply not published because of confidential information, one can only guess. However one interesting article was found. House and Price (1991) discussed *The Return map*, a tool used by Hewlett-Packard

for tracking product teams. The two dimensional tool tracks the progress of time and money in the project combined with some Key Performance Indicators (KPI). One of the strengths of the tool is that when it is updated along the project, the effects of changes on time, money and the KPIs can be easily seen.[100]

An important consideration in the development and use of an NPD tool is:

> *"Missed forecasts are inevitable, but managers who punish employees for missing their marks will only encourage them to estimate conservatively, thus building slack into a system meant to eliminate slack. Estimates are a team responsibility, and deviations provide valuable information that spurs continuous investigation and improvement."*[101]

In Appendix C, section 2 the development of such tool is being further discussed as the construction of this goes beyond the scope of this study.

[100] See House and Price 1991, pp. 92-100.
[101] House and Price 1991, p.42.

6 Limitation, recommendations and conclusions

6.1 Limitations as a result of organizational specific findings and missing data

At the beginning of this study some assumptions have been made which have to be revised. The assumption being that only the cost of a project could be considered as a variable for project performance, because time and quality were fixed. While hypothetical this should be the case in practice it is different. Sometimes it is found necessary to make concessions to quality in order to deliver the project on time or within the budget. This however may result in a product that fails more frequently, leading to complains from the customer and putting a lot of strain on the quality department. A second implicit assumption that was made is that the provided information was complete and correct. This however proved to be an issue. During the interviews with the Project Managers it already became clear that project reports contained missing and not always correct data. This of course puts question marks at the reliability of the remaining data.

Another limitation is external validity of this study. This however was clear from the beginning and it was mentioned in the literature that deviation factors are very organization or even project specific.[102] The results of this diagnostic qualitative research are very case specific. What remains then is to which extend is it valid for Sensata globally? As this study was performed at Sensata Almelo in the Netherlands one has to account for the culture in the specific organization. Fortunately Sensata has structured its NPD with their GNPD process, what is used globally. Additionally some project teams include engineers from another international location. At the moment it is even the case that some Bulgarian engineers are being trained at Sensata Almelo with as goal to start a engineering department in Bulgaria, that eventually also can do NPD.

[102] See Link 1987, pp. 109-117; Belassi and Tukel 1996, pp. 141-151; Pinto and Kharbanda 1996, pp. 45-46; Sauser et al. 2009, pp. 676-677; and Rauniar and Rawski 2012, p. 949.

These developments suggests that the results of this study can be generalized to Sensata globally, especially to the future Bulgarian engineering department.

A final limitation has to be attributed to the empirical part of this study. Although the World Café can be considered a success, it was not without faults. The attendance was low, and less than expected, limiting the amount of contribution from different stakeholders. The table hosts also remarked that because of the limited time, topics could not be discussed in great detail, this problem was also recognized by Fuller et al. (2013).[103] The result of this is that it is also questionable if the results on the Wall of Knowledge are findings that resulted from the World Café or ideas the guest had upfront. The time seemed to short for people to constructively generate actionable solutions together.

6.2 Recommendations for Sensata based on practical problems and theoretical solutions

What do the findings of this study contribute to the organization? From the analyses of the financial statements is becomes clear that the reliability of the actuals should be considered when evaluating the budget. It should become a priority to make sure that this information is complete and accurate. Trying to improve budgeting based in incomplete information only leads to a garbage in, garbage out process.

Based on the findings from the interviews and NPD Café a list of deviation factors has been compiled and ranked according to appearance and priority. Using this list, solutions can be sought and evaluated on how much they contribute to solving the different DFs. The Wall of Knowledge revealed some causes for the DFs and guidance for possible solutions.

However a more structural solution is probably desired and for this the solutions in the literature are discussed. First, Based on the rapid result initiative a TOP-team is suggested in order to find problems to prevent them in future projects. Secondly it is suggested that current management style regarding projects is evaluated, is it actually the right approach for the job? Finally the functioning of the multi-disciplinary teams needs to be examined, because of unsufficient shared knowledge between the specialists glitches (deviations factors) may occur. Communication is central in this issue and needs to be further investigated.

[103]Fuller et al. 2013, p.304.

6.3 summarizing the study approach and answering the research goal

The goal of this study was to find an explanation for the budget deviations of the projects at Sensata Almelo. This was done in three steps, first the information from the project reports was analyzed. Secondly these results were discussed with the PM's in an interview and put into perspective using relevant literature. The final step was confronting the "project stakeholder" with the found deviation factors during a World Café event. Together with the literature this resulted in possible solutions. In addition, based on the results of the wall of knowledge a tool was developed to make the risk and consequences of some deviations insightful (see Appendix C).

Initially deviations up to 50% were expected and this was confirmed after analyzing the project reports. However it was found that the deviation of all the projects were below the forecasted budget and never above. The most likely explanation of this is incomplete information, unfortunately this severely limits the reliability of the data and thus the possibility of getting clear answers.

In conclusion, the answers on research questions directly contributed to the goal of this study: *Identify the causes for the deviation from the project budget within Sensata and give an overview of the problems, supplemented by an investigation for possible solutions.* The answers to the research questions directly contribute to the goal of the study. Twenty three deviation factors were found and based on these problems and the solutions generated during the NPD Café, three possible solutions found in the literature are discussed and how they may benefit Sensata.

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Appendix A. Interview Guide

1 Dutch version

Interview:

1. Introductie:

   Voorstellen en onderwerp introduceren, eigenlijk zoals in de e-mail.

2. Vragen:

   2.1. Kun je me in het algemeen wat vertellen over dit project?

   2.2. Hoe gaat het opstellen van de begroting in zijn werk?

   2.3. De grafieken introduceren en aan de hand hiervan de relevante project fasen bespreken en de oorzaken van de verstoringen die in de fases voorkomen.

   2.4. Het algemene verloop van alle posten bespreken en de oorzaken voor de verstoringen voor opvallende afwijkingen bespreken.

   2.5. Ben je, met betrekking tot dit project of projecten in het algemeen, nog andere verstoor factoren tegengekomen?

3. Samenvatten:

   De besproken problemen (deviation factors) herhalen.

4. Bedanken:

2 English version

Interview:

1. Introduction:

   Introduce myself and the subject, as in the e-mail.

2. Questions:

   2.1. Can you tell me something about this project in general?

   2.2. How does the preparation of the budget happen?

   2.3. Introduce the graphs and discuss the deviation that occur in the relevant project phases and the reasons for these deviations.

   2.4. Discuss the general course of all budget items and the reasons for any notable deviations.

   2.5. Have you encountered, in this project or others, any other deviation factors?

3. Summarize:

   Repeat the discussed deviation factors

4. Wrap up:

Appendix B. World Cafe

1 Table host instructions

NPD Café

Invitation: Different kind of meeting where everyone will have an active opportunity to contribute.

Central Question: What would it take to get rid of these deviation factors?

Setting the context:

- Purpose: Learning conversation to find actionable solutions for the deviation factors.
- Participants: PMs + Stakeholders (Managers and Finance)
- Parameters: Three groups, Three tables were another Theme is discussed. One permanent table host to record, summarise and stimulate the discussion. The starting point or guidelines are the Deviation Factors.
- At the event: Remember those coffee machine conversations, were some of the best ideas originate?

Create hospitable space: Informal, lunch time conversation

Explore questions that matter: Genuine questions: Ones for which we donâĂŹt already have answers, are open invitations to innovation. Calling forth ideas and insights that don't yet exist.

Encourage everyone's contribution: Inviting everyon's contribution. Encourage to contribute, but do not push to contribute in a verbal way. Facilitate it.

Cross-Pollinate and connect diverse perspectives: What happened at the previous table, how is it related?

Listen together for patterns, insights, and deeper questions: Goal is to learn from each other

Harvest and share collective discoveries:

- Welcome the guests
- During each round, fill a flip-chart that answers:
- encourage everyone to write, draw or doodle.
- What have we discussed?
- What have we learned during this conversation?
- What are the important questions?
- What have can we do tomorrow to solve these problems?
- What is missing from the picture? What needs to be clarified?
- Reflect on and consider ideas.
- Round 2 and 3: How does this Theme connect to the other Themes?
- This output is used as input for the next round
- After round 3 ask: Write on a sticky note what key insight, idea, discovery or solution have you found during the conversations?

2 table cloths

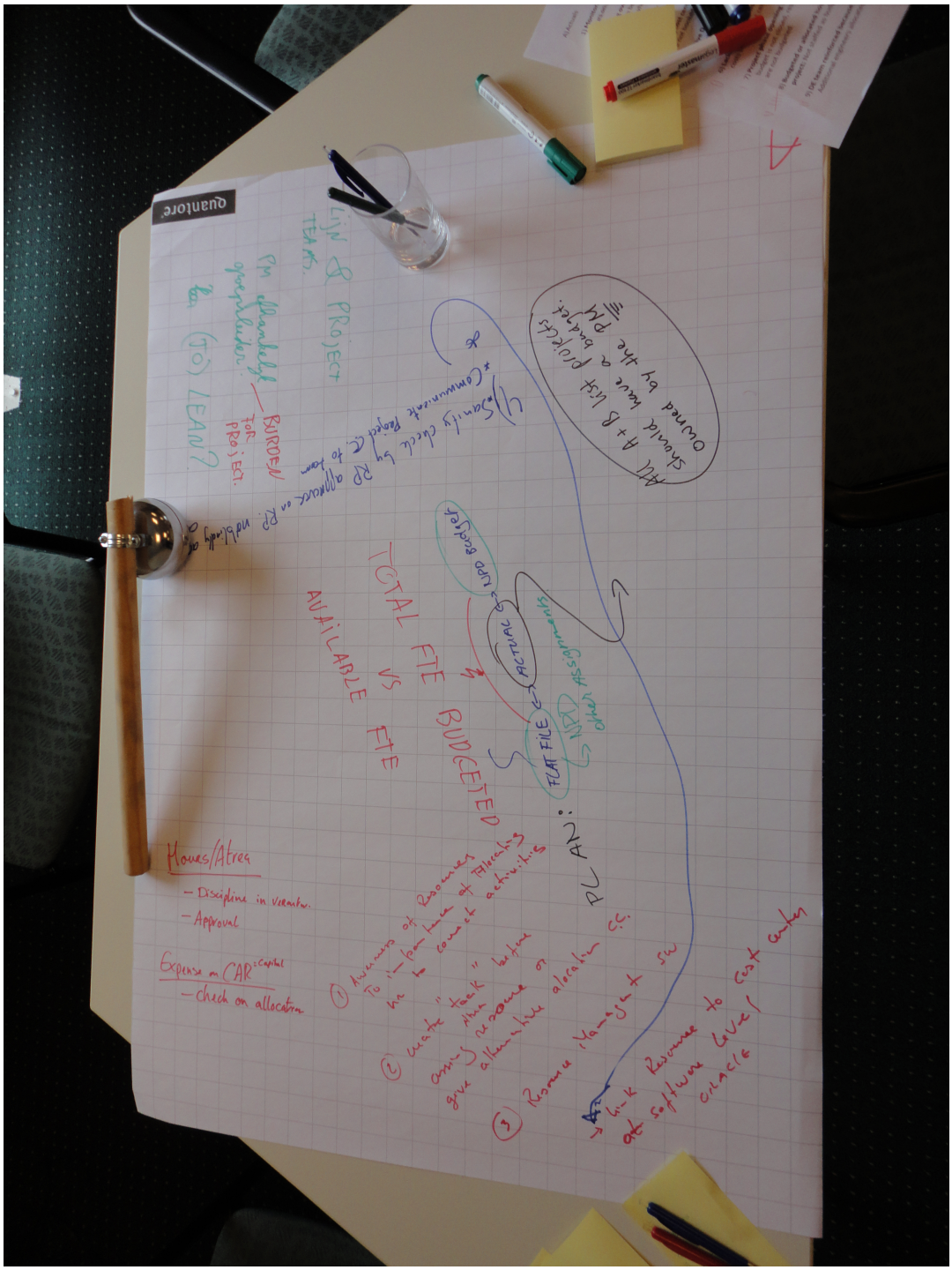

Figure B-1: The tablecloth of the Actuals table.

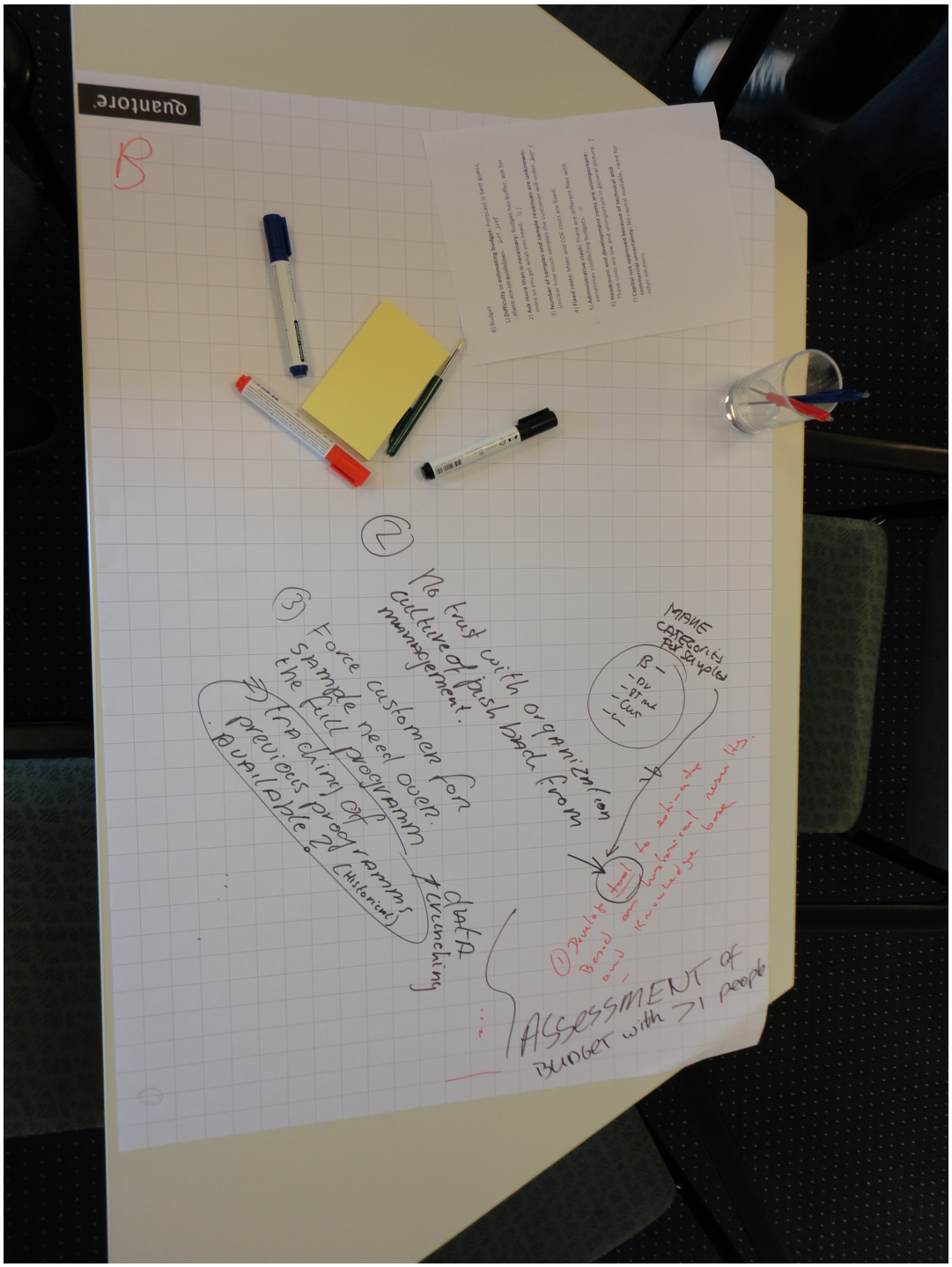

Figure B-2: The tablecloth of the Budget table.

B.4

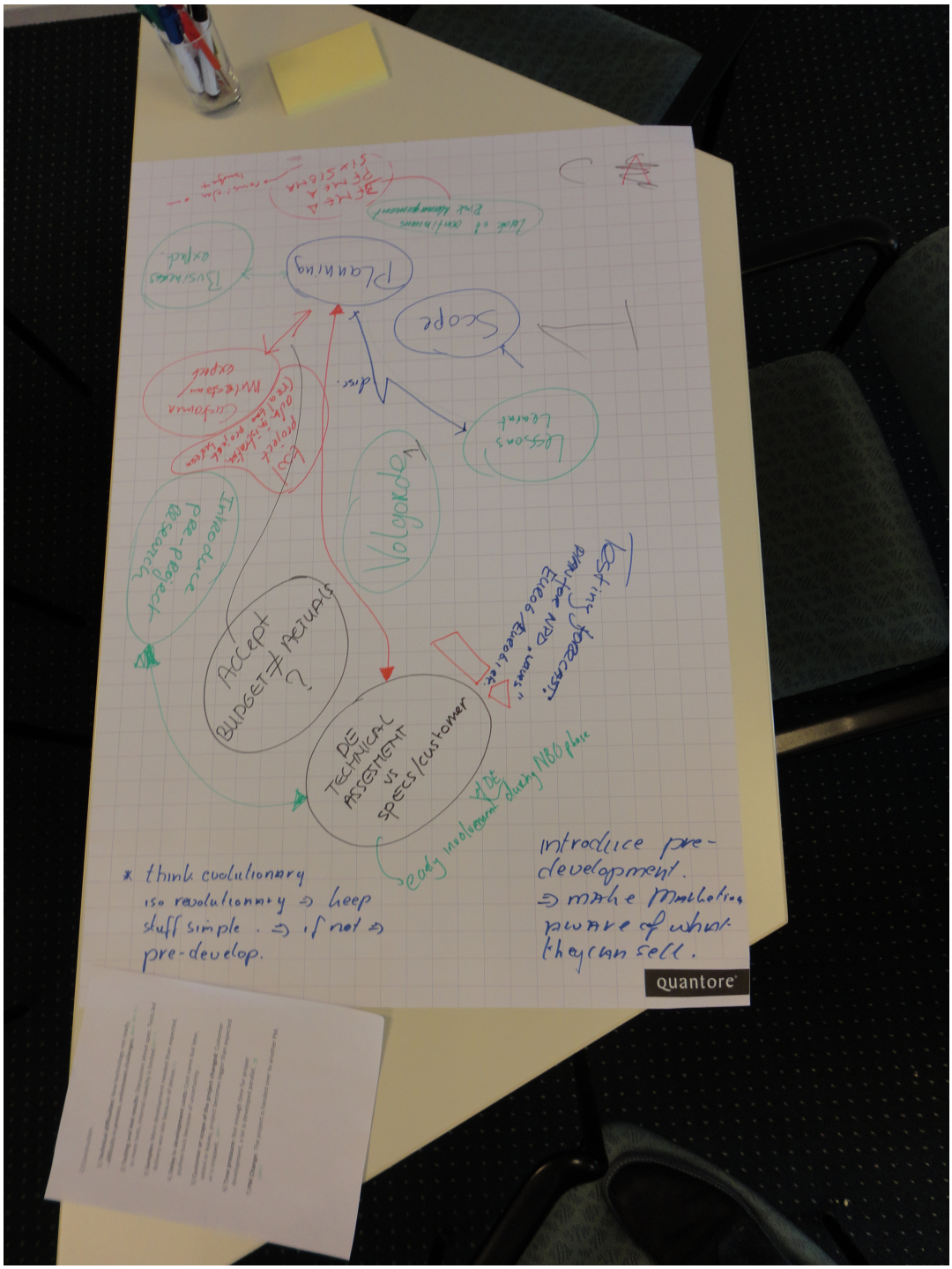

Figure B-3: The tablecloth of the Construction table.

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Appendix C. Tool

1 Tool construction

As part of the assignment, a tool based on the study findings was developed. During the initial phase several possibilities for the tool were considered. Although a database with all available historic project data was preferred, this was not obtainable in the available time. The obvious choice was to develop the tool in Microsoft Excel, this had several reasons: First, all the data of each TOP-list project was consolidated in its own Excel workbook based on the same Project Reporting template. Because of this it was possible to develop a new worksheet that could be plugged-in into each project workbook. Secondly Excel already was a widely used program among the PMers and within Sensata, making it a user friendly solution for the user-base.

The purpose of the tool is to offer insight regarding possible deviations. In other words; why and how much will the project deviate from its monthly projection. By making the effects of "expected" deviations insightful in a early stage, actions can be taken to bring the project back on track. An additional feature of the tool is that it reveals deficiencies of the collected actual financial data. If gaps or unexpected deviations occur, this may be due faulty source data.

The tool is build to aid in the three themes found in this study: Actuals, Budget and Construction. It helps Budgeting by providing a platform to make a budget with minimal slack, the effect of risks during the Construction can be evaluated. By doing this there is no need for extra margins in the budget and the budget can be according the most likely scenario. In addition the available Actuals are shown together with the budget and the risk spread in a graph. The relation between these metrics is clear this way and missing information is easily spotted.

Based on the top 10 DF (see table C-1), that account for about 70% of the deviations, this ABC-Top tool tries to aid the PM during the budgeting of the project. The reason that not all the DFÂťs are included it to prevent the tool from becoming to laborious to use. It is aimed at preventing the most common and important deviations with minimal effort. However, two "blank" fields are included for the PM to add project specific or unique deviations that have such a large impact that they need to be included.

These Deviation Factors are operationalised based on risk, that is analysed based on its potential consequences and probability of occurrence, such as is common in the risk

Technical difficulties
Difficulty in estimating budget
Customer or scope of the project changes
Hours and expenses booked to wrong cost centre
Budgeted or allocated hours are not fully spent on the project
Make and COE costs
Number of samples and sample revenues are unknown
Testing and test results (Design Engineering)
Sample and sample delivery
Time pressure

Table C-1: How to ensure a project's failure

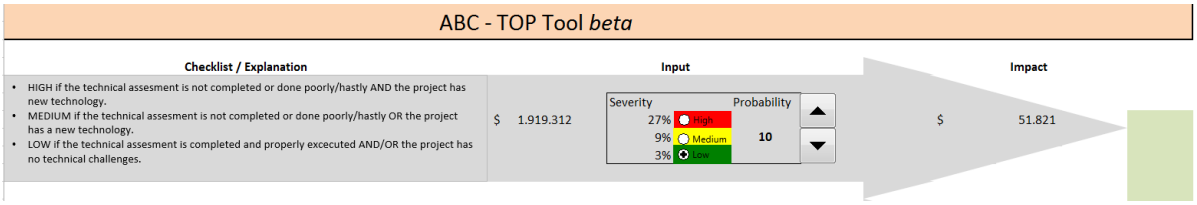

Figure C-1: Imput field of the ABC-Top Tool

management literature.[104] The size of the risk of the deviation factors is determined by calculating its impact. The impact is a monetary value that is calculated using a base valuer and a severity and probability rating. The base value depends on the deviation factor and the severity and probability are to be estimated by the PM. The final impact value can be positive or negative, depending if the probability is negative or positive. Negative meaning that a deviation below estimate is expected and positive a deviation above estimate. The severity can be low, medium or high, each with a corresponding severity rating. In figure C-1 the input field of the ABC-Top Tool is pictured, including the checklist/explanation field.

All the data is collected in a graph to give a comprehensive overview, as can be seen in figure C-2. The blue line is the budget, the green area gives the expected spread based on the impact of the deviation factors. The light red lines give the upper and lower limits of the deviation, this is the maximum deviation that can be expected, or in other words; The worst case scenario's. The red line gives the actuals, of course the aim is that the actuals follows the budget, or at least within the green area. In figure C-2 this is

[104]Baccarini and Archer 2001, p.139-141.

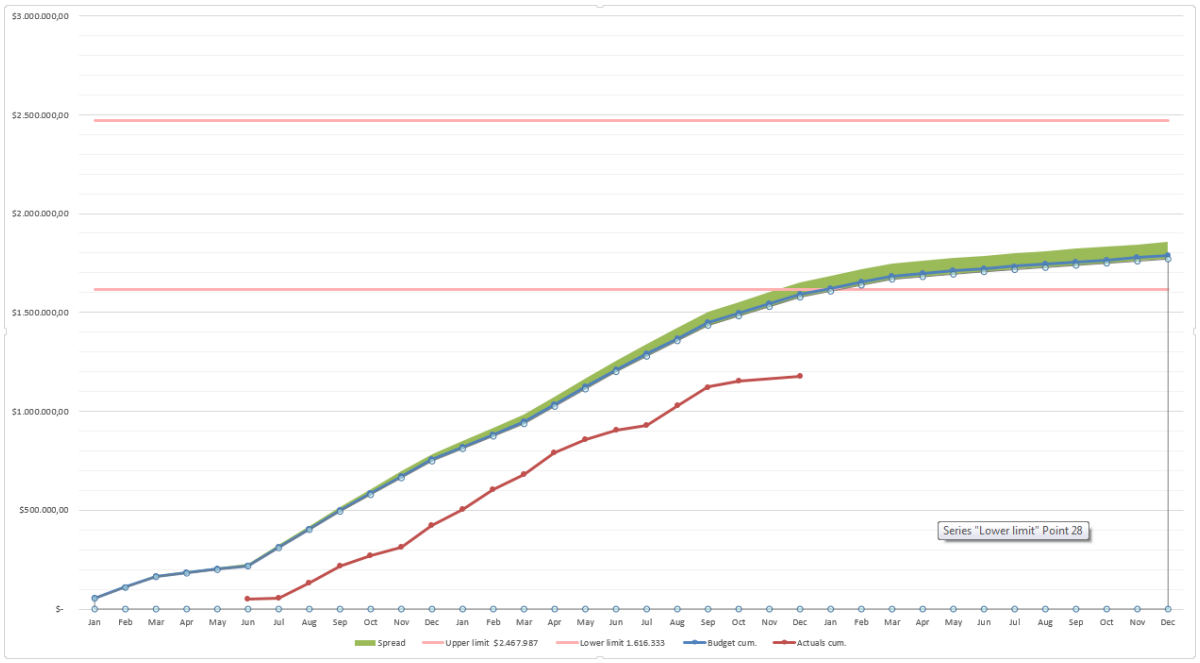

Figure C-2: Overview graph of the ABC-Top Tool

obviously not the case, but as can be seen the actuals start five months later then the budget. This can explain why it lags behind the budget, it is unknown if this is because of a delay at the project start or only missing data.

Although the tool offers an easy an quick way to asses the progress of the project there are some limitations. First when implementing the tool worksheet in all the Excel workbooks it appeared that not all workbooks were the same. Some were based on different versions of the Project Report Workbook template, while others had intrusive modifications to them. In addition there were some problems caused by the different versions of Excel that were used. The tool was originally made in Excel 2013, while Sensata was still working with an older version. This mainly resulted in errors with the used macro's and some minor layout issues. These problems were solved by converting the tool and the macro's to a special compatibility mode, however future problems caused by new Excel versions are not unthinkable. A second issue is that the tool is untested. The initial data is partly based on findings in this study supplemented with input from the PMs. It is advised that the tool is tested during some complete project cycles to evaluate for example the values used for the different levels of severity. Finally the tool depends greatly on the data that it used for input. If there are errors in this data or it is

incomplete the tool will give a wrong impression. Or, as is the case with many analytical tools: Garbage in = Garbage out.