Master thesis

Department of Industrial Management and Logistics
Production Management
Lund Institute of Technology

Managing Product Development

– Mapping efficient resource allocation

Authors **Björn Fröberg**
Martin Kållberg

Supervisors *SW Seed:*
Bengt Jacobsson,
Marketing director
Mattias Pålsson,
Business Controller

Lund University,
Faculty of Engineering:
Ola Alexanderson
Department of Industrial Management and Logistics, Production Management

Preface

The plant breeding industry was in many ways a blank chart for us when we accepted the challenge to understand the difficulties in this kind of product development (PD). Now, after some six months in a tower room in Svalöv, the picture is somewhat clearer and paints an exciting canvas of an industry facing the challenging task to incorporate, in many ways unique, internal and external uncertainties through their long PD cycles. Throughout this thesis great aid has been provided by our supervisors at SW Seed, Bengt Jacobsson and Mattias Pålsson – our discussions on difficulties and possibilities as well as your encouragement have been vital to the end result. We also like to thank all the respondents at SW Seed who freed time in busy agendas to answer our questions and helped in building our understanding of the plant breeding secrets. Special thanks go to Tina Henriksson who carried a heavy burden by being our key target in the mapping of the PD process and answered our often less insightful questions with great patience.

The work with this master thesis marks an end to our MSc studies in Industrial Engineering and Management at Lund University, Faculty of Engineering (LTH). In this final effort, we've been guided by our supervisor at LTH, Ola Alexanderson, whose thoughtful comments helped us pinpoint several interesting areas connecting the academic world with the reality outside university premises. In all, the years in Lund have rewarded us with countless moments of laughter and many exciting insights within various industries and theoretical fields, but they also demanded a tribute through early mornings, late hours and, from time to time, neglected close ones. For the support we've received from our families and friends we're truly grateful. Especially our thanks go to our respective fiancées, Sara and Pernilla – without your support we wouldn't be here today.

Lund, 12th of June 2008

Björn Fröberg & Martin Kållberg

Abstract

Title Managing Product Development – Mapping efficient resource allocation

Authors Björn Fröberg, Industrial Engineering and Management student -05, LTH
Martin Kållberg, Industrial Engineering and Management student -04, LTH

Supervisors Bengt Jacobsson, Marketing Director, SW Seed
Mattias Pålsson, Business Controller, SW Seed
Ola Alexandersson, Department of Industrial Management and Logistics, LTH

Backgrund Product development (PD) in the plant breeding industry is characterized by long development cycles and decisions framed with uncertainty concerning key questions such as likely future competitor actions or the market outlook 10-15 years from now. In many ways the contemporary picture of the industry is changing rapidly; new technologies are developed to shorten the length of PD cycles and time-to-market, competing with proven methods to deliver on key objectives such as sufficient properties in resistance and quality traits. The ambition to position SW Seed as a key player in this changing environment demands a structured way to incorporate both certain and uncertain factors in the strategic as well as tactical decisions made in PD.

Purpose This thesis addresses this demand by delivering on three objectives; firstly the current ways of developing crops at SW Seed are elicited, complete with price tags on key activities driving the major costs. Secondly the elicited process is analysed and tweaked according to the latest findings in the theoretical field of PD in order to develop a generic process better suited to describe and evaluate the activities in PD. Thirdly a set of key metrics to follow up and manage the process are proposed, both to adjust a flawed process proactively and to measure the PD process performance in a longer time perspective.

Method The task of costing the current PD process follows the activity-based costing (ABC) methodology, acknowledging that activities in a process rather than functions deliver value and customer satisfaction. A prerequisite of allocating costs to activities is a map over the activities conducted, described at a reasonable level of detail. No such map of the current PD process at SW Seed was in place prior to the thesis, rendering the compilation of one the first prioritization. In delimiting the thesis perspective a decision was made to model the description based on the Winter wheat Baltic programme. The programme had sufficient size, characteristics as well as the staff requirements sought. Following the walk-through methodology in process mapping; identifying and interviewing key personnel in the PD process, a mapping of the conducted activities were achieved.

Conclusions The thesis main result is the BREED process; Breeder’s Roadmap to Efficiency and Excellency in product Development. The building of BREED included elements of process design, using the elicited activities in the current process as building blocks, structuring them to facilitate the introduction of formal decision-points (DCP). In four DCP's, spread over the thirteen year long PD process, external as well as internal factors are weighted to enable tough project reviews, aiming to allocate resources to the projects best aligned with SW Seed strategy, holding the biggest potential for future revenues. A dugout in the company accounting system showed that 87 % of the direct costs – the costs that affects, and is affected by, the sought decisions – can be allocated to the BREED activities. In all, the methodology proposed by the BREED process should create new opportunities for SW Seed to evaluate and manage their PD process in a way better suited to cope with the internal and external challenges inherent in PD in general and plant breeding specifically.

To manage a PD process aspiring for efficiency and excellency the key is to evaluate and adjust the process according to four critical success factors (CSF); develop a clear innovation and technology strategy, enable empowered multifunctional PD teams, scrutinize PD projects through portfolio management and implement a rigorous stage-gate process (such as BREED). The challenge for top level management is to translate the overall strategy objectives, expressing them both in terms of these CSF's and through the connections between these factors and the day-to-day work within the PD process. To aid general management in this task a metrics-matrix for gap analysis between current and best practice is presented to deliver on the third thesis objective.

Key words Product development, resource allocation, plant breeding, process mapping, the BREED process, Stage-gate, decision-points, new product performance, measuring processes, key performance indicators (KPI), SW Seed

Sammanfattning

Titel Managing Product Development – Mapping efficient resource allocation

Författare Björn Fröberg, Industriell ekonomi -05, LTH
Martin Kållberg, Industriell ekonomi -04, LTH

Handledare Bengt Jacobsson, Marketing Director, SW Seed
Mattias Pålsson, Business Controller, SW Seed
Ola Alexandersson, Institutionen för Teknisk ekonomi och logistik, LTH

Bakgrund Produktutveckling inom växtförädlingsindustrin karaktäriseras av långa utvecklingscykler och beslut omgärdade av osäkerhet rörande nyckelfrågor så som konkurrenters troliga handlingar och marknadens utseende 10-15 år in i framtiden. I många avseenden förändras den samtida bilden av industrin snabbt; nya teknologier utvecklas på jakt efter kortare produktutvecklingscykler och en snabbare ledtid till lansering, samtidigt som de måste klara samma krav som beprövade metoder och leverera resultat inom produktegenskaper så som resistans och kvalitet. Ambitionen att positionera SW Seed som en aktör att räkna med i denna föränderliga miljö kräver ett strukturerat sätt att införliva både säkra och osäkra faktorer i de strategiska och taktiska besluten som fattas inom produktutvecklingen.

Syfte Det här examensarbetet adresserar detta krav genom att leverera resultat inom tre mål; det första är att kartlägga den nuvarande processen för att utveckla grödor inom SW Seed, komplett med prislappar på de nyckelaktiviteter som driver de största kostnaderna. Det andra är en analys och justering av den kartlagda processen i enlighet med de senaste rönen inom det teoretiska området för produktutveckling, detta för att utveckla en mer allmängiltig process, bättre lämpad att beskriva och utvärdera aktiviteterna inom produktutvecklingen. Det tredje målet är att föreslå en samling nyckelmått eller KPI:er (key performance indicators) för att kunna följa upp och styra processen. Detta både för att kunna justera en felaktig process proaktivt och för att kunna mäta produktutvecklingsprocessens resultat på längre sikt.

Metod Kostnadssättningen av produktutvecklingsprocessen följer arbetssättet i ABC-kalkylering, något som understryker åsikten att aktiviteterna i en process snarare än olika funktioner är det som levererar värde och kundtillfredsställelse. En nödvändig förutsättning för att allokera kostnaderna är en beskrivning, på en lämplig detaljnivå, över de aktiviteter som utförs inom produktutvecklingsprocessen. Innan detta arbete fanns det inte någon sådan karta varför sammanställandet av densamma blev en första prioritet. En avgränsning av kartläggningen har gjorts till att beskriva processen inom programmet för höstvete (för norra Europa). Detta då programmet bedöms ha tillräcklig storlek, karaktäristik samt rätt personaltillgångar för att möjliggöra en framtida generalisering av den funna processen. Genom att använda en genomgångsmetodik i kartläggningen av processen innebärande att nyckelpersoner identifieras och intervjuas, så kunde den sökta processbeskrivningen tas fram.

Slutsatser Ett huvudresultat i detta examensarbete är BREED-processen; Breeder’s Roadmap to Efficiency and Excellency in product Development (växtförädlarens vägbeskrivning till effektivitet och excellens inom produktutveckling). Byggandet av BREED inkluderar element av processdesign, där de kartlagda aktiviteterna används som byggstenar, strukturerade för att möjliggöra introducerandet av formella beslutspunkter. I fyra sådana beslutspunkter, spridda över den tretton år långa produktutvecklingsprocessen, vägs såväl externa som interna faktorer in i tuffa projektgranskningar. Ambitionen är att allokera resurser till de projekt som bäst överensstämmer med SW Seeds affärsstrategi och har störst potential för att nå framtida intäkter. En djupdykning i företagets bokföringssystem visade att 87 % av de direkta kostnaderna – de kostnader som påverkar, och påverkas av, de sökta besluten – kan allokeras till BREED och dess aktiviteter. Metodiken som föreslås genom användandet av BREED bör generera nya möjligheter för SW Seed att utvärdera och styra sin utvecklingsprocess på ett sätt bättre anpassat för att hantera de interna och externa utmaningar som är naturligt förekommande inom produktutveckling.

Att styra en produktutvecklingsprocess med ambitionen att uppnå effektivitet och excellens kräver utvärdering och justering av processen relativt fyra kritiska framgångsfaktorer; utveckla en klar innovations- och teknologistrategi, möjliggör bemyndigade multifunktionella produktutvecklingsteam, granska projekten genom återkommande portföljanalyser och implementera en formaliserad process med definierade stadier och mellanliggande beslutspunkter (så som BREED). Utmaningen för den högsta ledningen är att översätta den övergripande affärsstrategin och dess mål i en terminologi som tar hänsyn till dessa kritiska framgångsfaktorer samt kopplar dem hela vägen till det dagliga arbetet i processen. För att stödja ledningen i denna uppgift presenteras en mått-matris för gapanalys mellan det nuvarande och det bästa sättet att mäta processens resultat.

Nyckelord Produktutveckling, resursallokering, växförädling, processkartläggning, BREED, Stage-gate, beslutspunkter, resultat från nya produkter, processmätning, key performance indicators (KPI), SW Seed

Contents

1 Introduction

In this introducing chapter the background for this master thesis is outlined and the commissioning company SW Seed presented. The problem addressed is described and delimitated in a qualitative way as well as in absolute terms, separating the purpose, objectives and expected results with the thesis. A presentation of the disposition of the thesis ends the chapter.

1.1 Background

This master thesis report is written during the spring of 2008 by two students studying MSc in Industrial Engineering and Management at Lund University, Faculty of Engineering. The report is commissioned by SW Seed, an international plant breeding and seed production company with head office in Svalöv, Sweden.

SW Seed is currently undergoing a restructuring program aiming to focus its businesses towards chosen core markets, reducing its product portfolio in the same process. To support existing customers SW Seed still keeps obsolete products in stock during a transition period but the number of products in the portfolio that undergo continuous product development (PD) is cut in half compared to just a few years ago. This process aims to focus internal resources to the products best aligned with corporate strategy, holding the biggest potential for future revenues.

Focusing on the right products is a sound plan, but with it comes the challenge of choosing them among others. This is especially difficult when the PD cycle time spans over 10-15 years and the external environment is filled with uncertain factors. As figure 1.1 below illustrates (with hypothetical figures for costs, revenues and timelines) the result of a decision to invest in a certain product won't prove to be correct or incorrect until the product hits the market over a decade later – and the marketplace forecasted at the time of the decision could very well prove to be a totally different one due to unexpected events.

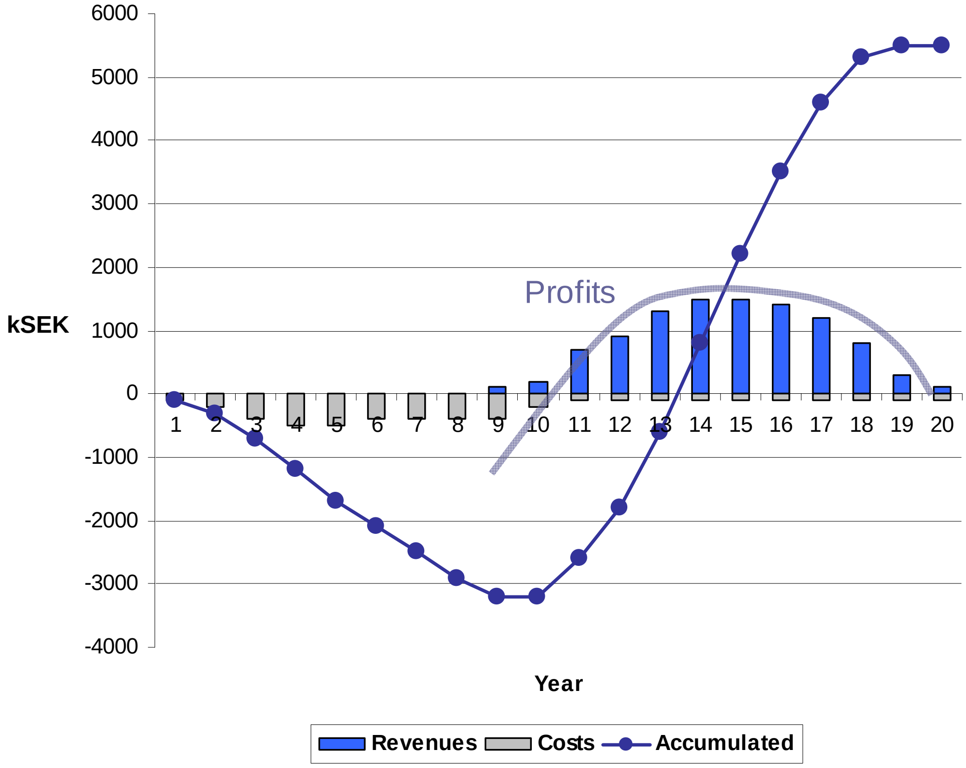

Figure 1.1 Cash flow over product lifetime (hypothetical figures for costs, revenues and timelines)

Moreover, the long awaited profits from year ten forward typically follows a 'bell-shaped' curve (the profit line in figure 1.1 above), limiting the life-span of the product. For the decision maker at year zero this means that the product only have a given, and at beforehand uncertain, number of years to earn the needed revenues before other costs such as marketing and new improved products makes his or her product non-profitable and obsolete. This uncertainty regarding future revenues and markets calls for a disciplined way of controlling the more certain aspects – internal costs and processes.

1.2 SW Seed

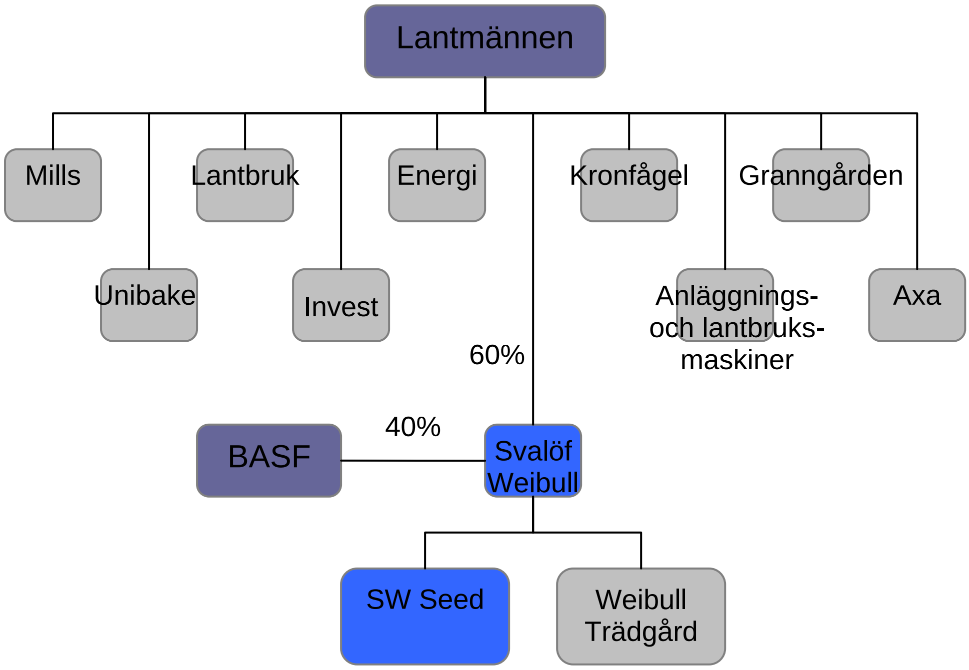

Figure 1.2 Business areas in Lantmännen; Svalöf Weibull and its business unit SW Seed highlighted (Source: Lantmännen Annual Report 2006)

The Lantmännen Group has a turnover of MSEK 35.989 (2007), with a contribution by Svalöf Weibull at 3 percent or MSEK 921, making it the smallest business area in the Lantmännen Group.[1] As shown in figure 1.2 above, the two business units SW Seed and Weibull Trädgård together constitute the company Svalöf Weibull AB, which in turn is owned by the Swedish agriculture company Lantmännen (60 percent) and the German chemical company BASF (40 percent).[2]

SW Seed's history began as early as 1870 in the form of W Weibull AB. Via a merger with Svalöf AB, Svalöf Weibull AB saw daylight in 1993. SW Seed was formed in 2004 and incorporated the agricultural units of Svalöf Weibull AB. Today SW Seed has 348 employees[3] and a yearly turnover of MSEK 442 (2007).[4]

SW Seed serves four groups of customers, internally labelled the four F's; farm, feed, food and fuel. The characteristics of the typical customer changes widely between them, as do their needs and requirements:[5]

- *Farm* – Farmers, Seed companies
- *Feed* – Farmers with livestock, Animal feed producers
- *Food* – Mills and bakeries, Maltsters and breweries, The cooking oil and margarine industry, Oat millers
- *Fuel* – Bio-ethanol industry, Rape Methyl Ester (RME) manufacturers

[1] Lantmännen (2007), *Årsredovisning 2007*, p.1
[2] Ibid., pp.18-19
[3] Lantmännen (2008), *Delårsrapport januari-mars 2008*, p.12
[4] Lantmännen (2007), *Årsredovisning 2007*, pp.18-19
[5] SW Seed, www.swseed.com, accessed 2008-01-15

In 2006 the strategic focus of SW Seed was restructuring through internal cost management – resulting in the disposal of operations in Canada and the United Kingdom. Remaining core markets are Northern and Central Europe, where SW Seed operates in the area of plant breeding and seed production. SW Seed has processing plants in Sweden, Germany and Netherlands producing its core products; grains, oilseeds and pasture & forage crops, see figure 1.3 for percentages of total turnover.[6]

In 2007 the strategic focus shifted from cost management towards business development and streamlining of the PD process.[7]

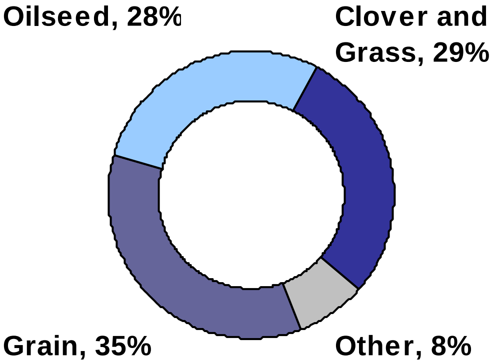

Figure 1. 3 Sales, SW Seed 2007 (Source: Lantmännen Årsredovisning 2007)

1.3 Purpose

The uncertainty in forecasting the future is a challenge that goes with any business enterprise – and working with development processes spanning long into the future calls for a structured way to make decisions framed with uncertainty. This master thesis report supports SW Seed in this process by analysing the PD processes currently in place targeting the cost structure and identifying ways to make early predictions on the economic outcome of the development process. In figure 1.4 below, the larger arrow describes a holistic view of the PD process and the smaller arrows exemplify part processes vital for its purpose. Aiming to optimize the entire process a breakdown in smaller parts is necessary; mapping how, and where, value for SW Seeds customers and stakeholders are created.

In order to manage the process as efficiently as possible SW Seed seeks ways to measure the PD progress proactively rather than reactively – this described by pushing measurements in the form of Key Performance Indicators (KPI) towards the start of the PD process.

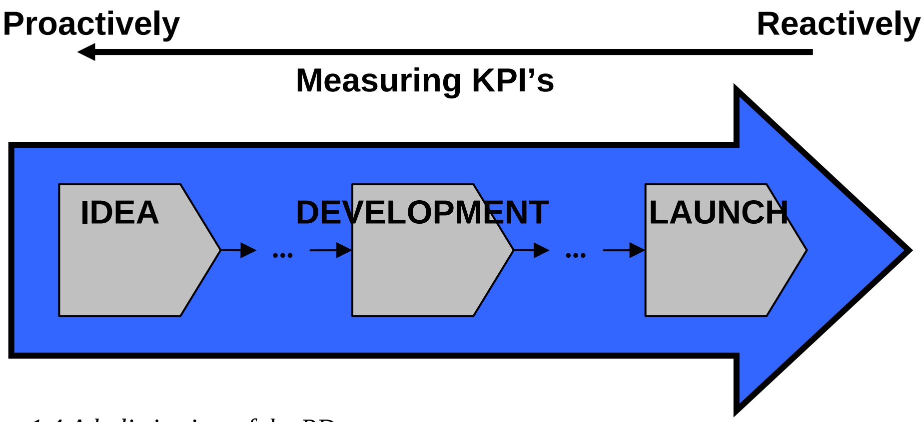

Figure 1.4 A holistic view of the PD process

[6] Lantmännen (2007), *Årsredovisning 2007*, p.20
[7] Lantmännen (2006), *Annual Report 2006*, pp.19-20

This two-folded purpose aim to put the decision makers at SW Seed in a better position when choosing which products to develop as well as the amount and kind of resources to allocate to the PD projects.

Aligning PD and business strategy by implementing a structured decision process provides common ground for several functional areas at SW Seed in discussing the future positioning of the company. For example, the R&D department, managing the PD process, needs input from marketing in making logically correct choices concerning their project portfolio. The financial boundaries focusing the organization's efforts are drawn by the controlling department and the vision and positioning of SW Seed as a whole is set by general management who points out the strategic direction in which the PD should be conducted. In other words there is a third aspect of this report – to facilitate a common platform for intra-organizational strategic communication.

1.4 Objective

Returning to figure 1.4 above achieving the purpose means a thorough understanding of the PD process – from idea to launch, specifying the phases as well as the decision points in between. In this master thesis report the objective is three-fold:

- Elicit the PD process currently in place at SW Seed's development of winter wheat, focusing on the allocation of costs to the product developed
- Generalize the elicited process through describing it in the terminology of a generic, theoretically ideal process so that SW Seed can use the findings for all its PD processes
- Suggest appropriate KPI's to follow up, evaluate and manage the PD process

1.5 Delimiting the study

A first delimitation is made in focusing on describing the PD of winter wheat, and more specifically on the Winter wheat Baltic programme[8]. SW Seed develops several product groups (crops) simultaneously, using similar although not identical processes. In delimiting the study to just winter wheat with the following ambition of generalizing the results there is a risk of missing specific product characteristics. Knowing this, caution should be used when extending the results of this study in SW Seed's other PD processes. This extension – testing the generalized process against the other PD processes – is not part of this study.

When eliciting the process focus is kept on assigning and estimating the costs incurred. As mentioned above there's a significant challenge in estimating the future revenues and profits as well. Doing this will be a vital part of using the result of this thesis and even though pointers will be given to the kind of information needed, these estimations are not part of this study. Another delimitation concerning the cash flow is that of marketing and sales. In a typical launch phase of a product a severe amount of resources is spent on marketing with the aim of gaining a certain market share or volume of products sold. In this study focus lies on costs controlled by the PD department, i.e. costs for marketing and such activities are excluded, while after launch costs directly incurred by PD department are included.

The third objective in this thesis is to suggest KPI's for follow up, evaluation and managing of the PD process. Selecting appropriate levels for these KPI's and managing the process accordingly are actions closely connected with the strategic level of management of any corporation. In this thesis suggested KPI's connected to SW Seeds corporate strategy will not be quantified. In selecting appropriate KPI's

[8] SW Seed's winter wheat programme is divided in two parts; one focusing of the Nordic and Baltic regions and one directed towards the Central European market. The information gathered and conclusions drawn in this thesis stems from identified activities in the PD process of Winter wheat Baltic.

there will however be a qualitative discussion with the ambition to give a normative description of their usage.

1.6 Expected results

The first two objectives are fairly straightforward when specifying the expected outcome in this thesis.

Eliciting the PD process currently in place is just that – the result being a descriptive model of the PD process in which the part processes as well as activities and decision points are clearly structured. The second objective is to analyze the elicited process in the light of a theoretical PD process. The outcome here is a gap analysis identifying differences, if any, between the processes followed by recommendations on how to pursue with them. The theoretical process is likely to be too generic to be applicable directly, i.e. its biggest contribution may lie in its terminology and structure – giving SW Seed means of transparent comparison when generalizing and communicating the findings in this thesis.

The last objective, suggesting KPI's, is closely related to corporate strategy as mentioned in the delimitations. The strategic aspect of PD is not a focus in this thesis implying that the result, in terms of KPI's suggested, will focus on the operational aspects of PD such as meeting budget, follow up on cost estimations, timeliness and so forth.

1.7 Target groups

Primarily the target group consists of employees at SW seed working in PD or in areas related to PD such as marketing, controlling and strategic decision making. Secondly this thesis targets students and staff at universities.

1.8 Disposition of the thesis

Chapter 1: Introduction
In this introducing chapter the background for this master thesis is outlined and the commissioning company SW Seed presented. The problem addressed is described and delimitated in a qualitative way as well as in absolute terms, separating the purpose, objectives and expected results with the thesis. A presentation of the disposition of the thesis ends the chapter.

Chapter 2: Methodology
This chapter presents the methodology of the thesis. Different alternatives are presented followed by a short reasoning about their pros and cons as well as the choices made. The chapter starts with a general discussion about the nature of the study and is followed by discussions on methodology and the methods used.

Chapter 3: Theoretical frame
In this chapter the theoretical foundations to the thesis are presented. The starting point is taken in a holistic approach to managing a corporation and as the chapter continues a narrowed scope provides focus on the, for this thesis, most relevant areas; processes, product development, measuring and the allocation of costs to activities.

Chapter 4: Empirical findings
This chapter presents the empirical data collected through document studies and interviews. Mapping the PD process calls for a certain level of knowledge in plant breeding theory and to facilitate a

minimum level of understanding for the common reader (outside SW Seed) a short description on the subject opens the chapter. The elicited process is presented in an iterative manner, leading up to the end result. The allocation of costs to the found activities and data concerning the strategic dimension of PD ends the chapter.

Chapter 5: Analysis
This part of the thesis discusses and analyses the theories and empirical findings presented earlier. Based on the description of the elicited PD process in the previous chapter the BREED process is presented more in depth, justifying the choices made in the structure. The disposition of the chapter follows the thesis objectives; presenting the proposed new PD process and the sought generalization as well as the costs assigned to different activities. The concluding part of the chapter connects the BREED process to the current structures for strategic discussions and proposes possible KPI's by which to measure and rate SW Seed's product development.

Chapter 6: Conclusions
In this final chapter of the thesis the most important parts of the analysis are summarized; aiming to deliver on the thesis objectives presented in chapter 1.4. A brief discussion on what's next and possible ways to further improve SW Seed's PD through complementing projects and initiatives ends the chapter.

2 Methodology

This chapter presents the methodology of the thesis. Different alternatives are presented followed by a short reasoning about their pros and cons as well as the choices made. The chapter starts with a general discussion about the nature of the study and is followed by discussions on methodology and methods used.

2.1 The nature of the study

The nature of the study originates from the problem background and is further directed by the purpose and objectives. The question "*what does the thesis hope to achieve?*" guides the choices of methodology as well as methods further on. Björklund & Paulsson presents a classification of different typed of studies based on the accumulated amount of knowledge on the subject and the goal with the study[9].

- *Explorative*. When examination is used because little or no facts are known about the topic and basic understanding is the goal of the study.
- *Descriptive*. When basic knowledge and understanding exists and the goal of the study is to describe but not explain relations.
- *Explanative*. When deeper knowledge about the topic is wanted and the goal of the study is both to describe and explain.
- *Normative*. When knowledge and understanding about the topic exists and the goal of the study is to give guidance and propose measures to take.

This thesis is mainly normative with some elements of an explorative study. It's normative in the sense that it will present guidelines for SW Seed to work with based on well established theories. The

[9] Björklund, M. & Paulsson, U. (2003), *Seminarieboken - att skriva, presentera och opponera*, p. 58

explorative elements are connected to the measurement of the PD process, a topic with little scientific literature – or at least, little absolute truth – to refer to.

2.2 The approach

Initializing a research study calls for an important discussion on how to relate to existing theories on the subject before hand. Should theories or empirical findings guide the hypothesis, later on confirmed or discarded in the light of the observations or selected theories respectively? This discussion boils down to one of three different starting points – a deductive, inductive or abductive approach[10].

2.2.1 Deduction, induction or abduction?

In the *deductive* approach predictions about the empirical findings are made based on a thorough theory study.[11] The empirical work then verifies or rejects the hypothesis with experiments or observations before conclusions are drawn. This represents a path from an abstract level (the theory) to a concrete level (the empirical work), an approach sometimes also referred to as *hypothetic-deductive*[12]. The objectivity is considered strengthened because the hypothesis is based on existing facts and not on a single researcher's subjective assumptions. A problem with this approach could be that completely new findings are hard to detect when existing theories sets the boundaries for the research.

In an *inductive* approach no theory studies are made in advance[13]. The empirical data is collected unbiased and thereafter a theoretical framework is formulated. This is a walk from a concrete to a more abstract level. Induction has from time to time been criticized for that the theories withholds nothing but empirical findings[14]. Further more; induction has been criticized since no real unbiased studies can be made. The researcher always has a preconceived notion about what will be found.

Abduction is in a way a combination of the above. Based on experiences from occasional events a hypothesis is formulated, similar to induction. The hypothesis is tested on new cases for verification or further development of the hypothesis, similar to deduction[15]. Abduction can't be made in a schematic way like induction or deduction, but requires previous experience from similar cases or the topic that's being examined, this showing both the strength and the weakness of abduction[16]. It allows the researcher to keep a wider perspective on the findings but since no research is done completely unbiased there is a risk that a hypothesis is formulated in a way that excludes possible conclusions[17]. However, the abductive approach presents a way to gain completely new knowledge that strictly inductive and deductive methods lacks[18].

Most studies involve aspects of all approaches mentioned above at some points, but a discussion on the subject still adds credibility to the study, providing insights in the researcher's background for the reader. In this thesis several factors points out the direction of a deductive approach, proposing that a main theory frame is created before any empirical data are collected:

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[10] Björklund, M. & Paulsson, U. (2003), *Seminarieboken - att skriva, presentera och opponera*, p. 62
[11] Ibid., p.62
[12] Davidson, B. & Patel, R. (2003), *Forskningsmetodikens grunder*, pp.23-24
[13] Björklund, M. & Paulsson, U. (2003), *Seminarieboken - att skriva, presentera och opponera*, p.59
[14] Wallén, G. (1996), *Vetenskap och forskningsmetodik*, pp.89-93
[15] Davidson, B. och Patel, R. (2003), *Forskningsmetodikens grunder*, p.24-25
[16] Wallén, G. (1996), *Vetenskap och forskningsmetodik*, p. 48
[17] Davidson, B. & Patel, R. (2003), *Forskningsmetodikens grunder*, p.24-25
[18] Andersen, H. (ed.) (1994), *Vetenskapsteori och metodlära – en introduktion*, pp.144-145

- The *normative nature* of the study suggests that there is a *significant amount of research* literature written on the subject, making it logically to build on the existing knowledge base
- the relatively *short track-record* of the researchers calls for an acknowledged theoretical foundation on which to build the hypothesis
- the purpose with the study clearly directs parts of the results (e.g. finding the cost structure of the PD process), adding a *need for a recognized terminology*
- the ambition to generalize the findings to other crops developed by SW Seed also indicates benefits with a *theoretically acknowledged starting point*

2.3 Different views

When examining a certain situation two different views can be taken; a more mechanistic view suggesting that the sum of the parts is equal to the whole, or a more holistic one, proposing that the whole is larger than just a summarization of its parts.[19]

The mechanistic or *analytic* view has the ambition to reach an objective answer to the problem as completely as possible. No respect is taken to a subjective view and the solution is considered independent of the researcher; the results would be the same if a new study was to be made. The study is trying to establish cause-and-effect relations where the sum of the parts is equal to the whole.

With the holistic, or *system theory* view synergy effects and relations between the parts are often as important as the parts themselves and contribute to the understanding of the system as a whole. The researcher examines the connections and relations between the parts to understand the underlying factors. Main parts in a system theory analysis are[20]:

- System boundaries, including the function of the system and adjacent areas towards the system surroundings.
- System foundations, including how the parts of the system are organized and what happens if the view is changed, from one system level to another.
- System flows, including inner flows and flows to and from the system.
- System control, including counteractions between the parts of the system and control functions of the system.
- System change over time, including various definitions such as instability, balance and cyclic phenomena.

In this thesis the relations between the parts of the system, for example the interaction between different functional areas such as the PD department and marketing, is vital to describing and managing the entire process. Analyzing the parts in isolation and expecting them to work frictionless when putting them together would likely result in a sub optimized process. The ambition to acknowledge the parts as well as the relations results in a system theory view. An impact of this assumption is that the results from the thesis will depend on aspects that are not fully examined here. For example the difficult work with forecasting revenues from a PD project is not a part of this study although a vital part of the strategic decision making. Moreover, the boundaries of the PD process are adjacent to areas such as the strategic considerations, which highly affect the outcome of the studied system (the PD process).

[19] Björklund, M. & Paulsson, U. (2003), *Seminarieboken - att skriva, presentera och opponera,* p.59
[20] Wallén, G. (1996), *Vetenskap och forskningsmetodik*, pp.28-29

2.4 Models

In order to describe the PD process currently in place and describe it in general terms a structured modelling is critical to success. Models can be of various kinds but a fundamental aspect is that the model represents a simplification of the reality. When models are used to describe an occurrence, phenomena or object, Wallén presents five criterions that should be kept in mind:[21]

- *Systematic*. There must be an inner logic and consequence in the model.
- *Efficiency*. The model should be efficient in prognostication and easy to use.
- *Validity*. The model shouldn't have any systematic faults. As a part of the validity, the model should use relevant variables and parameters, *theoretical validity*, and have well defined concepts, *concept validity*. One way of testing the validity is to apply it on historical data where more facts are known.
- *Model conditions*. The conditions that must be met for the model to give correct results should be noted.
- *Generalizability*. Under which conditions the model can be applied to other circumstances.

This thesis use existing models based on thorough research applying them on SW Seed's PD process with necessary adjustments. The criterions mentioned above is taken in consideration both when the models are selected – they must be applicable in this specific project – and when they are adjusted so that they are of valuable use for SW Seed in their further work with the outcome of the thesis.

2.5 Qualitative and quantitative

Depending on the objective in a study, a *quantitative* or *qualitative* method can be used[22]. If the study comprise information that can be quantified or valued in numbers a quantitative study often is preferable. However, there is a limit on the amount of knowledge that can be generated by quantitative methods. When deeper understanding about a specific topic is sought a qualitative study often proves more suitable. A downside with the qualitative method is that the increasing depth of the analysis may result in fewer possibilities to generalize the results from a qualitative study.

One common form of a qualitative study is the case study[23]. The case can consist of single individuals, a smaller group or an organisation, and is often used when processes or changes are studied. The possibility to generalize the results is dependent on how the case is chosen, something that should be kept in mind when this is done – it's often hard to let one object represent a bigger entirety. One advantage of the case study is that it brings the researcher closer to the object, in comparison with for example a statistical, more quantitative study[24].

The objective of this thesis, eliciting the current PD process, is a case study of SW Seed's PD process of winter wheat, making it a qualitative study. An alternative could have been making a more quantitative approach focusing on the PD processes of several crops; however, this would have given a more superficial result if it were to be conducted with the same resources.

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[21] Wallén, G. (1996), *Vetenskap och forskningsmetodik*, pp.59-60
[22] Björklund, M. & Paulsson, U. (2003), *Seminarieboken - att skriva, presentera och opponera*, p.63
[23] Davidson, B. & Patel, R. (2003), *Forskningsmetodikens grunder*, p.54
[24] Ejvegård, R. (1996), *Vetenskaplig metod*, pp.30-31

2.6 Validity, reliability and objectivity

When analyzing the results from the thesis it's important to reflect over the methods used – do they provide the result that was intended or is the result biased in any way? The traditional measurements of the credibility of a study are validity, reliability and objectivity:[25]

Validity is the term for measuring what's intended[26]. If there are well defined measurements and methods that's not a problem, but that's not always the case[27]. For example, using statistics from different countries can present problems, since different measurement methods could have been used resulting in difficulties when comparing the statistics. Even bigger problems occur when there isn't an obvious metric to describe the object to be measured. Sometimes new metrics has to be created and validity is of great concern when this is done. In some cases there isn't possible to create a suitable metric but only parameters that can describe the object. The more parameters that can be used, the better validity of the method can be achieved.

Reliability is the correctness of the study, i.e. if the same results would be given again if the study were remade[28]. To avoid poor reliability a few reliability tests can be made such as[29]:

- *Retesting*. The same object is measured once again. Big variations in the results indicate that the method has poor reliability, although changes over time are a factor that needs to be taken into account.
- *The halving method*. The results are randomly divided in half. If the results from the two halves are similar to each other, the method can claim good reliability.
- *Parallel method*. Two different surveys are made with the intent to measure the same thing. If same results are given, the reliability is good.
- *Control questions*. When surveys are made, a few control questions can be asked; previously asked questions are asked again with a different formulation. If the object has answered differently on the questions there is reason to question the reliability of the method.

Validity and reliability is often compared with a game of dart. High reliability is accomplished if all the darts hits close to each other. High validity is reached if the darts hits close to the centre. This is further illustrated in figure 2.1.

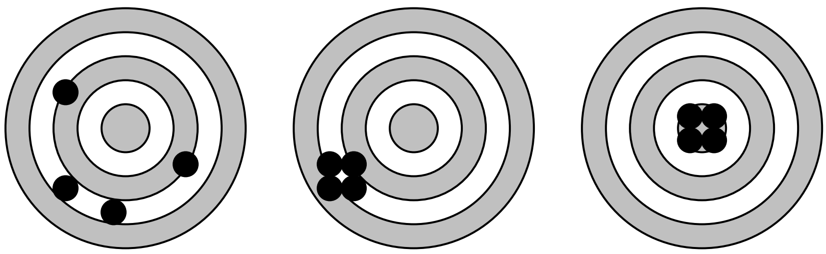

Figure 2.1 An illustrative example of reliability and validity (Source: Björklund, M. & Paulsson, U, (2003), p.60)

Objectivity is to what extent the researcher's valuations affect the study[30]. For example, objectivity problems can occur when researchers review the work of other researchers and writers. Things to bear in mind in these cases are:

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[25] Björklund, M. & Paulsson, U. (2003), *Seminarieboken - att skriva, presentera och opponera,* p.59
[26] Ibid., p.59
[27] Ejvegård, R. (1996), *Vetenskaplig metod,* pp.70-71
[28] Björklund, M. & Paulsson, U. (2003), *Seminarieboken - att skriva, presentera och opponera,* p.59
[29] Ejvegård, R. (1996), *Vetenskaplig metod,* pp.68-69

- Facts must be summarised correctly.
- The facts must be recaptured in a balanced way, i.e. not only facts that support the arguments for the study should be mentioned.
- Avoid emotionally charged words.

The validity problem of this thesis lies in the problem with generalizing the PD process after only have studied one crop; winter wheat. SW Seed, with insight in all the PD processes in progress, is the decision maker of witch crop to study, and takes the generalizability in consideration when making this choice. A possibility to strengthen the validity further is to take the generalized process and try to apply it on other PD processes and see if it fits.

By having more expert opinions about a subject the reliability can be strengthened. This can be done by having interviews with more respondents on the same subject. Some of the information given during interviews done in this thesis has been retested on other respondents, as well as been rechecked with the original respondents again. The reliability could be considered strengthened in this way.

An important part of this thesis was building a model and costing its parts. To improve the validity well established methods in mapping processes and costs have been used, which also should improve the reliability. To use the illustration in figure 2.1; using a well established method could be similar to throw the all darts in the same way, which should result in the darts ending up in the same spot, close to the bulls-eye.

By discussions about the methods used in this thesis the objectivity can be strengthened. Further more, by having interviews with more respondents when possible about for example the PD process, subjectivity from the respondent’s side can be avoided.

In the theory chapter some criticism to the theories has been presented in order to give the reader a chance to take a critical stand against there use. This is done in order to try to improve the objectivity.

2.7 Data collection methods

The collection of data in this thesis is guided by two comprehensive methodologies addressing the first objective of the thesis; *Elicit the PD process currently in place at SW Seed’s development of Winter wheat, focusing on the assignment of costs to the product developed*. In order to deliver on this objective *Process mapping* – describing the process structure, and *Activity-based costing-methodology* – allocating the costs involved, are used. These methodologies are described in more detail in the following chapters (see 2.7.1 and 2.7.2).

When collecting the empirical data a separation is made between *primary* and *secondary* data, distinguishing between what’s collected first hand for the study, and what’s been collected for some other purpose, but used in the study. A short description of the chosen methods is presented below (chapter 2.7.3 and 2.7.4), followed by a brief discussion on some of the alternatives (chapter 2.7.5), as well as source criticism (chapter 2.7.6).

[30] Björklund, M. & Paulsson, U. (2003), *Seminarieboken - att skriva, presentera och opponera*, pp.59-62

2.7.1 Mapping processes

In the mapping of a process[31] it's important to focus on *what's* being done, not *where* it's done – the map of the process should go beyond traditional organizational boundaries[32]. A main theme throughout the theoretical frame in the next chapter (3) is that processes in generality and PD processes specifically are a cross-functional or multidisciplinary phenomena. The implications of this is the need for a holistic approach in mapping the process – from the end; the need that justifies the process – to the start; the object or event that initiates the process.

The ambition with the mapping is the identification and structuring of the process building blocks; the activities and sub-processes involved. In this quest Larsson & Ljungberg proposes one, or a combination, of four approaches:[33]

- *Walk through* – a person or a team is responsible for the mapping and literally walks through the process. A long the way they interview persons performing the found activities. The benefits of this approach are that it's fairly quickly and cheaply results in an outline of the sought process. The downsides include feelings of passivity among the people working with the process and the risk of a process description biased by the responsible team.
- *Virtual walk through* – gathering representatives of different activities at a meeting and there discuss the process layout with the mapping responsible persons as leaders of the discussion. The pros and cons are similar to the walk through above but the group procedure often adds trust and understanding for the mapping procedure and the end product; the process.
- *Mapping team* – a thorough method where representatives from different parts of the process together make up the team responsible for the mapping. This method requires more resources and there is a need to educate the team in process theory before the work can take off. One benefit is that the team members become advocates for the process idea and give the project legitimacy in the organisation.
- *Process design* – used when there's no process in place to begin with. In this case involved personnel have to agree on how the process should be constructed in the best way.

In this thesis the mapping of the PD process follows the *walk through* method, although influenced by the *process design* approach. The persons responsible for the mapping, the writers of the thesis, initially have a limited understanding of the actual technology in the activities making acting as discussion leaders less preferable. The resources available for the process mapping also put constraints on the involvement of needed key personnel to make up a mapping team. The element of process design is due to the third objective of the thesis – proposing KPI's to evaluate and manage the process. This could mean introducing process elements not currently in place, adding the dimension of designing a partially new process complementing the elicited sub-processes and activities.

Larsson & Ljungberg proposes that the mapping of the sought process could consist of 8 steps:[34]

1) Define the purpose of the process, as well as its starting and ending point.
2) Carry out brainstorming sessions to elicit all eventual activities.
3) Arrange found activities in order.
4) Put activities together, if possible, and add lacking activities.
5) Define the needed "object in" and "object out" from the activities.
6) Make sure that all activities are connected through these objects.
7) Secure that all activities is described on the same (and the correct) level of detail and that they all have appropriate names.

[31] *Note:* The process concept is defined in the theoretical frame, see chapter 3.2 for a complete description of the analogy used in this thesis on this specific subject.
[32] Larsson, E. & Ljungberg A. (2001), *Processbaserad verksamhetsutveckling*, p.200
[33] Ibid., pp.204-206
[34] Ibid., pp.206-209

8) Make corrections until the mapped process is adequate.

2.7.2 Allocating costs – the ABC methodology

When making an activity-based costing (ABC) system[35] Ask & Ax presents a five step process. The process is iterative rather than sequential since the steps aren't independent and some choices should be made with the following steps in mind. For example, step 1 and step 3 are closely related. The process is presented below:[36]

1) Identify and choose activities
2) Allocate costs (resources) to the activities
3) Choose cost drivers
4) Determine cost driver volumes
5) Calculate product costs

1) *Identify and choose activities*: When making an ABC system in principle, all activities that are performed should be a part of the system. In practice, this would probably lead to several hundreds of different activities on a very detailed level, a system that's to complex and too costly too be of practical use.

2) *Allocate costs (resources) to the activities:* This is a critical part that requires a thorough analysis. If this isn't done in a realistic way the activity costs will be misrepresented. When this step is finished all activities should have a cost.

3) *Choose cost driver* is the step where a products consumption of activities is calculated. The aim is to find a cause-and-effect relation where the consumption of the activity should vary with the cost driver chosen. One way of keeping the number of activities down is to see which activities that have the same cost drivers and consolidate them. Another way of keeping the activities down are to consolidate activities with a small portion of the total cost and then choose a proper cost driver for the consolidated activity.

4) The step *Determine cost driver volumes* is where the cost of one "unit" of the cost driver is calculated. To do this the total cost of the activity is divided by the cost driver

5) In *Calculate product costs* the costs for each activity used to produce a product are summarised to calculate the total product cost.

When making an ABC system a starting point could be taken in the functions of the organization and then use one or several of following methods:[37]

- Interviewing personal from different functions to elicit the activities performed. This could be a sensitive task since it involves a close-up study of individuals work.
- Observations of the PD process.
- Document studies of existing process maps or organizational charts (require that such documentation exists).

[35] Activity-based costing is further explained in chapter 3.6. Some short definitions are presented here: Activity-based costing is a way to cost products, services, processes etc. within an organization. A product requires several *Activities* to be performed e.g. blueprinting, testing or sawing, on its path from idea and development to finished product. All activities consume *resources* that incur costs for the company.
[36] Ask, U. & Ax, C. (1995), *Cost Management – produktkalkylering och ekonomistyrning under utveckling,* pp.62-76
[37] Ibid., pp.62-76

In the PD process of Winter wheat the number of people involved are limited to a handful with insight in the process. Interviews with these representatives present the whole picture with a reasonable effort and are therefore the method chosen for this thesis. In chapter 2.7.5 possible alternatives are discussed briefly.

2.7.3 Document studies

Document studies can be performed as a pre-study to get basic knowledge of a subject, or as a way to describe actual occurrences and events[38]. The secondary data collection in the thesis mainly consists of studying internal documents, such as information from the internal accounting system, and the compiling of the theoretical frame. Relevant source criticism is important; who has created the document and what's the purpose of its creation? Another important aspect when using secondary data in a study is the risk of biased data collection – does the researcher gather data showing both sides of a given issue, or just the data supporting his or hers view? Chapter 2.7.6 below discusses source criticism and some of risks involved in this thesis.

In the early work with the thesis, parallel with the compiling on the theoretical frame, the ambition was to find secondary data in the form of studies targeting industry specific PD processes in industries similar to SW Seed's. The purpose was to enable a benchmarking study between this process and the empirical findings of this thesis. The result of the search was a disappointment; there were few such studies (with similar industry characteristics as SW Seed) and those found delivered nothing worth benchmarking. The information that was to be found was on a too high level of abstraction, offering nothing extra compared to the theory on generic PD processes already compiled.

2.7.4 Interviews

Interviews are collection of data through questions. Although in some ways similar to questionnaires, there are significant differences. In an interview there is a relation between the interviewer and the respondent that can affect the answers given as well as the interpretation of them – both body language and the choice of words could affect the outcome.[39] Interviews can be classified depending on the level of standardisation of the questions, directing how openly the respondent can answer. All questions can be predetermined and strictly followed, resulting in a *structured* interview[40]. A *semi-structured* interview has a predetermined topic, but the questions are asked depending on previous answers, giving more room for interaction between interviewer and respondent. An *unstructured* interview has the form of a conversation between the researcher and the respondent.

In this thesis interviews with key personnel involved in the PD process of Winter wheat are the backbone of the data collection. The respondents well as SW Seed are presented in more detail in chapter 4.2. However, the interviews conducted in the thesis had semi- and unstructured form. Initially unstructured interviews were held to elicit the basic structure of the PD process in order to compensate for the agro technical shortcomings of the writers. In a second, more formal phase of interviews the form developed into semi-structured, allowing the following of the methodologies presented in chapter 2.7.1 and 2.7.2 above.

2.7.5 Alternatives

As discussed above the thesis is based on a qualitative case study, making quantitative methods such as questionnaires less appropriate. However, an alternation in objectives could have been made to allow a more quantitative approach. In that alternate scenario an initial phase of outlining the key

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[38] Davidson, B. & Patel, R. (2003), *Forskningsmetodikens grunder*, pp.63-65
[39] Ibid., p.69
[40] Björklund, M. & Paulsson, U. (2003), *Seminarieboken - att skriva, presentera och opponera*, p.68

activities of a generic PD process could have been followed by a phase filled with one or several rounds of questionnaires with all breeders (each responsible for a crop) as respondents (15 in total). A research design like this might prove successful in solving some or all of the objectives of the thesis, although initial discussions deemed the qualitative approach more likely to succeed given the available resources.

A possible complement to the interviews could have been the conducting of observations, where behaviours and developments in its natural environment can be studied[41]. A drawback with this method is that it's expensive and time consuming. It can also be hard to know whether the observed behaviour is representative or not. The key reason why observations aren't part of the methods used in this thesis is that the nature of plant breeding calls for observations spanning over a calendar year to claim justification. The possibility to complement the interviews with more limited observation were discussed initially but such an approach was considered to reveal little extra knowledge of value.

2.7.6 Source criticism

In the compiling of the theoretical frame well established and often cited theories have been selected. The ambition with the theoretical framework is that it should take a holistic approach, working with a wide perspective initially focusing in on important subjects thereafter. These two factors have guided the literature search with the aim to counteract misunderstandings and the pitfalls related to choosing a narrow scope too early in the process, coming up short in the ambition to present a complete picture. In this process inherent weaknesses in some theories have been brought to daylight, commencing a wider theoretical search on the subject to parry found downsides. This became specifically clear when compiling theories on the Net Present Value-method[42], a widely used and often cited method although as it shows, sometimes produces flawed results. The found criticism led to an increased search on the subject resulting in complementing theories on real options and decision trees (see chapter 3.8.2 and 3.8.3).

When describing the generic PD process the theoretical base is mainly that presented by Robert G. Cooper (2001, 2002, 2007), a fact that could indicate a biased starting point for the thesis. However, a rigorous literature search have been made on all the selected theories (e.g. through the extensive databases connected the Lund Institute of Technology) and specifically Cooper is regarded as an authority on the PD process domain, having done significant synthesis work on the subject.

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[41] Davidson, B. & Patel, R. (2003), *Forskningsmetodikens grunder*, pp.87-89
[42] A method to calculate the time value of money in order to compare costs today and costs occurring in the future, see chapter 3.7.1 and 3.7.2 for more detail.

3 Theoretical frame

In this chapter the theoretical foundations to the thesis are presented. The starting point is taken in a holistic approach to managing a corporation and as the chapter continues a narrowed scope provides focus on the, for this thesis, most relevant areas; processes, product development, measuring and the allocation of costs to activities.

3.1 Taking the holistic approach – viewing processes as a part of a greater entirety

A corporation can be analyzed in a wide variety of ways depending on the goal with the analysis as well as the analyst in question. What does the organizational structure look like? Which strategic routes are taken? What about the staff, the culture, the key values? Kaplan & Norton conclude that no single measure or perspective can provide all the information needed to manage the corporation. A combination of measures is needed and as a framework assisting managers in choosing the right ones, they propose using their model the *Balanced Scorecard*.[43]

The Balanced Scorecard (BSC), see figure 3.1 below, presents four key aspects of an organization:[44]

- How do customers see us? (customer perspective)
- What must we excel at? (business process perspective)
- Can we continue to improve and create value? (learning and growth perspective)
- How do we look to the shareholders? (financial perspective)

[43] Kaplan, R. & Norton, D. (1992), *The Balanced Scorecard – Measures that Drive Performance*, p.71
[44] Ibid., p.72

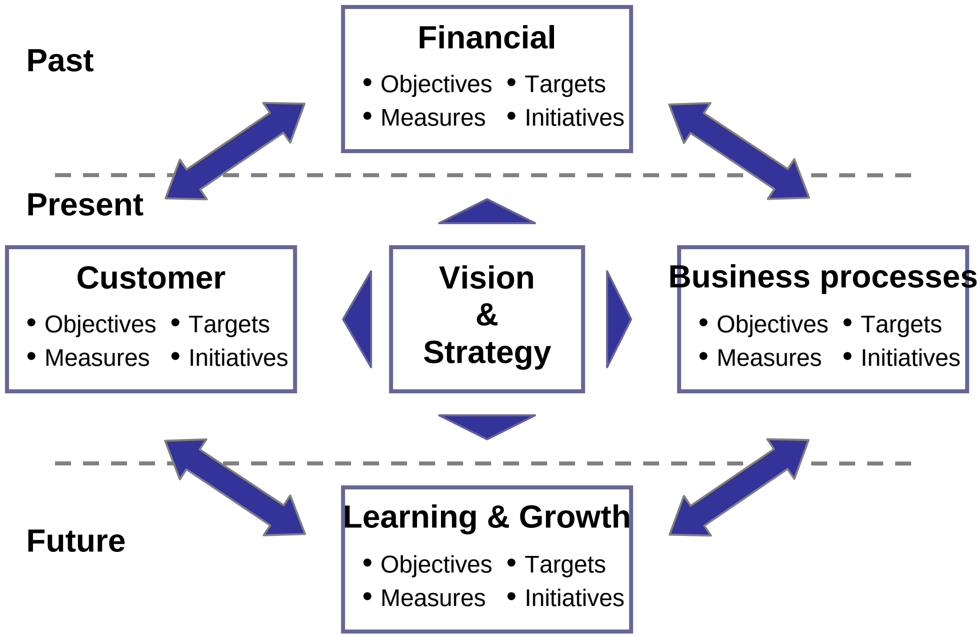

Figure 3.1 The Balanced Scorecard (Adapted from Kaplan & Norton (1992) and Trump University (2008))

Their proposal is based on the idea that these four perspectives, targeted concurrently, guards against sub-optimization so that one area can't be improved at the expense of another. A narrow-minded focus on internal processes could otherwise render lacking customer orientation or an ambition to deliver great financial results may reduce much needed investments in innovation and learning. Another argued benefit is that focus on these key aspects of an organization will minimize information overload from too many measures on corporate performance – "*Companies rarely suffer from having too few measures. More commonly they keep adding new measures whenever an employee or a consultant makes a worthwhile suggestion*".[45]

In figure 3.1 above there are time aspects added that, at least explicitly, weren't part of Kaplan & Norton's original article on BSC. Larsson & Ljungberg presents these aspects as one of the most important parts of the BSC-idea[46]. The traditional way of measuring performance – the financial, reflects performance in past time. The customer as well as the internal process perspective captures performance in present time while innovation & learning takes the corporation into the future.

In this thesis the BSC-idea is used as a holistic framework in order to put the PD-process, and thereto connected decision points in perspective. Each area is critical for success but stand alone they aren't sufficient; only viewed in perspective to each other they guide performance. The PD-process is vital to most companies' businesses, although part of a bigger setting which puts constraints to the decisions made in the PD-process. This "bigger setting" will not be fully explored in the chapters to come where focus is kept on PD, although pointers towards important adjacent areas will be discussed.

A first step in understanding how the PD-process can contribute to corporate excellence is to understand the concept of the process, a subject discussed in the following chapter.

[45] Kaplan, R. & Norton, D. (1992), *The Balanced Scorecard – Measures that Drive Performance*, p.72
[46] Larsson, E. & Ljungberg A. (2001), *Processbaserad verksamhetsutveckling*, p.265

3.2 The process

> "*A process is a methodology that is developed to replace the old ways and to guide corporate activity year after year. It is not a special guest. It is not temporary. It is not to be tolerated for a while and then abandoned.*"
>
> - Berry, T.H., *Managing the Total Quality Transformation* (Quoted from Cooper, R (2001), p. 113)

According to Larsson & Ljungberg, working with processes demand a concrete definition of the process concept in order to focus all efforts in the right direction stating that "*it's a challenge to look for, or describe, something that you don't know what it is.*"[47] When defining a process several writers propose the analogy of a sequential chain, leaving out the contemporary trend of regarding internal flows in a company as well as links to their external transaction partners as being part of a network. Acknowledging the network aspect, the definition used in the thesis is:

> "*A process is a repetitively used network consisting of linked, in order, activities which use information and resources to transform "object in" to "object out", from identifying to fulfilling a customers needs.*"
>
> - Larsson E., Ljungberg A., *Processbaserad verksamhetsutveckling*, p.44. (translation)

In this definition there is also an emphasis on the process as an, although repeatable, empty shell that facilitates the transformation of objects only due to resources and information inputs. Stand alone, without a needed "object out" the process or activity lacks justification. In figure 3.1 below the idea of the process is outlined:

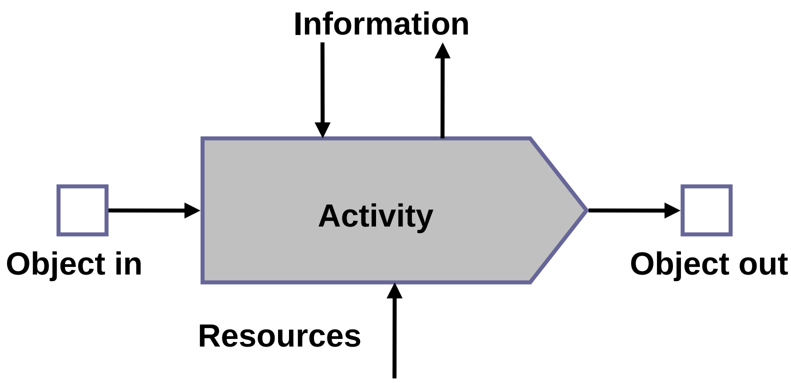

Figure 3.2 The process idea, including objects, information and resources (Source: Larsson & Ljungberg (2001), p. 202)

The components of the process are defined as:[48]

- *Object in* – initiates the process, without it the activity can't start.
- *Object out* – the result of the activity and the need that justifies the entire activity or process. Without it, the process lack purpose and the organizational resources used here should be redirected.
- *Activity* – the operation that refines object in, or any other input, to object out.
- *Resources* – needed to perform the activity.
- *Information* – supports or directs the process

[47] Larsson, E. & Ljungberg A. (2001), *Processbaserad verksamhetsutveckling*, p.42
[48] Ibid., pp.191-195

In the BSC model presented above *Business processes* is proposed as one of four important areas to which the management focus should be directed. In an organization however, a multitude of activities and processes exists. It seems an impossible task to focus equally on all of them. Larsson & Ljungberg identifies the most important processes as *Main processes* and, while acknowledging the difficulties in "choosing" the right ones, describe them as fulfilling the following criteria:[49]

1) Processes whose activities refine goods or services to an external customer
2) Processes that puts the business concept into practice
3) Processes that together form a system that constitutes the foundation for the organization. If removed, the organization will fall
4) Processes of special importance for the organization

Kaplan & Norton takes a similar position, stating that "… *excellent customer performance derives from processes […] Managers need to focus on those critical internal operations that enable them to satisfy customer needs*" and that "*[the business processes in the BSC are] the business processes that have the greatest impact on customer satisfaction.*"[50]

These "top level" processes follow the structure outlined in figure 3.2 as well as the more ordinary one on an operational level. The actual numbers of main processes for different organizations vary but according to Larsson & Ljungberg they are typically 2-10, depending on the sought level of detail. Presented in figure 3.3 are some that normally exists in any organization:[51]

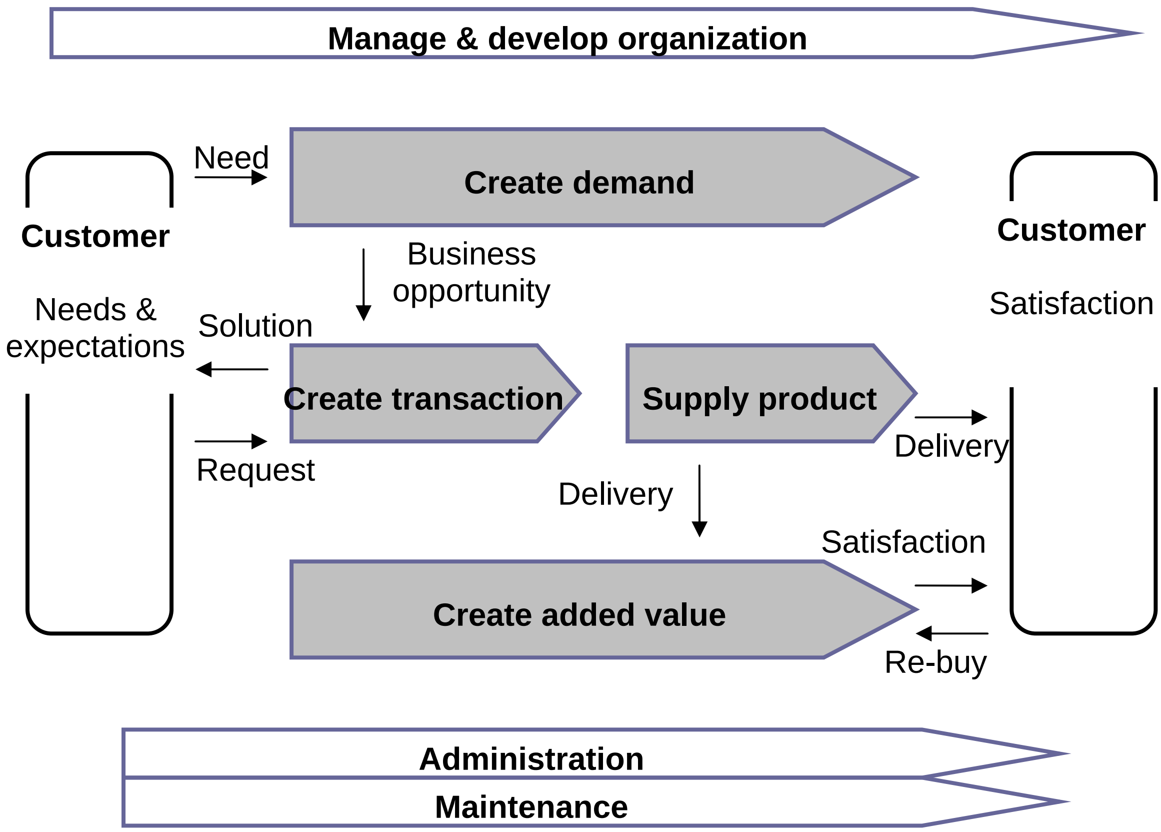

Figure 3. 3 Example of Main processes, Management processes and Support processes (Source: Larsson & Ljungberg (2001), p. 86)

[49] Larsson, E. & Ljungberg A. (2001), *Processbaserad verksamhetsutveckling*, pp.82-84
[50] Kaplan, R. & Norton, D. (1992), *The Balanced Scorecard – Measures that Drive Performance*, pp.74-75
[51] Larsson, E. & Ljungberg A. (2001), *Processbaserad verksamhetsutveckling*, pp.86-87

- *Create demand* – knowing the organisation, the offerings and matching them with the market and its needs
- *Create transaction* – closing the deal; on the basis of a business opportunity a solution for a specific customer is created and agreed upon
- *Supply product* – the transaction is realised through the production and delivery of a product or service
- *Create added value* – the customers' usage of the product often leads to further interactions such as problem-solving or support. If an added value can be created for the customer, this service process often constitutes a source to new business opportunities

The PD-process is not an explicit part of the example above (figure 3.3), although highlighted by Larsson & Ljungberg as one of the most critical and important main processes, present in virtually every company. Besides main processes there are also a different kind of processes presented in figure 3.3; Administration, Maintenance and Manage & develop organization. These are *Support processes* (Administration and Maintenance) and *Management processes* (Manage & develop organization). Not all processes are critical to the business concept directly, although they contribute in an indirect way. [52]

The purpose of **support processes** is to aid the main processes in their quest for customer satisfaction. In this they shouldn't be ascribed a value of their own; instead they should be valued on how well they succeed in their support function of the main processes. The number of support processes in an organization often exceeds the number of main processes by far (billing, accounting, IT, etc) and there is a need to focus on the most important ones in order to enable a structured way of working with them. The line between main and support aren't always clear, although the final classification is important; the value and attention assigned to main processes should (and do) exceed that assigned to the support processes.

Management processes on the other hand have the purpose to manage the main as well as the support processes, guiding the organization onwards. These are of course vital in the same way as the support processes, they aren't however directly a part of fulfilling the business concept, implying that they shouldn't be judged or managed by the same ruler as the main processes. A typical description of the task involved in management processes could be:

- choosing direction in which to develop the organization
- leading the way by communicating the chosen direction and assign suitable objectives
- create the right conditions so that the objectives can be achieved
- follow up, evaluate and adjust when needed

The following chapters put the PD-process in focus, from time to time adjacent areas are addressed but always from a PD perspective.

3.3 The PD process[53]

The topic of pinpointing success factors in new product development processes has been well researched in the last 40 years[54]. The reason for this is easy to comprehend – new product successes or failures can decide a corporation's ability to compete in the short as well as in the long run. Product

[52] Larsson, E. & Ljungberg A. (2001), *Processbaserad verksamhetsutveckling*, pp.184-187
[53] (A note to simplify complementation of the theory by the reader) In the thesis the term Product Development is shortened to PD to fit the company terminology. It's however appropriate to mention that a significant amount of literature chooses the acronym NPD instead (adding the prefix *New*), still discussing the same field of management.
[54] Cooper, R. (2001), *Winning at new products – accelerating the process from idea to launch*, p.70

Development and Management Association (PDMA) assign 33 percent of the average company's sales to new products (products the companies didn't sell five years ago), putting pressure on the PD processes in place to deliver[55]. Moreover, benchmarking studies show that the average success rate of fully developed products is as low as 67 %[56]. Taking the killed PD projects, the projects that never reaches the market, into the equation this figure decreases even further. Cooper quotes Booz-Allen & Hamilton (1982) and PDMA (1991) in the fact that only 1 out of 7 initiated PD projects reach the market (and the 67 % chance of success)[57].

3.3.1 The problem

With the ambition to enhance the odds outlined above several studies have been conducted with the goal to extract the "do's and don't's" in developing new products and Cooper lists the seven most significant problem areas according to his findings:[58]

1) *Lack of market orientation* – Companies tend to omit critical marketing tasks, especially those early on in the process such as mapping customer needs and wants and preliminary as well as detailed market studies.
2) *Poor quality of execution* – The activities undertaken in most PD processes tend to be deficient if carried out at all. Less than 2 percent of examined projects in Cooper's study are deemed to be complete, regarding included activities and their quality.
3) *Moving too quickly* – The lacking quality of execution is often due to an ambition to save time. This short-cutting and omitting of key activities hurt projects in the long run.
4) *Not enough up-front homework* – There seems to be a rule of a macho "ready, fire, then aim"-mentality when it comes to the initial analysis of PD projects. The effect is that too many bad ideas move on to the full development phase, absorbing resources from better ideas and projects.
5) *Lack of product value for the customer* – Vital to successful PD is developing products that match customer needs. A competitive environment also calls for products that have a revolutionary nature rather than just focusing on minor, incremental changes. To achieve this, the customer has to be "internalized" in the process.
6) *No focus, too many projects, and a lack of resources* – Scarce resources are spread over too many projects due to deficient front-end homework, resulting in starvation of the projects with true potential.
7) *Lack of a systematic new product development process with discipline* – Key tasks is omitted or isn't performed proficiently. Sometimes there isn't a PD process in place, other times it's there, but it's flawed or simply not used.

3.3.2 The critical success factors

Burgess et al. identifies the decision to terminate a project mid-development as "*notoriously difficult to take but critical to preventing project failure, for example through timing, product inferiority or changing customer needs.*"[59] Cooper takes a similar position and based on the seven problem areas above as well as several benchmarking studies looking for the "do's" of PD he presents several critical success factors, summarized in "*The Performance Diamond*":[60]

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[55] Griffin, A. (1997), *Drivers of PD Success: The 1997 PDMA Report*
[56] Cooper, R. (2001), *Winning at new products – accelerating the process from idea to launch*, p.11
[57] Ibid., p.11
[58] Ibid., pp.46-47
[59] Burgess, T.F. et al. (2001), *Revitalising new process development in the UK fine chemicals industry*, p.1139
[60] Cooper, R. & Kleinschmidt, E. (2007), *Winning businesses in product development: The critical success factors*, pp.9-10

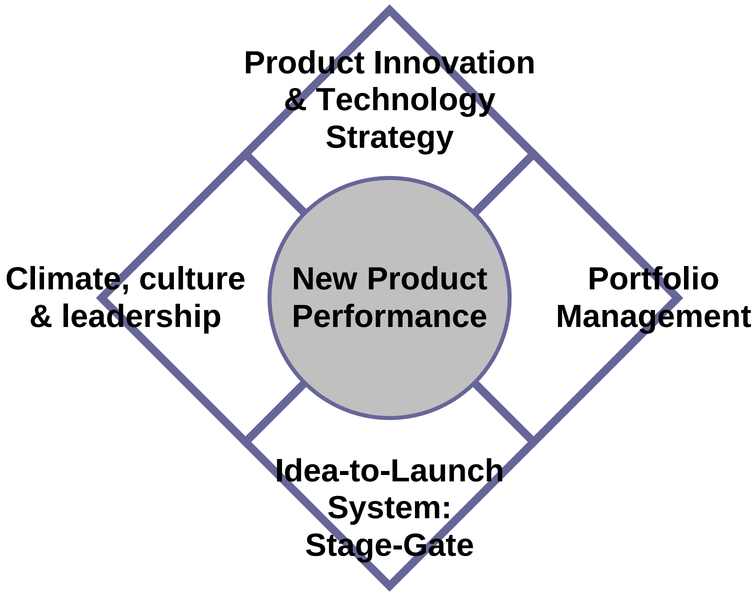

Figure 3.4 The Performance Diamond (Adapted from: Cooper (2007), p. 10 & Stage-Gate Inc. (2008))

The Performance Diamond (sometimes also referred to as *The Innovation Diamond*) consists of four key areas of best-practices and a reminder (the grey circle) to measure the PD performance in all of them[61]. The effective management of each of these areas could easily be the base of several master theses respectively and the run-through below is not a complete description of the complexity of the areas. However, some important aspects of the first three areas are presented below, and the fourth – the focus of this master thesis – the Idea-to-Launch System, is given a more complete description in chapter 3.4.

1) *Innovation & Strategy* – The product innovation strategy must be connected to the overall strategic vision for the business. This connection includes business goals for PD and planning for the strategic areas in which to compete with its R&D efforts. The strategy guides how and where the organisation spends its money and should cover five elements:[62]

- *The goals for the organisation's total PD efforts*
- *The role of PD; how new products fit into the organisation's overall goal*
  (1 and 2) How PD and product innovation should help the organisation to reach its business objectives. Potential statements are "By 2010, 30 percent of the business's sales will come from products launched within the last five years" or objectives concerning the desired financial returns from new products

- *Arenas of strategic focus; markets, technologies, product categories, including priorities*
  Deciding the battlefields where the attack is focused. This specification spells out what's "inbounds" and what's "out-of-bounds" when it comes to markets, applications and chosen technology platforms.

- *Deployment; spending allocations (or splits) across these arenas (R&D funds or people, possibly marketing and capital resources for developments)*

[61] Cooper, R. & Kleinschmidt, E. (2007), *Winning businesses in product development: The critical success factors*, pp.9-10
[62] Cooper, R. (2001), *Winning at new products – accelerating the process from idea to launch*, pp.352-356

The relative emphasis of the strategic arenas; often several key markets exists – this part of the innovation strategy priorities them relative each other. How important is success in a certain market or through a certain technology?

- *How to attack each arena in order to win*
  The road to success may lie in a differentiated strategy in different strategic arenas; in a certain market or segment innovation may be crucial, stressing a need to continuously launch new products. In another market emphasizing key attributes may be a better way. An initiative within this element of strategy may result in a product roadmap specifying a series of wanted products and their timing.

2) *Portfolio management* – Resources assigned to PD is too scarce to waste on the wrong projects, but as discussed in chapter 3.3, several studies show that most PD projects are losers. The challenge in managing the project portfolio is two-fold; first – most projects in the average company are marginal ones – minor incremental enhancements that may be unfit for commercialization. Secondly, there're always far more opportunities to pursue, than resources to realize them. These challenges call for a disciplined methodology to choose the right projects and to find and drown some puppies before they consume too many resources. However, this is not an easy task; studies show that the current track-rate of the average company is that 3 out of 4 projects selected for the development phase fails, giving management a 25 % success rate – or in Cooper's words – "*you'd be better of tossing a coin*"[63].

The drowning of puppies, or project selection, is a vital part of a disciplined PD process as stated above in the problem area discussion in chapter 3.3.1. However, this is a multifaceted subject and there is an intimate connection between portfolio management and overall business strategy that's not discussed in depth here due to the delimitations of the thesis. In figure 3.5 below the two levels of project selection are presented briefly.

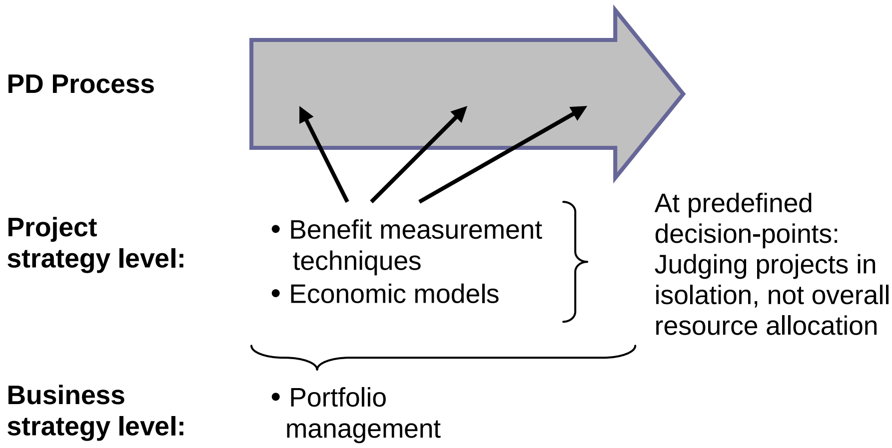

Figure 3.5 Separating project strategy level and business strategy level

At *project strategy level* projects are judged at certain decision-points on their own merits, against predefined criteria. The methodology to facilitate project rating could be *benefit measurement techniques* such as checklists or scoring models, or more rigorous *economic models* such as Net Present Value analysis or Internal Rate of Return[64].

Selecting the opportunities to pursue is also done at a *business strategy level* where projects are judged against each other with the strategic vision of the whole corporation in mind. This aspect of portfolio management is based on an overall strategy where, for example, a project aimed at positioning the

[63] Cooper, R. (2001), *Winning at new products – accelerating the process from idea to launch*, p.215
[64] Ibid., pp.213-216

company in a new market very well could be justified, even though it doesn't pass the normal criteria for a certain decision-point[65].

The structure of the decision-points is discussed further in chapter 3.4, *The Stage-Gate process* below.

3) *Climate & culture* – Developing new products is a multidisciplinary process that needs input from several different functions in order to be successful. In order to solve the problem stated earlier (see chapter 3.3.1) there is a need for cross-functional teams including members from marketing, finance and operations, before the projects even gets close to the development phase[66].

Creating the multidisciplinary teams is only the first step – the next and most important one is in the organizational design; making the teams work. Key aspects are strong and empowered project teams and leaders, working in a climate that reward and encourage creativity and innovation. It is also vital that the climate doesn't punish failures. When working in an uncertain environment as PD, there will be failures – and the only way to avoiding them is not taking any risks at all, hardly something to recommend in a PD department. Cooper summarizes his thoughts on the subject:

> "*The next time you have a failure, throw a party – not to reward incompetence, but to celebrate all that you have learned. Of course, the real reason is to send a message to would-be entrepreneurs that it's okay to fail*"[67].

4) *Idea-to-Launch System* – Most companies today have a structured PD process implemented, there is however differences in how well it works. This fourth success factor is fundamental to the thesis, why a thorough description is presented in the following chapter.

3.4 The solution – a Stage-Gate process

In the pursuit for a generic PD process for the fine chemical industry in the UK Burgess et al. acknowledge the critical activity of rating, and if necessary, terminating projects mid-development and that these decisions could be "*eased considerably by pursuing a series of "decision gates" informed by appropriate criteria, within the PD process*"[68]. Kotler and Crawford, respectively, propose the use of similar processes – mixing activities and decision-points to logically determine the best PD projects to pursue[69,70]. Although positive to the structuring of PD efforts, Ottosson comments on the development of generic PD processes that they "*tend to be bureaucratic and too detailed*" and that "*the complexity … [in describing] … the product development process in detail*" makes them difficult to use for practitioners, exemplifying with Crawford's (1991) model consisting of 5 stages and 67 specific activities for PD processes[71].

Burgess et al. concludes that the diversity of markets, products and companies makes a generic model either inappropriate or too abstract and that industries and organisations have moved towards developing their own models instead of applying a generic one[72]. They also conclude that the various PD processes available in scientific literature and industries all share common characteristics in the separation of stages and gates, and that the generic model proposed, and refined, by Cooper (1993, 1996, 1999) is a suitable base, from which to derive an industry-specific PD framework.

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[65] Matheson, D. & Matheson, J. (1998), *The Smart Organization – Creating value through strategic R&D*, p.202
[66] Cooper, R. (2001), *Winning at new products – accelerating the process from idea to launch*, pp.95-96
[67] Ibid., p.97
[68] Burgess, T.F. et al. (2001), *Revitalising new process development in the UK fine chemicals industry*, p.1139
[69] Kotler, P. et al. (2002), *Principles of Marketing*, pp.501-518
[70] Crawford, C.M. (1997), *New Products Management*
[71] Ottosson, S. (1996), *Dynamic product development: findings from participating action research in a fast new product development process*, pp.151-169
[72] Burgess, T.F. et al. (2001), *Revitalising new process development in the UK fine chemicals industry*, p.1140

Cooper builds the Stage-Gate PD process on the foundation of the seven problem areas and critical success factors outlined above[73] (see chapter 3.3.1 and 3.3.2) and this chapter begins with a description of the key characteristics of the model, see figure 3.6 below, before the structure is discussed in detail.

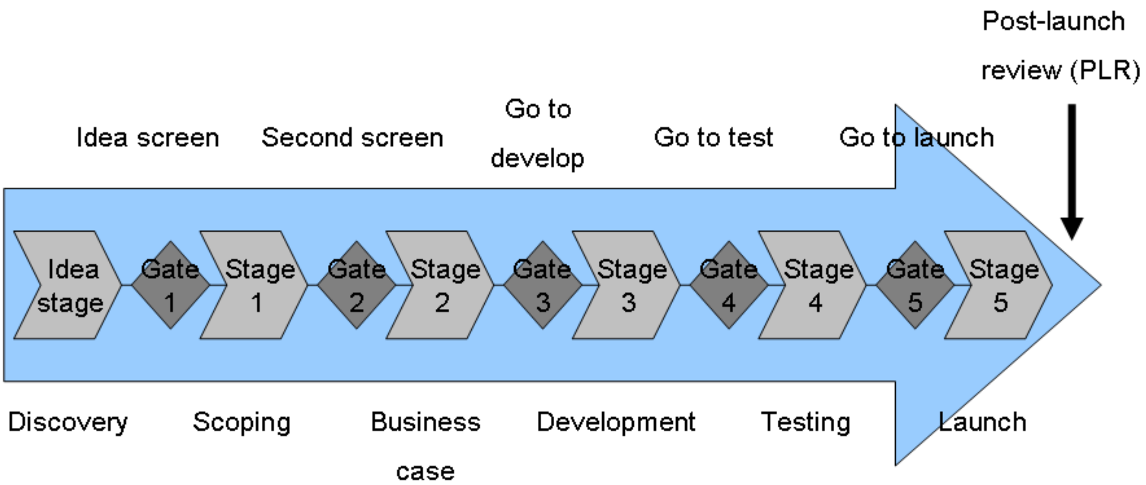

Figure 3. 6 Stage-Gate, a five stage, five gate model along with an Idea stage and a Post-launch review (Source: Cooper (2001), p. 130)

One ambition with Cooper's model is that it should assist PD in managing the risks involved. Total risk avoidance in developing new products is impossible due to the nature of the task, but buying in to a project at incremental steps presents the opportunity to "peak around corners" at a low cost. Based on the fact that the concept of risk has two components – the amount at stake and the probability for an event to occur (see figure 3.7 below) – Cooper presents five gambling rules that guide his Stage-Gate model[74]:

1) If the uncertainties are high, keep the amount at stake low
2) As uncertainties decrease, the amount at stake can be increased
3) Dividing the decision process in incremental steps breaks the initial "all-or-nothing" bet into a series of minor decisions
4) Be prepared to pay for the relevant information needed to reduce risk
5) Provide for bail-out points where there is an opportunity to fold or walk-away

The structure with stages and gates provides the opportunities asked for in gambling rules three and five. Rules one, two and four state that, ideally, stages closer to the end of the process should gradually be the more expensive ones and that accepting this increase in stakes at the gates calls for a reduction of uncertainties due to the activities undertaken in the stages.

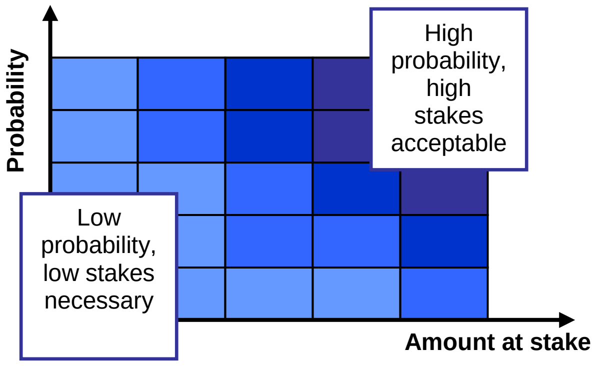

Figure 3. 7 Risk-diagram showing that high probability for success allows higher stakes in play

The stages are designed to gather or produce the output needed to drive the process forward. This is done in a multidisciplinary way – there's no "R&D" or "Marketing"

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[73] Cooper, R. (2001), *Winning at new products – accelerating the process from idea to launch*, pp.129
[74] Ibid., pp.123

stage, the activities are completed by the cross-functional teams as they are needed.
The gates all have a common format (see figure 3.8 below) with three components[75]:

1) *Required deliverables* – Certain outputs of the preceding stage. These deliverables are predefined for each gate providing clear goals guiding the project team's work to this point.

2) *Criteria* – The base of the go/no go-decision. The criteria should have both the nature of "knock-out"-questions which the project must meet in order to stay in the game, and "should-meet"-criteria on which the project can be rated against other projects. Usually these criteria change from gate to gate.

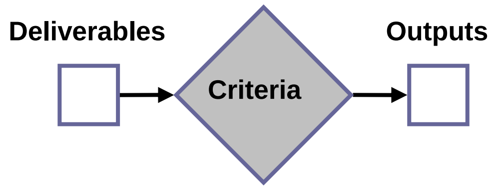

Figure 3.8 The format of a gate (Source: Cooper (2001), p. 132

3) *Outputs* – Besides the go/kill/hold/recycle-decision, an approved action plan (with resources required and timelines) for the upcoming stage should be included. Finally the deliverables in the next gate should be revised if needed and the gate-meeting scheduled. The set of output-decisions is straightforward in its interpretation: *go* means go ahead with the action plan; *kill* means stop the project – and spend no more on it; *hold* means that the project could be an OK one, but that there is other projects in better need of the scarce resources available; *recycle* means go back where you came from and do the activities in the previous stage correctly.

The attendees (gatekeepers) at these gates varies but managers responsible for the resources required must be part of them in order to clear the resources required to create an empowered project team in the next stage. This also means that the gatekeepers shouldn't consist of only managers from one functional area, such as marketing or R&D – all the resources needed in the next stage should be represented. The attendees could vary from different gates, or different projects, based on place in the process or amounts at stake for the specific project. However, there should be some continuity that preserve the ability to compare projects as parts of the company portfolio.[76]

The gates deal with *three aspects of quality*: quality of execution; business rationale; and quality of the action plan:[77]

1) *Quality of execution* – Have the activities in the previous been carried out in a quality fashion? Are the key deliverables in place? Is the project on time and on budget?
2) *Business rationale* – Does the project continue to make economic and business sense? Is it strategically aligned with the business? Can the product generate profits? Does the product have unique benefits and a demanded value for the customer?
3) *The action plan* – Is the proposed action plan through to launch a good one? Are the resources requested reasonable? Available?

A more thorough description on possible criteria and decision methods for each gate is given in the following chapter (3.4.1).

3.4.1 A Stage-Gate run-through

In this chapter each stage and gate in the generic process (see figure 3.6 above) is outlined to present the central aspects of them respectively. Unless explicitly noted, the run-through follows Cooper.[78]

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[75] Cooper, R. (2001), *Winning at new products – accelerating the process from idea to launch*, p.131
[76] Ibid., p.236
[77] Ibid., p.117
[78] Ibid., pp.132-141

Idea stage; Discovery

No matter how well-functioning the PD process is, it can't turn bad seeds into star products – if the product ideas feeding the process are mundane the outcome will be as well, at the best.

In Cooper's earlier versions of the Stage-Gate process, developed and refined through the 1980's and 90's, the product ideas were assumed given. In the third generation of the process this idea stage has been added in order to force management to look at central, but often overseen, questions on the subject: Where does the product ideas come from? Where should they be coming from? Are they good ones? Are there enough of them? Is there a new product idea generation system in the corporate business? [79]

The search for them has to be both a top-down and a bottom-up idea generation, with ideas coming from top management as well as from the co-workers at the floor. It is vital that it's guided by a product innovation & technology strategy, often directed from high level management, pointing out key markets, customers or strategic arenas towards which new products should be focused. However; the ideas generated by the development personnel, or by salespersons with close contact with the end customer often prove to be successful launches as well. Cooper proposes several ways to work with idea generation, including[80]:

- *Strategic outlook* – looking for disruptions in the customers industries. This includes mapping the customers industry rigorously; value chains, industry drivers, historical as well as expected trends, and matching the findings with an internal assessment on the company's strengths, weaknesses and core competencies.
- *Scenario planning* – but do more than just develop the mainstream, or official, scenario. Establish best cases, worst cases, strange cases, etc. Assign these alternate scenarios with little probability, but they could still have impact on the choice of which new product ideas to pursue.
- *Voice of Customer (VoC)* – new products aim at solving problems, the hard part is finding which problem to solve. And asking why, to completely understand the true needs behind the demand. Often used techniques when interacting with customers include value analysis, observations, and dialogue with key customers or focus groups.

Gate 1; Idea screen

In this gate the first commitment of assigning resources to a project is made. Cooper describes this gate as a "gentle" one, subjecting the project to a handful of should-, or must meet criteria, but little financial ones. Key aspects are strategic fit, market attractiveness and project feasibility. Typical instruments are checklists and a few scoring models to help focus the discussion.

Stage 1; Scoping

In stage 1, a quick scoping of the project is made. The hours and resources put into the project are still relatively few and Cooper states that the typical extent of this stage is 10-20 person-days work effort. The target is two-fold; to present a preliminary market assessment and a preliminary technical assessment of the project as input to gate 2. There is a limited effort put into the project meaning it can be carried out by a relatively small group of people – nevertheless it is an important step, estimating the probability of product success in order to decide whether additional resources should be granted to develop the more detailed business case in stage 2. The preliminary market assessment includes determining the market size, potential and acceptance – information often available in-house at low cost. The technical assessment consists of outlining development and manufacturing routes, feasibility, times and costs as well as any eventual big roadblocks or hurdles ahead.

[79] Cooper, R. et al. (2002), *Optimizing the Stage-Gate Process: What Best Practice Companies are Doing – Part One*, p.3
[80] Cooper, R. (2001), *Winning at new products – accelerating the process from idea to launch*, pp.156-177

Gate 2; Second screen
This gate is essentially gate 1 all over again, although a bit more rigorously – now with the additional information prepared in stage 1. If a go decision is given, the following process includes heavier spending. The decision criteria still has the nature of should- and must meet checklists complemented by a minor financial calculation (for example a quick payback-calculation).

Stage 2; Building the Business Case
This is *the critical homework stage*, where studies quoted above show that most companies fall short. The vital homework includes five different, although adjacent, areas, some of them addressed as "preliminary" in stage 1, now with the prefix "detailed":

- *Product definition* – Delineation of the product, a product positioning strategy and a clear value proposition.
- *Market research* – Who exactly is the target customer? User needs-and-wants studies and concept tests.
- *Competitive analysis* – What's our competitors up to? In the same markets? Products with the same benefits?
- *Technical appraisal* – Can the product be developed at time and at the right cost? Do we need new partners?
- *Business and Financial appraisal* – Does the concept hold water and is it still an economically attractive project? Can we reach needed market shares and volume-sales to hit positive figures at the bottom-line?

The functional diversity in the competencies needed to complete these activities calls for a cross-functional approach to this stage.

Gate 3; Go to Development
In gate 3 the projects get a "sign off" on the product and project definition – the homework up to this point should vouch for a sound reasoning behind the market offering about to be developed. This is also the last chance to kill the project before heavy spending is initiated. The approval of increased spending means that a more rigorous analysis of the financial calculations, in conjunction with should- and must meet criteria, is undertaken here.

Stage 3; Development
The physical development of the product. As development progresses lab, in-house or alpha tests are carried out and regulatory, legal and patent issues are resolved. For most projects several milestones and periodic project reviews takes place during this stage. These are not gates in the same ways as the formal gates – go/kill-decisions aren't made here, although these checkpoints are important to the management of the project.

Market research and customer feedback are still part of the process in an iterative way. Information is collected; suitable product adjustments carried out and so forth. Concurrently a test, marketing and production plan are developed and as gate 4 approaches this information along with an updated financial analysis are compiled.

Gate 4; Go to Testing
Did the development stage turn out satisfactory? Once again the financial analysis is revised, based on new and more accurate data. The action plan for the following stage consists of chosen test and validation strategy as well as detailed marketing and operations plans for probable execution.

Stage 4; Testing and Validation
When stage 4 is completed, the decision is to launch or not, meaning that extensive external validation takes place here. Further in-house testing is as well as user, field or formal tests, to ensure that the product functions under real use conditions are carried out. Production scale-up in different forms (e.g. trial, limited or pilot) is performed to analyze and enhance the production process. Test marketing or trial selling are useful tools to specify the economic estimates that build up the financial analysis.

Gate 5; Go to Launch
The last gate – and the last chance of killing the project. This gate puts focus on the activities performed in the previous stage; did the tests prove what were expected? Is there still a positive expected financial return? If so, and if all marketing and operations plans still pass the review, the go-to-launch-decision is given.

Stage 5; Launch
Implementation of the marketing and operations plan. If the PD process in place has worked so far the odds are in favour of another product success.

Post-launch review (PLR)
At some point after the product launch the PD project should be terminated (Cooper states 6-19 months) and the product takes place in the company's portfolio of regular products. This is also the time to audit the project:

- Concerning the latest data on sales and costs – did we forecast the future correctly? Did we follow the plans developed? Is the product performing as expected?
- How did the project perform? Strengths and weaknesses are discussed and lessons on what to improve to the next project learned.

After the PLR, the PD project is terminated, although the project team is still responsible for the project during this review.

3.5 Measuring performance

The phrase "what you measure is what you get" is a common truth in the field of management research and literature as well as in other professions. If this truth holds water – and that seems to be the case – it challenges corporations to ask themselves which behaviours they encourage and why? From this viewpoint Larsson & Ljungberg proposes that any corporation should spend a considerable amount of time and care in deciding what to measure, accompanied with the more traditional strategic questions such as what the corporation aim to achieve and why this achievement is desirable. The purpose with measurements is two-fold; they aim to provide basis for an action or adjustment and they creates knowledge that in turn creates understanding.[81]

> "*Measuring generates knowledge and knowledge is a prerequisite to understanding development and improvement. […] we can't manage and develop what we can't communicate, we can't communicate what we can't measure, we can't measure what we can't define and we can't define what we can't understand*"
>
> - Larsson E., Ljungberg A., *Processbaserad verksamhetsutveckling*, p.226. (translation)

So, what does the organisation want? Which are the demands on the process that should direct choice of measurements? As shown in figure 3.9 the demands could be divided into three parts; *demands from the end-customer, the sub-processes and the organisation*. The end-customer demands is probably different from the sub-processes', and they are of course important for success but as are the internal demands. A sub-optimized process missing out on the demands from sub-processes will under

[81] Larsson, E. & Ljungberg A. (2001), *Processbaserad verksamhetsutveckling*, p.215

perform in the long run. The demands from the organisation stems from the strategic agenda (e.g. return on invested capital (ROIC), or initiatives such as re-directing a program to capture a new market). These demands are often separated from, or at least difficult to translate into, process goals; illustrated in figure 3.9 below by a suggested three level approach – strategy, critical success factors and process goals.[82]

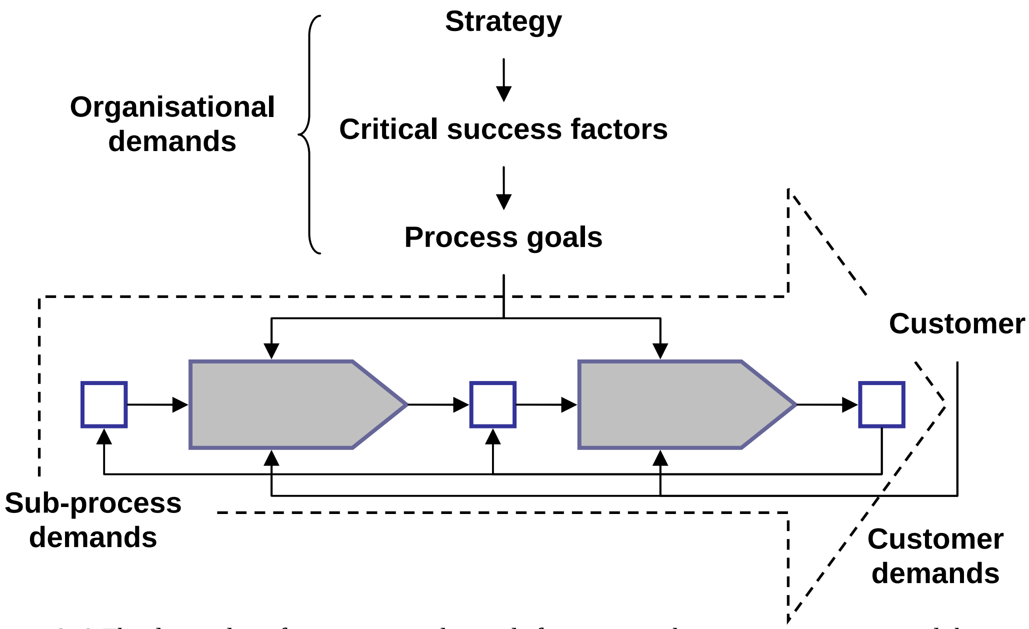

Figure 3. 9 The demand-set for a process; demands from external customers, strategy and the process itself (Source: reworked from Larsson & Ljungberg (2001), p. 240)

The discussion on the different demands that exists on a certain process should be focused around the demands and *not* if they are measurable or not. The "how to" in measuring is a different discussion with the prerequisite of knowing what to capture. This discussion could be aided by the structure outlined in figure 3.10 below. This model for measurements is based on:[83]

- Measurements could be related to *object in*, the *process* or *activity* itself, *object out*, *resources* or *efficiency*
- The measurement connected to *object in/out* or the *activity* can be divided into *process properties* or *object properties*
- The desire to measure both the *immediate result* of the process as well as the *effect* in a longer perspective

[82] Larsson, E. & Ljungberg A. (2001), *Processbaserad verksamhetsutveckling*, pp.236-240
[83] Ibid., p.240

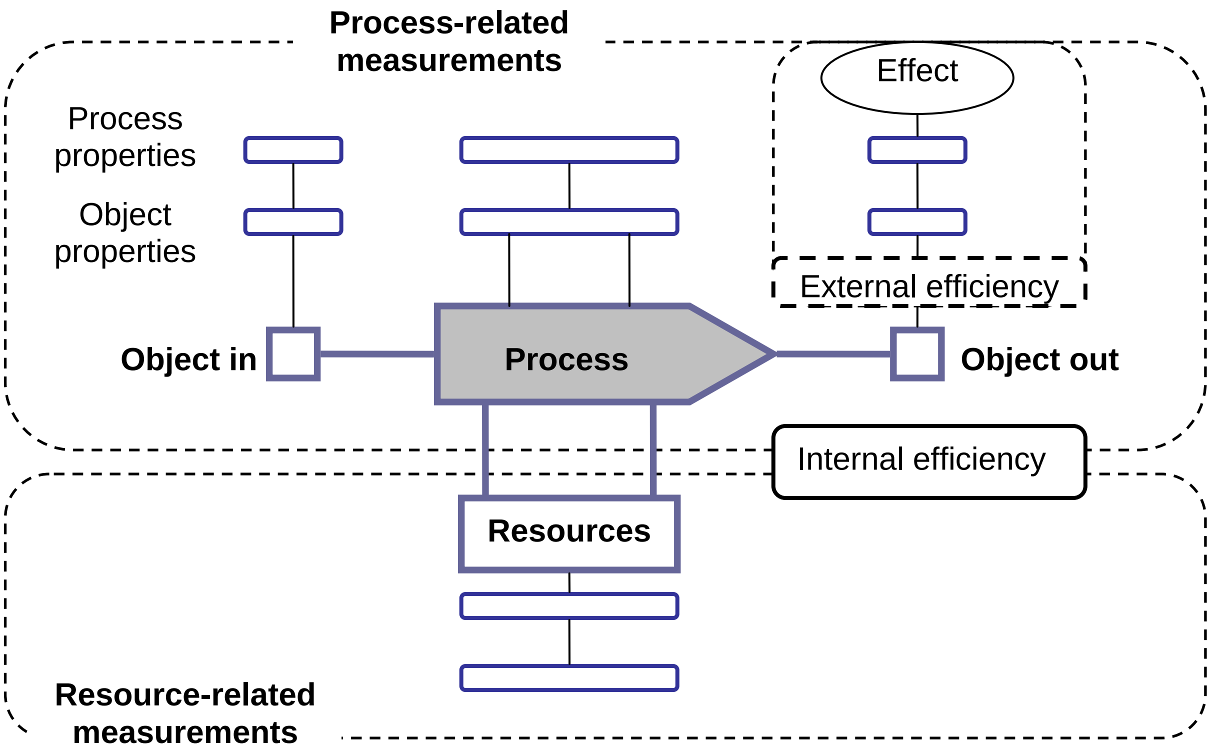

Figure 3. 10 Model for measurements of processes (Source: reworked from Larsson & Ljungberg (2001), p.244-245)

Process and object properties in the figure above are related to the *how* and *what* of the process result. For example timeliness is a process property (how) while flawlessness (what) is an object property. The end result of a process or an activity could be divided as well, separating the immediate result (object out) and the result in a longer run (accumulated effects of the process). Another proposed measure is the level of internal efficiency; resources spent for a certain object out.

Cooper addresses this issue in somewhat less detail (although similar in structure) separating the proposed measures in two broad categories *post-process metrics* and *in-process metrics*[84]. His focus is solely on PD so their application is more direct than for the model proposed by Larsson & Ljungberg.

Post-process metrics – how well are we doing at new products? These are metrics that's measured after the products have been launched (both shortly after and long term). Examples include:

- *Short term*
  - Timeliness (e.g. cycle-time for certain stages, actual project time vs. fastest possible)
  - Budget
- *Longer term*
  - Financial (e.g. profitability, sales, costs)
  - Success rates (percentages of launched products relative to the number of "successful" products) – here the term *successful* needs an internal definition
  - Attrition curves (number of products vs. stage in the process)
  - Percentage of sales revenues (or company growth or profits) generated by new products (an internal definition of *new product* is needed; e.g. launched in the last three or five years)

[84] Cooper, R. (2001), *Winning at new products – accelerating the process from idea to launch*, pp.345-348

In-process metrics allows for a shorter response time and could serve as important early warning signals – is our PD-process working as it should? Examples include:

- Quality of gate meetings (and deliverables)
- Degree of deviation from the agreed PD-process
- Timeliness in reaching gates
- On-budget performance

Although both Larsson & Ljungberg and Cooper warn organisations to have too many metrics, they suggest using many at first, followed by a reduction to a set of the most important ones.

3.6 Activity-based costing

Activity-based costing (ABC) was developed in the 1980's by Robin Cooper and Robert S. Kaplan as an answer to a widespread dissatisfaction of existing costing methods used in American corporations. They made a survey among 31 companies and studied about 50 costing systems during a five year period. The study revealed that eight of the companies, independently of each other, had made new similar costing systems. This came to influence a series of articles presented 1988-1989 named "The rise of activity-based costing: Part I-IV" that launched the Activity-based costing method. The name *activity-based costing* was taken from one of the companies, John Deere Component Works. Numerous articles on the subject have been written since, resulting in a significant number of different definitions and extensions of its use.

In the following chapters costing of products are discussed. The reader should bear in mind that costs for processes and programmes could be calculated in the same way. The terminology chosen is because ABC by far is mostly discussed in the manufacturing process in the literature.

3.6.1 Why ABC

In many companies costs incurred are derived into responsibility centres like R&D, Sales & Marketing, and so on. This meets the requirements from an accounting point of view, but when costs are to be tied to a specific product for pricing purposes or others this can be a problem. Some costs are easily linked to each unit produced, direct labour (DL) and direct material (DM) for example, and are dependent of the volume of the product produced. Other costs are independent of volume and are often incurred not only by one product but many, for example fixed or overhead (OH) costs. For example, one machine can be used by many different production lines and the costs from the machine are therefore harder to tie to a single product. In volume-based costing (VBC) OH costs and fixed costs are allocated based mainly on the volume of a product as a percentage markup on the direct costs.

Ask & Ax quotes Cooper (1987) when describing the problems with VBC:[85]

- Products that are difficult to produce showed good profitability
- Results of quotation could be difficult to explain
- Quotations of a competitor could be much higher or much lower
- Customers didn't argue about some price increases
- Suppliers could offer higher or lower offers than expected
- The misbelieve of the costing system caused departments within a company to create own costing systems

[85] Ask, U. & Ax. C, (1995), *Cost Management – produktkalkylering och ekonomistyrning under utveckling,* pp.41-42

The study also concluded that the share of fixed costs and OH costs had increased and the share of direct costs decreased, resulting in having volume based cost drivers more inappropriate.

In VBC, DM and DL is the most commonly used factors to determine the markup for indirect costs. The OH costs and fixed costs of the company are derived to either DM or DL as percentage that in some cases can be several hundreds of percent. A problem in VBC is that high volume products will carry the lion part of the fixed and OH costs and therefore will appear less profitable than low volume products. The reason for this is the difficulty to detect underlying economics of production batches and product variety in VBC systems. This problem was the main driver of the evolvement of ABC.

3.6.2 The theory of ABC

In Activity-based costing there are two central definitions; activity and cost driver. During the time elapsed since the first articles, numerous of new definitions have been introduced and the meaning of some have been altered, leading to an unclearness in the definitions. Thus, there might be a difference from the ones presented here and other literature on the subject.[86]

Ask & Ax states that *Activities* are everything that is conducted in a company for example “receive and inspect goods”, “transport of material”. The activities can be classified in five different levels, see figure 3.11. Every company is unique and the number of levels and the activities conducted on each level can vary from company to company. Following levels are presented:[87]

1) At the *company/factory level* activities are conducted for the purpose of the whole company. Top management and accounting are typical activities.

2) The *production process level* includes activities that supports the entire production process and are independent of the number of products in the product portfolio and batches or units produced.

3) *Product level* includes activities that support individual products within a product portfolio. They are independent of number of the batches produced.

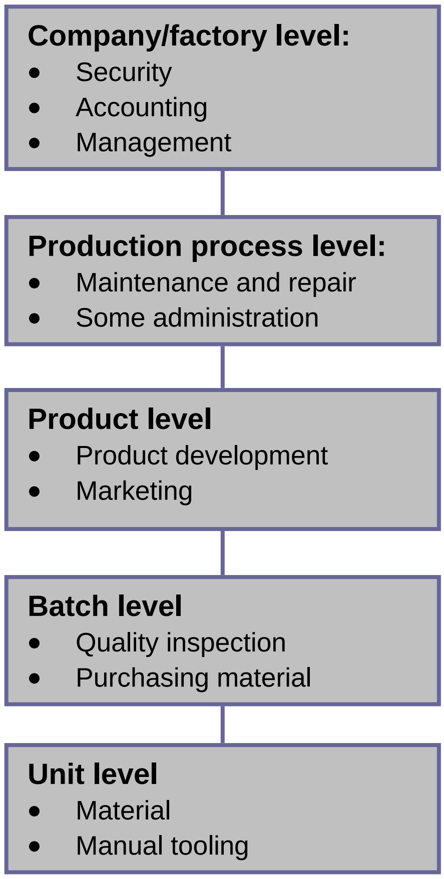

Figure 3.11 Activity levels and examples of activities conducted on each level (Source: Ask & Ax (1995), p.57)

4) At the *batch level* the activities are conducted independently of the size of the batches. A typical example is calibration of a machine when shifting from one batch to another. The calibration cost is the same no matter the size of the batch. However, different products could still cause different costs.

5) *Unit level* activities are conducted for each unit produced. This is the only level where the costs are proportional to the volume produced. The post “material” in figure 3.11 isn’t an activity in its true sense, since it isn’t a task that’s performed but the used material for each unit. Its counterpart in the VBC is direct material.

[86] Ask, U. & Ax. C, (1995), *Cost Management – produktkalkylering och ekonomistyrning under utveckling*, pp.54-55
[87] Ibid., pp.55-59

Two commonly citied definitions of *cost drivers* according to Ask & Ax are:[88]

> *"A cost driver is any factor whose change causes a change in the total cost of a related cost object. Drivers are causal factors whose effects are increases in total costs" (Quoted from Horngren & Foster (1991))*
>
> *"A cost driver is a variable which determines the work volume or workload of a particular activity" (Quoted from Innes & Mitchell (1992))*

Ask & Ax states that a cost driver is a variable to trace costs to a specific product and it explains why the activity costs amount to certain sums. Typical activities and its cost drivers can be:[89]

- Purchase – Number of purchases or Number of suppliers
- Quality check – Number of components checked or Control hours
- Machine setups – Number of setups or Setup hours

The selection of cost driver is a trade-off between accuracy and cost efficiency. The more accurate the cost driver is the more complex and difficult and thus expensive it becomes to measure. Figure 3.12 below illustrates this further.

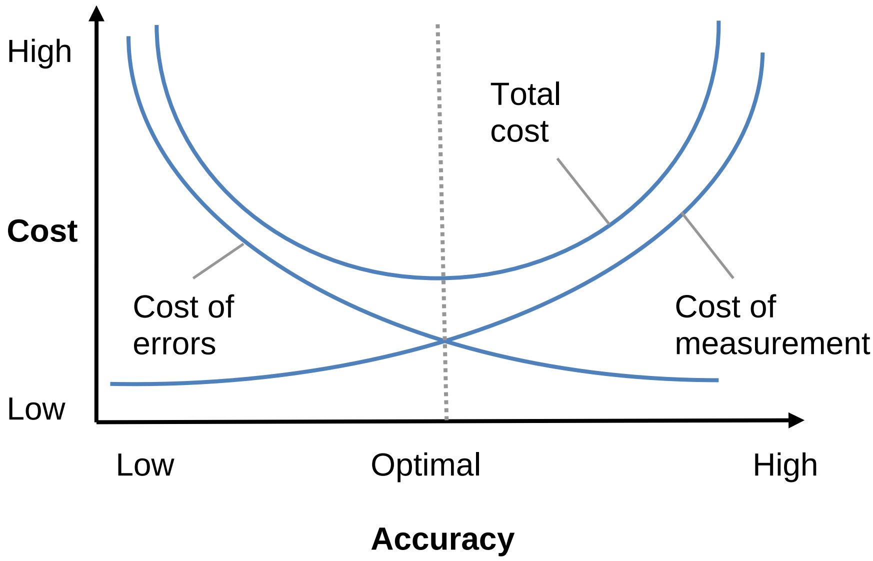

Figure 3.12 Trade-off between accuracy and cost-efficiency when choosing the level of detail in costing (Source: Cooper & Kaplan (1998), p.104)

Cooper & Kaplan lists three types of cost drivers in order of complexity to measure:[90]

1) *Transaction drivers* count how many times an activity is performed. They are often reasonably easy to measure and are therefore considered to be the least expensive type of cost driver. When using transaction drivers the assumption is made that the activity always consumes the same amount of resources. This can present a problem with the accuracy if the resources vary much from product to product.

[88] Ask, U. & Ax. C. (1995), *Cost Management – produktkalkylering och ekonomistyrning under utveckling*, p.59
[89] Ibid., pp.59-61
[90] Cooper, R & Kaplan, R.S (1997), *Cost & Effect – Using Cost Systems to Drive Profitability and Performance*, pp.95-97

2) *Duration drivers* are the time it takes to perform an activity. It is used when there are great varieties in time when the activity is performed. It is more costly to implement than a transaction driver since it requires an estimate of time needed each time an activity is performed. The gain is a better accuracy. Time isn't the only possible duration driver. For example distance can be an option for transportation purposes if it's easier to estimate.

3) *Intensity drivers*, also referred to as direct charging, are the most accurate but also the most expensive cost drivers. They calculate the exact amount of resources needed for the activity and charges it directly. Using intensity drivers is most useful when the activity performed is both expensive and variable in time.

To simulate duration and/or intensity Cooper & Kaplan suggest that a complexity index might be used. When a complexity index is used there is no need to estimate actual time or intensity, instead a classification is made. For example, setup for a machine can be divided in "easy" and "complex", with a variation of cost to simulate that some products demand a more time consuming setup than others. If a more accurate classification is wanted an extended index can be used.[91]

The cost driver should be taken down to the same level as the activity, i.e. a unit level activity should have a cost driver based on single units otherwise cost will be distorted in the same way as with regular VBC systems.

3.6.3 The criticism of ABC

The benefits of ABC are often emphasized in the literature. But according to Johnson there are downsides with ABC, and it should only be implemented if absolutely needed. Acknowledging that ABC could give a better product cost estimation he states that to become a successful company there must be a shift of paradigm, away from focusing on the short term and high margins on the bottom-line, to think in terms of quality and customer satisfaction. This is the only way to become a global competitor. ABC enhances focus on costs and tries to increase order sizes and production runs to gain economies of scale. The company then has to sell the most profitable products to the customers, not necessarily the products the customers want the most. In a just-in-time oriented world economies of scale is not relevant and thus ABC sends batch-oriented companies in a wrong direction. When they should focus on customer satisfaction they focus on costs. This postpones changes the company needs to do if it wants to do what customers want in a profitable way.[92]

According to an article summary by Price, Johnson claims that only two forces drive costs, time and material. By reducing variation and lead-time in the work, costs will decrease by itself.[93]

3.6.4 ABM

Activity-based Management (ABM) is based on the ideas of ABC but the purpose is different and thus ideas and definitions are adjusted to fit with the purpose. Ask & Ax presents ABM as concept that aims to give managers ideas and tools to use resources in a more efficient way when creating customer value. This doesn't necessarily mean that fewer resources are to be used, only that they are to be used in a better way. What's efficient is based on the goals that are to satisfy all the stakeholders of the company. Stakeholders can include stockholders, employees and the public community. The purpose of ABM is defined as:

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[91] Cooper, R & Kaplan, R.S (1997), *Cost & Effect – Using Cost Systems to Drive Profitability and Performance*, pp.98-99
[92] Johnson, T H, (1993), *To Achieve Quality, You Must Think Quality*
[93] Price, J. S., (2001), *It's time to stop overselling Activity-based concepts. Summary by J.S. Price*, http://maaw.info, 2008-03-04

> "*…an approach that aims for an efficient use of resources when creating customer value (or satisfying customer demand) given the goals (restrictions) that a company has put up and committed itself to.*"
>
> - Ask & Ax, *Cost Management – produktkalkylering och ekonomistyrning under utveckling*, p.96

The term *customer value* is central in ABM. Customer value is defined by:

(3.1) Customer acquisition – customer sacrifice = customer value

Customer acquisition is what the customer gets in form of physical products, quality, service etc. *Customer sacrifice* is what the customer give away, including payments and efforts made on getting the acquisition to work. Determine what creates customer value is not a part of ABM but are sought for with other tools.[94]

Activities and drivers are, as in ABC, definitions with importance, but the meaning of them varies with the writers. Ask & Ax concludes that the definitions from the ABC terminology aren't enough but needs to be developed.

Activities are given an attribute that makes it possible to classify them in some way. Commonly in literature the attributes are used to divide the activities in activity couples and the most frequently suggested are:

- Value-adding and nonvalue-adding activities
- Primary and secondary activities
- Positive and negative activities

The purpose of the classification is to track inefficient activities within the company and eliminate them. Ask & Ax states that from a customer value perspective it is insufficient with only two subcategories since eliminating all nonvalue-adding activities could cause a dysfunctional organization. Instead three categories are introduced, that can be branched further if needed:

1) *Refining activities* contains all activities that purify the product from raw material to finished goods, for example painting, assembling, etc.
2) *Value-adding activities* include activities that not refine the product but the customer can see a value in them. It can be direct value-adding activities such as service, repairs etc. but also indirect value-adding that includes activities that don't give the customer a value, but they realize the need for them. Examples can be administration, invoicing etc., activities that are needed for the company to function, but a customer wouldn't pay for them alone.
3) *Negative activities* are activities that not add a value at all to the customer and are completely unwanted since they only create costs. Negative activities can be activities that are performed twice or activities that corrects previous faults and flaws.

[94] Ask, U. & Ax. C, (1995), *Cost Management – produktkalkylering och ekonomistyrning under utveckling*, pp. 96-97

Drivers are categorized into four subcategories:

1) *Initiators* are drivers that cause an activity to start and thus explain why the activity exists within a company at all. Initiators could be reclamation that causes rework and a decision to develop a new product causing prototype development for instance.

2) *Resource drivers* explain the amount of resources consumed to perform an activity. They consist commonly by several factors that are related to the structure of the activity and to how the activity is executed. Working routines and personal are examples of resource drivers.

3) *Activity drivers* are explaining the extent of the activity, i.e. the frequency. As with resource drivers activity drivers are explained by several factors and are often based on decisions regarding strategies and policies made by the company. Number/size of batches and existence of buffer points could be possible activity drivers.

4) *Activity measure* is the ABM equivalent of the resource driver in ABC. It is a quantification of consumption of activities

By categorize activities in refining, value-adding and negative and assess the drivers behind an activity profile can be made for each activity in the company and then be managed accordingly in an efficient way.[95]

Cooper & Kaplan states that there are two levels of ABM, strategic and operational. In operational ABM the activities in the company are taken for given and the aim is to either increase capacity or reduce resources needed to perform the same output. Achieving the goal can be measured in cost avoidance due to obviation in new investments, reduced cost or higher revenues. Strategic on the other hand assumes that the activities are performed in an efficient way and thus tries to alter the demand for the activities to those with the highest profitability. Strategic and operational ABM are not mutually exclusive but are parts of the somewhat classical phrase “doing the right things right”, where strategic ABM aims at doing the right thing while operational ABM aims at doing them right.[96]

Smith suggests some caution to complete implementation of ABM/ABC. He states that customers want lower costs, higher quality, tight delivery times and product development and presents a number of management tools that together forms a synthesis to achieve satisfied customers, where ABM/ABC is the tool to reduce costs. But while reduced costs, higher quality and faster deliveries are possible to achieve together its more difficult to simultaneously achieve product innovation. The problem lies within the purpose of allocating all costs to the products that incur them, thus burdening new, in the beginning low volume products with more OH costs than a regular VBC system would. By urging away from product diversification, ABC in this way could punish new products in a way that harm the long-term success of the company. Smith concludes that the most entrepreneurial of organizations don’t fully adopt the management accounting systems due to heavy bureaucratic work and the “lack of excitement” that comes along when implementation of the systems. Instead only some good parts are picked out and used.[97]

3.7 Discounted cash flow

In order to judge whether an investment is worthwhile to do or not different methods can be used to calculate the value of the investment. In this section the net present value (NPV) method will be

[95] Ask, U. & Ax. C, (1995), *Cost Management – produktkalkylering och ekonomistyrning under utveckling,* pp.99-113

[96] Cooper, R & Kaplan, R.S (1997), *Cost & Effect – Using Cost Systems to Drive Profitability and Performance*, pp.137-138

[97] Smith, M. (1998), *Innovation and the great ABM trade-off*, pp.24-26

presented. The method is commonly used but the shortcomings are debated and some of them will be presented in chapter 3.7.2.

3.7.1 Net present value method

One basic fundamental principle of finance is that money today is more worth than money tomorrow, what Brealey et al. refers to as the time value of money, since money today can start earning interest.[98] Counting with discounted cash flow (DCF) methods there is a chance of valuing cash flows more if they occur earlier which becomes truer if the discount rate is high.[99] The use of DCF methods are widespread and over 80 % of companies in Sweden as well as in other countries uses some DCF method. In Sweden the net present value is the most common while foreign companies prefer internal rate of return (IRR)[100].

In the choice between the two methods, Brealy et al. suggest the use of NPV, concluding that NPV and IRR both are formally equivalent but IRR contains several pitfalls of which two will be presented here. First of all, IRR doesn't realize the difference between borrowing and lending, resulting that projects that borrow money with payback in the future will appear profitable, i.e. showing a high IRR, if the money is borrowed at a high rate of return. Second, IRR calculations can give multiple rates of return or sometimes no rate of return at all. This could happen when the cash flow stream changes sign with decommissioning as the most obvious example.[101]

When NPV is calculated, a project with a value above zero is considered profitable. NPV is calculated with formula 3.1: [102]

(3.2) $$NPV = C_0 + \frac{C_n}{(1+r)^n}$$

where C_n = cash flow year n and r = rate of return. C_0 is the cash flow of the investment year 0.

The rate of return represents the opportunity cost of capital. The rate of return is the return the organisation expects from the best alternative use of money if they where invested in another project.[103] Russel states that a high rate of return can be one way to compensate for uncertainty[104]. According to Persson & Nilsson this is a temptation that should be avoided. Doing this could in the long run damage the company since it profits short-term projects and penalize long-term projects that could be necessary to conduct.[105]

3.7.2 Shortcomings of the net present value method

According to Russel the NPV method can be a good support in decision making especially when it comes to decisions involving a relative simple business structure, uncomplicated projects and the environment enables reliable forecast about the future. In some environments the assumptions made when calculating NPV are so opposite to the reality that only a limited value is gained from the analysis. For example, future cash flow is expected to be forecasted in a predictable way when in reality this might be difficult to obtain as a reliable estimate. Ambiguous cause-and-effect links, insufficient information beyond forecast horizons, human factors and unforeseen opportunities and threats blur the insight of future cash flows even more.

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[98] Brealey R.A. et al. (2006), *Principles of corporate finance, 8th edition*, p.16
[99] Cooper, R.G (2001), *Winning at New Products – accelerating the process from idea to launch, 3rd. ed*, p.226
[100] Persson, I & Nilson S-Å (2001) *Investeringbedömning 6th ed.*, p.103
[101] Brealey R.A. et al. (2006), *Principles of corporate finance, 8th edition*, pp.91-95
[102] Persson, I & Nilson S-Å (2001) *Investeringbedömning 6th ed.*, p.73
[103] Brealey R.A. et al. (2006), *Principles of corporate finance, 8th edition*, pp.18-20
[104] Russel, T., (2001) *Business Value Analysis: Coping with unruly uncertainty*, p.23
[105] Persson, I & Nilson S-Å (2001) *Investeringbedömning 6th ed.*, pp.92-93

Russel concludes that one of the most critical limits with DCF is time related. Four time horizons are mentioned:

- Memory horizon – goes back in time; how far back in time can useful data be gathered?
- Budget horizon – how far forward in time does budget commitments go?
- Forecast horizon – how far do forecast regarding revenue, head count, product mix etc. reach?
- Commitment horizon – how long is the commitment to a marketplace, technology or a contract?

The period between memory horizon and forecast horizon is suitable for using DCF analysis with enough of information to make good predictions. The period between forecast and commitment is called the faith period during which solid information is hard to get and decisions are made more on faith than on facts. In this phase the DCF analysis need complements.[106]

3.8 Uncertainty

"Chance favours the prepared mind"
- Louis Pasteur

Uncertainty surrounds all decision making. Brealy et al. states that "*uncertainty means that more things can happen than will happen*".[107] Bodde states that uncertainties have a limited upside often imposed by counter-moving competitors but the downsides tend to be a lot less limited. Bodde calls this the fat tail problem and exemplifies this with the banking industry, where calculations of possible losses can be ten times worse than possible positive outcomes. This is further illustrated in figure 3.13 below.[108]

This illustrates the importance of being aware of problems that can occur during a project and be alert if warning bells are ringing. Chapter 3.8.1 to 3.8.3 will present some tools that can be used to handle uncertainty.

3.8.1 Sensitivity analysis and scenario analysis

One way to handle uncertainty is to conduct *sensitivity analysi*s by identifying key variables that determine if the project will be successful or not. By making a pessimistic and an optimistic estimate of the variables, they can be set up and compared with regard of impact on the project. Variables with great impact can then be investigated further to make a more accurate estimate or actions can be taken to make the pessimistic estimate less probable. However, there are limits with the analysis as well. First, there might be a problem with the terms optimistic and pessimistic. A probability could be set, for example that there shouldn't be more than a 10 % risk that a variable turns out to be worse than the pessimistic estimate, but there is a practical problem with determine the exact meaning of this. Another problem is that the underlying variables tend to be interrelated. The result is that it becomes less beneficial to look at variables in isolation.[109]

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[106] Russel, T., (2001), *Business Value Analysis: Coping with unruly uncertainty*, pp.17-18
[107] Brealey R.A. et al. (2006), *Principles of corporate finance, 8th edition*, p.245
[108] Bodde, D.L (2007), *Future Imperfect II: Managing Strategic Risk in the Age of Uncertainty*, pp.30-31
[109] Brealey R.A. et al. (2006), *Principles of corporate finance, 8th edition*, pp.246-248

When variables are interrelated Brealy et al. concludes that a *scenario analysis* can be done. When a scenario is done a combination of variables is studied if a certain scenario takes place.[110] Bodde also suggests scenario analysis when managing uncertainty. The benefits of scenario analysis on a project level are that it provides a "virtual wind tunnel" where implications to the project can be tested. Further it enables a possibility to stand ready to take action or even be proactive, when certain important events are about to occur.[111]

3.8.2 Real Options

Real options theory extracts from the financial world and financial option theory. An option is a right, but not an obligation, to take a specific action in the future. When a project is valued according to the NPV method in a setting surrounded by uncertainty there is a risk that only yes or no options are considered. A third option might be to wait until the future is less uncertain before a decision is made. Real options have evolved as way to handle the problems with uncertainty and NPV. Brookfield, Bodde and Russel all concludes that using a basic NPV method could give misguiding advice in decision situations like these. They all suggest real options as a way to handle the problem.[112,113,114]

Sometimes there can be an option to postpone decisions until more reliable information is possible to get and therefore reduce the risk with a project. In the *real options* theory this option has a value that could be expressed in monetary terms and thus be incorporated in the NPV analysis. Brealy et al states that there is four forms of real options:[115]

1) *Options to expand* is related to situations where an expansion might be necessary to meet future demands, but there is an uncertainty whether the demand will increase or not. By postponing the decision costs incurred by the delay might outweigh the cost of expanding if the demand doesn't increase. The value of possible later expansion can sometimes turn a negative NPV into a positive, making a project worth to continue because of the possibility of future expansion.

2) *Options to abandon* relates to the possibility to abandon a project when things turn out different than expected. Planning a project with alternative uses for made investments have a value. Comparing two projects, where one has a higher NPV but no alternative uses where the other project depends on investments that has a second hand value if sold would in a standard NPV analysis give a recommendation for the first project. Real options value the less uncertainty in a more favourable way for project two.

3) *Timing options* handle the value of more certain market forecasts. If a project is profitable in an increasing market there might be a possibility to wait a time period to see how the market evolves. If the market fails to meet the expectations the project can bee stopped before unnecessary investments are made. Real options theory values this possibility and adds it to the NPV.

4) *Production options* relates to alternative uses for investments made. A multifunctional tool can be used in other projects if the project it was purchased for is abandoned for some reason. The alternative use for the tool has value that a single function tool lacks and is valued thereafter.

Although very promising in theory real options present some problem in practical use. Brealy et al mentions three challenges. First, real options can be complex and valuing them can take a lot of time and effort. The second challenge is the lack of structure. Possible options during a project is numerous

[110] Brealey R.A. et al. (2006), *Principles of corporate finance, 8th edition*, p.248
[111] Bodde, D.L (2007), *Future Imperfect II: Managing Strategic Risk in the Age of Uncertainty*, pp.31-32
[112] Brookfield, D. (1995), *Risk and capital budgeting: avoiding the pitfalls in using NPV when risk arises*, pp.56-59
[113] Bodde, D.L (2007), *Future Imperfect II: Managing Strategic Risk in the Age of Uncertainty*, pp.33-34
[114] Russel, Thomas, (2001) *Business Value Analysis: Coping with unruly uncertainty*, p.19
[115] Brealey R.A. et al. (2006), *Principles of corporate finance, 8th edition*, pp.597-611

and to calculate underlying assets, exercise prices and time of exercise can in literature seem easy to specify but in real life harder to do. The third problem relates to competitors and their use of real options. Their actions can interact with the own company's and thus change the value of an option. Using real options can sometimes give the advice to wait and see which can result in that a competitor makes the first move.

3.8.3 Decision trees

Coles & Rowly suggests the use of decision trees as an aid when making decisions when risk is present. A basic structure for a decision tree is presented in figure 3.14 below. As a horizontal tool it can be used for forecasting, i.e. one decision can be made with future events that may occur, leading to more decisions to make. It also structures the problem and forces the decision maker to think of possible outcomes.[116]

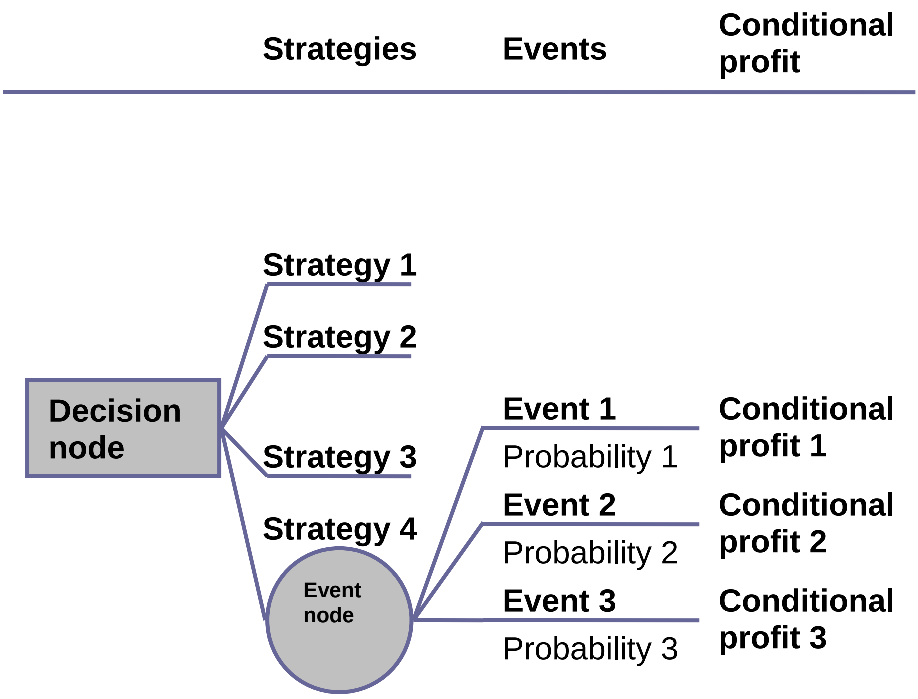


Figure 3. 13 The structure of a decision tree (Source: Coles & Rowly (1995), p. 46)

Faulkner offers decision trees as a tool to combine options thinking with the visible benefits of decision trees giving an intuitive understanding of the value of an option. A second advantage is that an assumption made in option theory is that uncertainties can be assumed to follow a log normal distribution, an assumption that very well may apply to the capital market, but not necessarily to R&D. With decision trees uncertainty can be modelled in any way that's appropriate.[117]

[116] Coles, S. & Rowly, J (1995), *Revisiting decision trees*, p.46
[117] Faulkner, T.W. (1996), *Applying "Options Thinking" to R&D Valuation*, pp.50-51

Faulkner states that options thinking, whether real options or decision trees are used, is likely to result in a higher NPV in following circumstances:[118]

- The future investment costs relatively the initial are high
- There is substantial uncertainty about future earnings
- Uncertainties can be resolved in future decision points
- The R&D phase is long and some uncertainty about future earnings exists

[118] Faulkner, T.W. (1996), *Applying "Options Thinking" to R&D Valuation*, pp.53-54

4 Empirical findings

This chapter presents the empirical data collected through document studies and interviews. Mapping the PD process calls for a certain level of knowledge in plant breeding theory and to facilitate a minimum level of understanding for the common reader (outside SW Seed) a short description on the subject opens the chapter. The elicited process is presented in an iterative manner, leading up to the end result. The allocation of costs to the found activities and data concerning the strategic dimension of PD ends the chapter.

4.1 A brief description of plant breeding – from parents to a new variety

Below a short description of the process from parents to a new variety is presented. It's mainly based on interviews with SW Seed personnel but some complementing information has been collected from literature. If the later is the case, a footnote reference is presented. All figures and numbers are from 2007 although fairly representative as an average for the programme over the years.

4.1.1 Overview

The main purpose with a breeding programme is to achieve a new stable and uniform variety with better characteristics than previous varieties. This is a long process; for winter wheat normally spanning over at least 12 years – other crops can have a shorter or longer development period. Methods, such as dihaploid (DH) or single seed descent (SSD) can speed up the process but have weaknesses that'll be discussed later. In the case of spring crops there are a possibility to sow in the northern hemisphere in the spring and in the southern hemisphere in the autumn. This, however, isn't possible with winter wheat since it requires a winter (+5 ˚C or below) of about eight weeks to flower, making the period in the ground between sowing and harvest longer, rendering it impossible to squeeze in two generations per year.

When the crossing parents are chosen there is an idea of the sought characteristics of the new variety, but most traits aren't possible to test until later in the process. This is due to the fact that from each crossing a population emerges and within each population a great variation of individuals develops. During the five years after the crossing the breeder tries to pick out the best individuals, make them uniform and propagate these prior to the yield trials. The following four years are yield trials where various traits are assessed; in particular yield, but starch and protein levels as well as disease resistance are also of importance. During this time a parallel process is undertaken, the *elite programme*, with a twofold aim; the *maintenance breeding* where uniformity is sought in order to pass the next hurdle (the national list testing) and *elite multiplication* for the launch phase, in order to have enough seeds for the market. The national list testing is a two year period where the Swedish board of Agriculture tests for adaptability and value for the farmer ("market value"). Parallel a *DUS*-test is conducted, testing for distinctness, uniformity and stability. Additionally, for marketing purposes mainly, regional testing can be conducted in order to see how well the new varieties adopt to regional conditions before they are launched to the market.

4.1.2 A looong PD process

Two varieties, the parents, are crossed in order to get a specific trait, e.g. resistance to rust, where *A* means resistant and *a* isn't. *A* is dominant and *a* is recessive.

F0: AA × aa

Offspring (F1):

	AA	
aa	Aa	Aa
	Aa	Aa

The crossbreed results in homozygote offspring with the genotype Aa. In the next stage, see below, the plants self pollinates, i.e. Aa × Aa, resulting in the F2 generation where one AA genotype, two Aa and one aa is received. The result will be that ¾ of the offspring will be resistant and ¼ will not. But the breeder is looking for a variety that always has an offspring that's resistant and thus need the AA genotype. In order to find the AA a number of generations are needed before unwanted genotypes are sorted out.

F1: Aa × Aa

Offspring (F2):

	Aa	
Aa	AA	Aa
	aA	aa

Figure 4. 1. A simplified model of a crossbreed (Source: Müntzing (1971), p.42

The first thing in the PD process is to find out what the market wants from a new variety. Most common is an incremental increase in yield, normally about 1-2 %, but sometimes a new disease occurs or another trait is wanted for some reason. The breeder selects parents with some of the wanted traits and crosses them with each other. Some genes aren't easily detected but a marker for that gene can make it possible. If a marker doesn't exist it needs to be developed, a rather expensive project that can take a year to complete.

The first year the parents, generation F0, are sown. Winter wheat is self pollinating and thus one plant must be emasculated before the pollination with another plant to get the crossbreed a few days afterwards. In the winter wheat programme about 450 successful crosses are made each year.

The next generation, F1, is mainly a propagation phase. From the F0 stage only a few seeds from each crossing are generated and more are needed. In F1 all plants are homozygote – they have the same set of genes (same genotype) but later on each will result in a selfing (in-house terminology) population where each population consists of individuals with different genotypes. In figure 4.1 the offspring from F1, the F2 generation is one population but with different genotypes (i.e. AA, 2×Aa and aa). From

F1 forward no emasculation or pollination is needed since winter wheat is self pollinating. The harvest from F1 is sown in F2, a more space demanding phase. Usually, each of the populations requires two plots of 10×2 m. In F2 a first selection is made and the work from now on consists of finding the best and most uniform and stable genotypes in each population. That means that a breeder needs to find the AA genotype. Although a selection is made in F2, the required space still increases to F3. The number of genotypes is now in the area of 50,000 sown in equally many lines; six lines amounts to one plot of 4×2 m. The following two years, F4 and F5, the number of genotypes decreases due to elimination of unwanted genotypes, resulting in less space required for each phase, see figure 4.3 below. During the early years laboratory tests are difficult to conduct, since the harvest is too small and not uniform. The first quantitative tests are conducted in F5, testing for hectolitre weight, thousand grain weight as well as the levels of starch and protein.

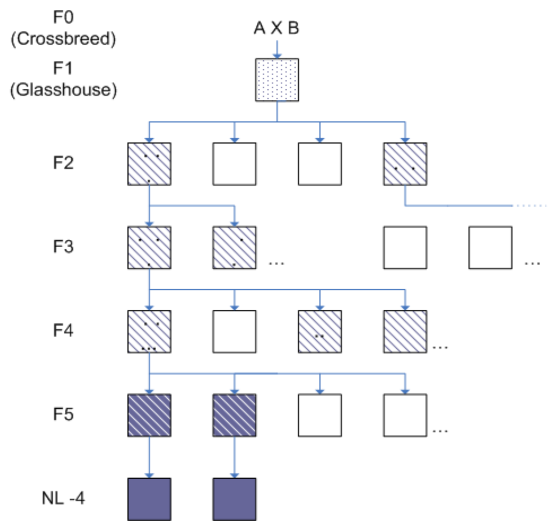


Figure 4. 2. The selection differs over the phases

As illustrated in figure 4.2, the selection and harvest differs over the phases. In F0 and F1 no selection is made and the plants are harvested by hand with a pair of scissors. In F2 through F4 the seeds are planted in lines of six, amounting to one plot. Each line is one potential new variety, i.e. have the same genotype. The breeder inspects all lines and selects lines with uniform plants that look good. In the early phases only ears from a few plants are harvested but in F4 three whole plants are harvested since each plot in F5 represent one possible variety, demanding more seed from F4. In F5 the plots that the breeder selects is harvested as a whole with a combine harvester, this marking a shift to the use of machines in the harvest. In the following yield stage results from laboratory tests are added to the basis of selection. The plots are of different forms and sizes to cope with demands from the elite maintenance breeding and as seen in figure 4.3 below the space required varies but in total amounts to a significant area usage.

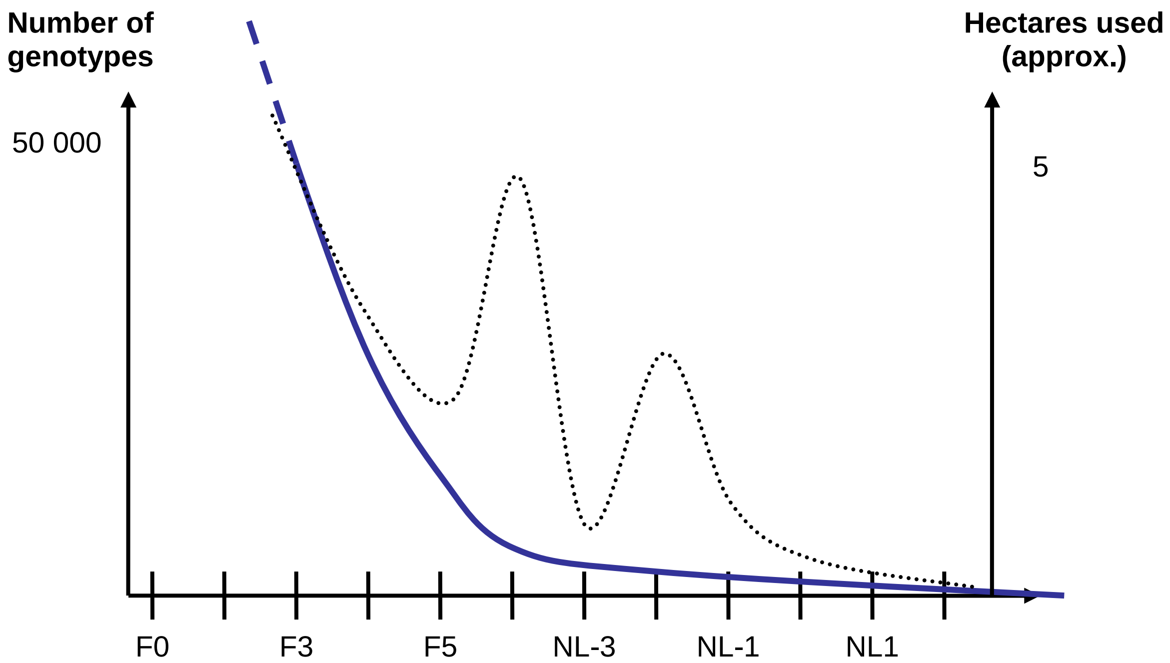
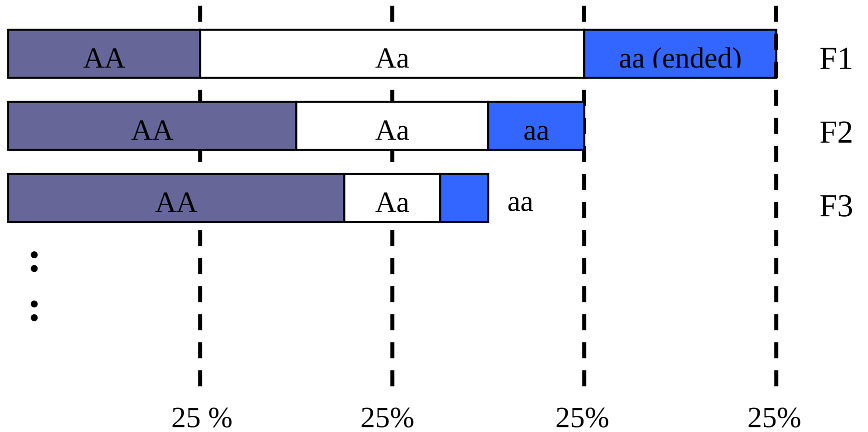


Figure 4. 3 A rough estimate of number of genotypes and required area usage over the PD process

During the first years the breeder has two options to speed up the process. Some of the seeds harvested in F0 can be used for dihaploid (DH) propagation. In the DH path the seeds are sown, as in F1, but are emasculated and then crossed with maize. The seed on the plant will only have a half set of genes, a monohaploid, since the maize can't contribute with anything. In the laboratory the monohaploid is "doubled" in order to create a dihaploid. The dihaploid is now completely uniform and stable and can be sown in F5 for propagation. The gain is a shorter process; the DH phase takes one year and replaces F1-F4, resulting in a three year shorter period. The process is however not bullet proof, the result is sometimes fewer plants than needed with the result that one extra year is needed to propagate the population. Further more; the bigger populations that come from the ordinary path can contain better individuals than in the DH path due to the larger variation among them. Another way to speed the process up is by Single Seed Descent (SSD). In this process the plants are grown in glasshouse. The winter is simulated in a vernalisation chamber during a six week process and as soon as one seed has grown that seed is harvested and sown again. In this way three years can be squeezed into one. The loss again is fewer possible genotypes due to smaller populations.

As the populations are sown and harvested the heterozygote genotypes will fall away, since 50 % of the offspring always will be homozygote and continue to be so. The unwanted homozygote genotypes are ended and hopefully, by the start of the NL testing stage, a stable and uniform new variety is created.



It should be mentioned that the picture of the breeding process here is simplified. Numerous factors make the breeder's world a complex place to work in but for the purpose of this thesis the very basics is enough to ease the understanding for a plant breeding novice reader.

Figure 4. 4. During the field stage and the following elite maintenance breeding the new variety becomes more and more stable. (Source: reworked from Müntzing (1971), p. 300)

After F5, the yield stage begins, within the Winter wheat Baltic programme labelled NL-4 to NL-1. The population is close to stable and uniform and enough material exist to enable the yield trials and laboratory tests. Various traits are tested dependent of the end user, but yield is the single most important factor independent of the variety's end use. Further, resistance to diseases such as rust, fusarium and mildew, is important. For feed wheat a high starch content and good straw stiffness is desired while bread wheat is more focused towards baking quality. A third segment is "special" consisting of users with various requirements. Many of these tests are performed in laboratory with more advanced instruments than have been used earlier in the process. For statistical reasons the yield trials needs to be done in two identical plots meaning that if 850 possible varieties exists 850×2 plots are needed. In these phases the varieties are tested on farms on different places, both in Sweden and other countries, to see how they perform under different conditions. For example winter hardiness is important in northern Sweden, but isn't considered valuable in southern Germany with warmer winters.

In the yield stage *represented varieties* may occur. A represented variety is developed by partners and are mostly an approved variety in some EU country (and thus allowed to be sold to farmers all over Europe) but farmers tend to only buy a variety that have been tested under conditions similar to their own. For this reason the variety is tested for a few years in the yield stage, normally from NL-2 and forward.

Parallel to the yield stage the elite programme begins in order to purify the varieties to pass the following national listing tests (described later) and (in NL1) to propagate them into volumes for launch on the market. The terminology for this process varies significantly among the different respondents, especially definitions of activities undertaken – the definitions and terminology used here is used throughout the thesis. The first part of the elite programme, *elite maintenance breeding*, begins in NL-4. In the maintenance breeding the breeder tries to make the variety uniform, eliminating all signs of impurity. This process is conducted parallel to the whole yield stage so that uniform seeds from this programme can be used in the NL testing.

After the yield stage the varieties enters the NL Testing in which the varieties are applied for national listing (NL) at the Swedish board of Agriculture. The variety is trialled for two years, NL 1 and NL 2, for agronomic performance, adaptability and economic value for the farmer. The variety is also tested for distinctness, uniformity and stability, the DUS-test. Between year one and two the breeder decide if the variety should go through the second year of testing. Additional regional tests can be conducted as well, especially if the variety is a represented variety. In regional testing the performance is tested under the conditions that apply for a specific region. Represented varieties do not need to be tested for the national list since they're already approved in another EU country. Instead they undertake two years of regional testing instead of the normal one. The regional testing is made primarily for marketing purposes and the costs for these are paid by sales, not by the breeding programme, and are thus not a part of the thesis.

Parallel to the NL listing the second part of the elite programme starts, the *elite multiplication*. In this part 1 ha of the variety is sown and harvested. The harvest is sent to chosen farmers who sow and harvest once more before launch in order to have enough volume for the market. From a legal aspect, as soon as the second multiplication-harvest is initiated the variety becomes the property of Lantmännen and it becomes their responsibility to handle the sales to the end user.

4.2 The plant breeding organisation at SW Seed

From a PD process perspective mainly three functions are involved in the development work:

1. Breeder
2. Breeding station
3. SW Lab

The *breeder* is responsible for a specific crop programme, e.g. Winter wheat Baltic, and is the one responsible for the programme to produce new varieties and for the evolvement of the programme as a whole. The breeder is involved during the entire process but much time is spent in the pre-work with deciding the parents suitable for cross breeding and in the stages after the field stage where a lot of data needs to be boiled down in order to decide whether a variety has a future or not. Costs in this function is mainly personnel (the breeder) but also test fees and costs for the yield trials performed in other locations than Svalöv is accounted for here.

The *breeding station* (BrSt) is an organisation supporting all crops at SW Seed. The station is responsible for the actual field work, both outdoors and in glasshouse, as well as some analysis conducted from F5 and forward described in chapter 4.1.2. The work at the breeding station is cyclical with intensive work during sowing and harvest and slow periods in between. During the hectic periods some of the work can be made by summer personnel, but lack of experienced personnel can sometimes be a bottleneck. For example the crosses needs to be done during a short few week period and is a high detail precision work that is performed up to three times faster with experienced personnel. For this reason parents are sown both in glasshouse, which gives a better result, and in the field where the emasculation and crossing can be done later. The breeding station is also responsible for performing the resistance tests, mainly performed in glasshouse during the winter. Although some of the field work can be performed by machine, much of the work in the earlier phases must be done by hand and thus personnel costs are a major part of the costs incurred by this function.

The SW lab is the laboratory of SW Seed that performs most of the tests made in the yield stage. They also develop markers that can be used to spot wanted genes early in the PD process. They are also responsible for making the dihaploids; the breeder sends seeds of the wanted becoming variety and gets, after a year, a plant that can be planted among the others in F5. The SW Lab has a pricelist for all their services that incur costs for the winter wheat programme and are thus treated as a “black box” in this thesis. The work they perform isn’t mapped any further; costs are directed to phases where they occur according to the pricelist.

Other functions involvements in the PD process, such as marketing and finance, have more of a counselling or administrative role. Marketing gives information about the development of segments and markets that can advice the breeder to look especially for certain characteristics. The costs of these functions are not looked upon in this thesis.

4.3 Mapping the current process – while outlining a new terminology

An important objective in this master thesis is to cost the different steps of the PD process – a task with the existence of a process in place as a prerequisite to the costing. There is of course a way of doing things and a tremendous amount of knowledge and competence on how to breed plants within the organisation; however, this is knowledge that’s not always easily available on paper or expressed as activities on an appropriate level of detail.

As described in chapter 2.7.1 the chosen method to map the process is the *walk-through*; following the activities carried out, conducting interviews with key personnel. A first round of interviews was carried out with respondents from the identified key organizational functions (see chapter 4.2); the *program breeder*, the *head of the Breeding station*, the *head of the SW lab* as well as with the *controller* responsible for PD. These interviews guided the selection of the following interviews, pointing out key information gaps. Among the respondents covering these areas are the *SW Seed marketing director* and the personnel responsible for the *PD IT-support* and *winter wheat glasshouse* activities. Adding to this numerous follow up interviews have been conducted with the *first round*-respondents in the mapping of the PD process.

Overall the chosen respondents should represent a complete set regarding the knowledge on sought activities and process.

In costing the PD process for winter wheat there is a need to understand the activities building up the process and the type of costs to look for in each one of them. Doing this has been an iterative writing process where conducted interviews lead to the sketching of the process and new interviews rendered new, improved sketches, and so forth. The complexity of this task is not only due to the difficulties in grasping the entire process (stretching over a 13 year period), but to some extent also the writers' lacking knowledge in plant breeding. These knowledge gaps rendered questions on a sometimes rather banal plant breeding level and difficulties in finding the appropriate level of describing the process.

The iterative way of working could of course be seen as a project risk; the final process is highly affected by the writers' intermediate sketch-work and dialogue with the respondents. The optimal way would perhaps have been to first describe the current process in an unbiased terminology, using descriptions of phases and stages that aren't chosen by the writers and influenced by the compiled theory. This however, is considerably more difficult when using a deductive approach and as mentioned earlier in the methodology chapter (see 2.2.1) this is a calculated risk that's difficult to work around. It's mentioned here as well to remind the reader of this possible shortcoming of the final result. In the following chapter the work process of collecting empirical data and outlining the PD process is described to provide a deeper understanding of the end result.

4.3.1 The building of an understanding – and a PD process

Through the first round-interviews a rough sketch was developed divided into years or generations providing a chronological estimate of the process. The different generations (or phases) in F0 through Launch (see figure 4.5 below) represents a thirteen year period containing several different part processes and activities.

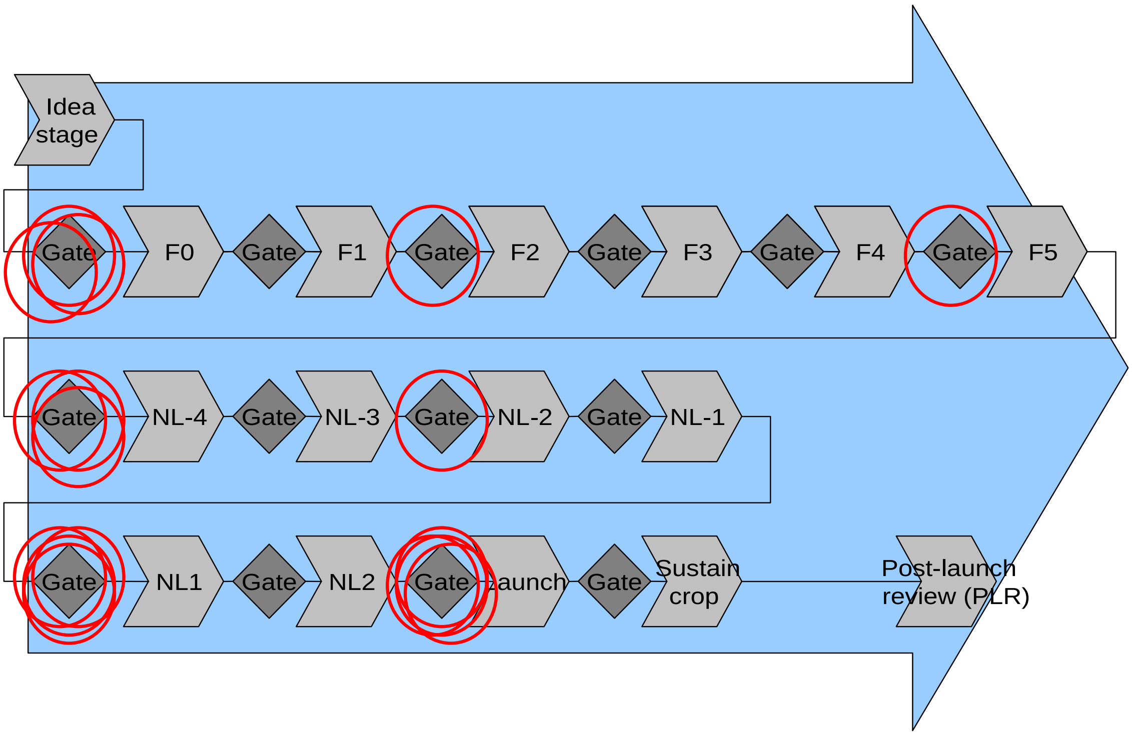


Figure 4. 5 Early sketch of the PD process, outlining the chronology. Marked in red are key decision-points chosen by the respondents.

The dividing of the process into phases with intermediate gates is influenced from Cooper's theories (see chapter 3.4). This sketch (figure 4.5) was used in two ways; firstly, it was used to structure deeper discussions concerning the phases and secondly the respondents were asked to identify which of the gates they thought were the key decision points. The chosen decision points should reflect where the respondents believed that a formal discussion should be held to reduce the number of potential varieties regarding to the information available and the need for a structured decision before going to next step.

The gates marked with circles in figure 4.5 above illustrate the answers and indicate an overweight for some of the gates. At this stage of the master thesis project there wasn't a need to finalize the position of the gates. It was however a useful result in the process of fine tuning the outlined PD process in the iterative sketching process mentioned above. The discussion on the possible gate-positioning made it easier to identify the grander schemes of the different stages, see figure 4.6 below.

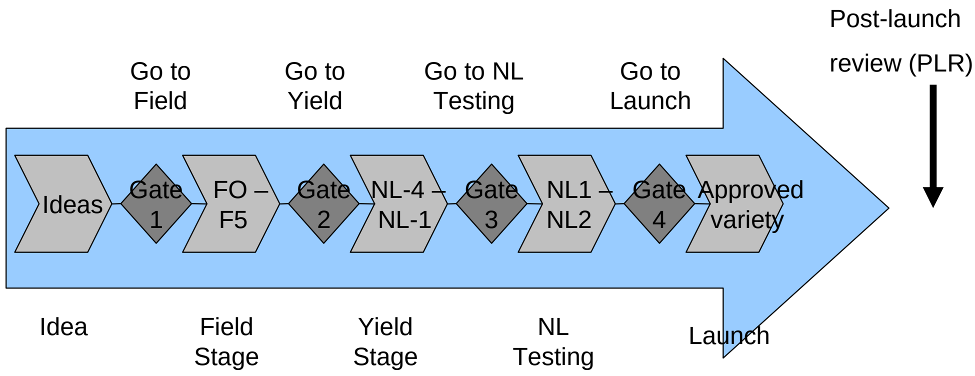


Figure 4. 6 Outlining of the PD process, identifying key gates and stages according to early interviews

Armed with a more precise process description, the following interviews were used to confirm or falsify this early sketch by probing deeper into the content of the stages (Idea, Field, Yield, NL Testing and Launch) and gates (1 through 4).

These stages in turn consist of several phases that all have some unique characteristics while sharing others. The timeline below illustrates some common traits that most generations of a common winter crop share (a modified truth; there aren't tests in every generation, and generations sown in glasshouse don't follow the same timeline as the ones sown in field, etc).

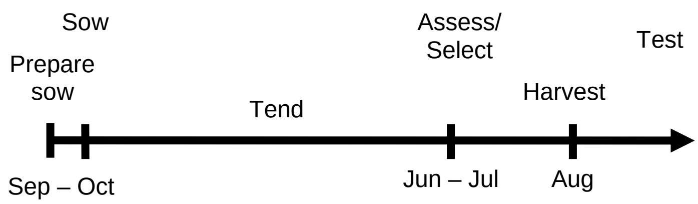


Figure 4. 7. Simplified timeline for winter crops

For each phase (F0, F1, …) the main activities were identified and described in order to enable an allocation of incurred costs. This part of the process mapping posed some difficulties in finding the "right" level of detail for the description. In order to understand a given activity and the work carried out in it, a certain amount of understanding of the plant breeding theories and work is needed. Often the documents studied, or the discussions had, were on a significant more detailed level than what's represented by the final process map.

Adding to the difficulties, there are several opinions on what the specific activities contained depending on respondent. This however, is often due to the individual and complex characteristics of each different crop, meaning that the plant breeder in charge of the specific program is the only one person that fully understands all activities. The interviews on this matter started out with a description of the phases sketched by the plant breeder, sought confirmation or falsification by other respondents, before finally complete the full circle interviewing the plant breeder again.

The final map over the elicited process has three different levels of detail all suitable for different discussions. To provide an overview of the process the first two levels of detail are presented below, while the process map as a whole is presented in appendix II together with a brief description on the activities included (see appendix I).

4.3.2 The BREED process; Breeder's Roadmap to Efficiency and Excellency in product Development

The BREED process? The naming of the elicited process should perhaps be a conversation subject in the PD department, rather then a desktop product. For reasons elaborated on in the analytical part of the thesis, *a* name is however desirable. The description of the process as well as the presentation of allocated costs are aided by a name for reference reasons so, at least for now, the *BREED* process it is.

As seen in figure 4.8 below, showing the top level of the final process, it's basically the same process structure as the early sketch shown in figure 4.5 above. The discussion on why this structure lasted all the way is kept in chapter 5, *Analysis*, but as seen in figures 4.10 – 4.12 (Field, Yield and NL Testing) there are similarities in the activities that motivates such a layout.

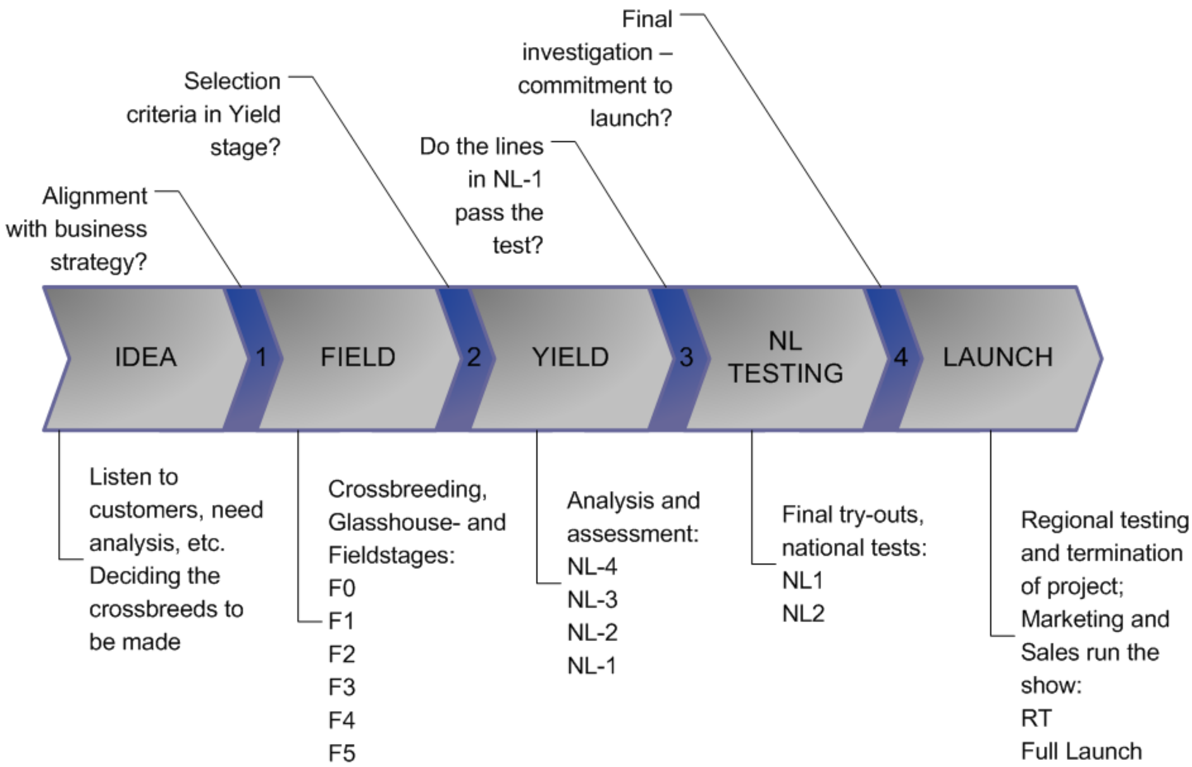


Figure 4. 8 The BREED process, top level view

The process represents the end result of the process mapping, and consists of five major stages, briefly presented in order below. Between the stages there are four gates, or decision-points, in where the structured discussions on how to proceed could be held.

The initial stage of the process is the IDEA stage, see figure 4.9 below, containing the work needed to decide the crosses to be made in F0. Marker tests are made in laboratory, searching for specific genes in the possible parents. The results from these tests as well as knowledge from other sources are compiled, resulting in a decision on the parents to be. This decision is guided mainly by two "sources" of information; the competence of the breeder and the strategic discussions held within the company. Mapping the IDEA-generation activities in a general sequence is to some extent a difficult task, e.g. due to the nature of the breeders individual reasoning. However, interviews showed that several activities supported the gathering of information (e.g. internal work focused on developing the program, attending conferences to gather new knowledge, discussing with customers to elicit their changing needs and desires).

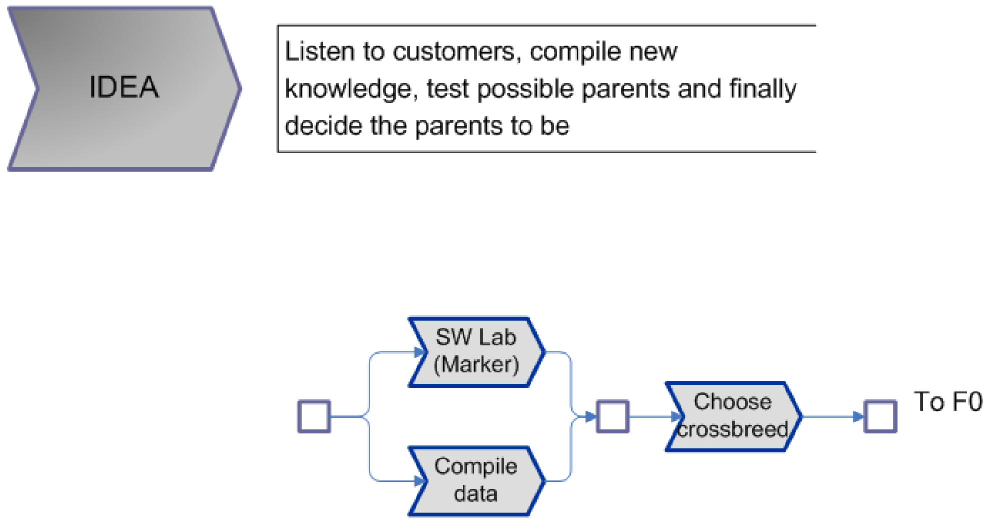


Figure 4. 9 The first step of the BREED process, the IDEA stage

Leaving the IDEA stage marks the first decision-point in the BREED process; which crosses should be made (and why)? The following phases, the Field stage (see figure 4.10 below), are the early years of plant breeding. During these years the genotypes representing possible future varieties are judged by "physical" traits; the plants looking the best or most resistant to diseases will go through to live another year. These are also years of propagation (getting more and more seeds from the interesting genotypes each year), a necessity when approaching the following Yield stage.

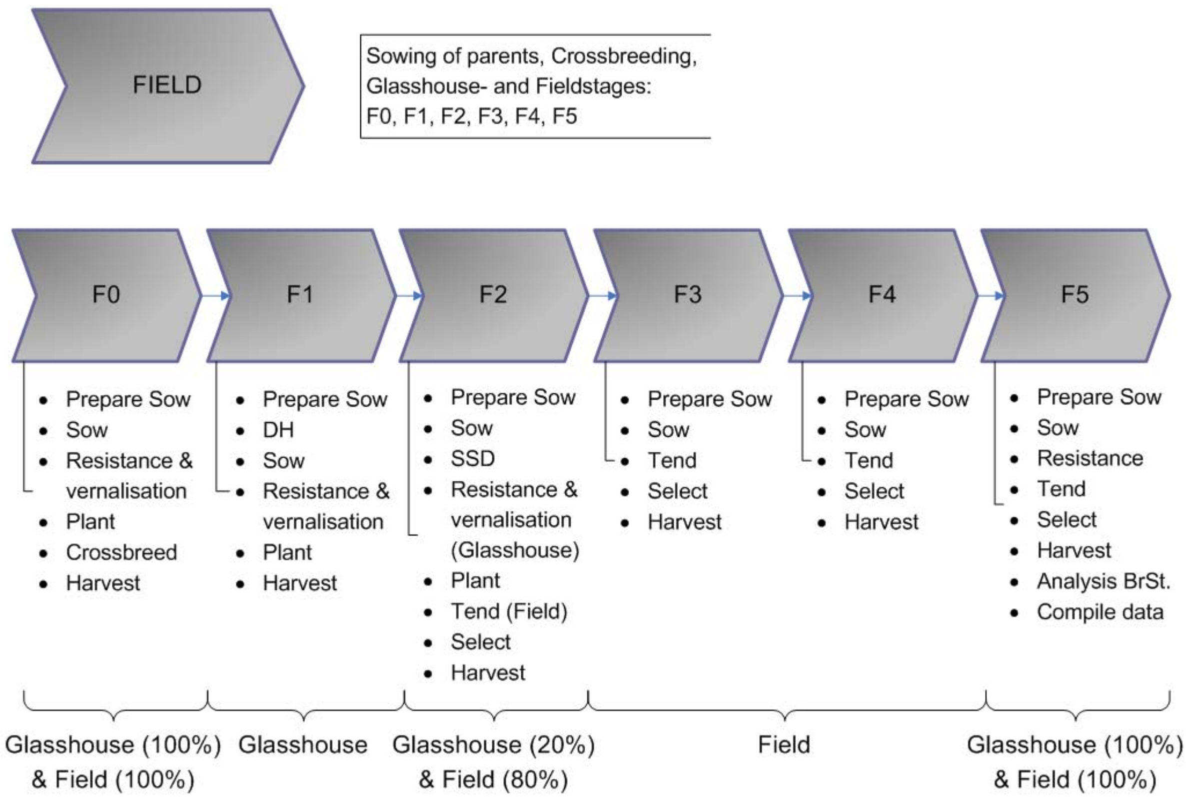


Figure 4. 10 The second stage of the BREED process; the Field stage

In chapter 5, Analysis, the elicited costs for different phases and stages are discussed – the next stage in the BREED process, the Yield stage, will prove to be an expensive one, indicating that a decision-point before entering could be a good idea. As the name implies, the Yield stage is mostly about yield. During these years the possible varieties (or *lines*) are tested for multiple characteristics, assessing the best ones suited to match customer needs. A difference towards the earlier *Field stage* is how the plants are treated in sowing, assessing and harvest. As shown in figure 4.11 below (the activities presented in the bullet lists), these years share several similarities indicating that they might be treated as a BREED process entity.

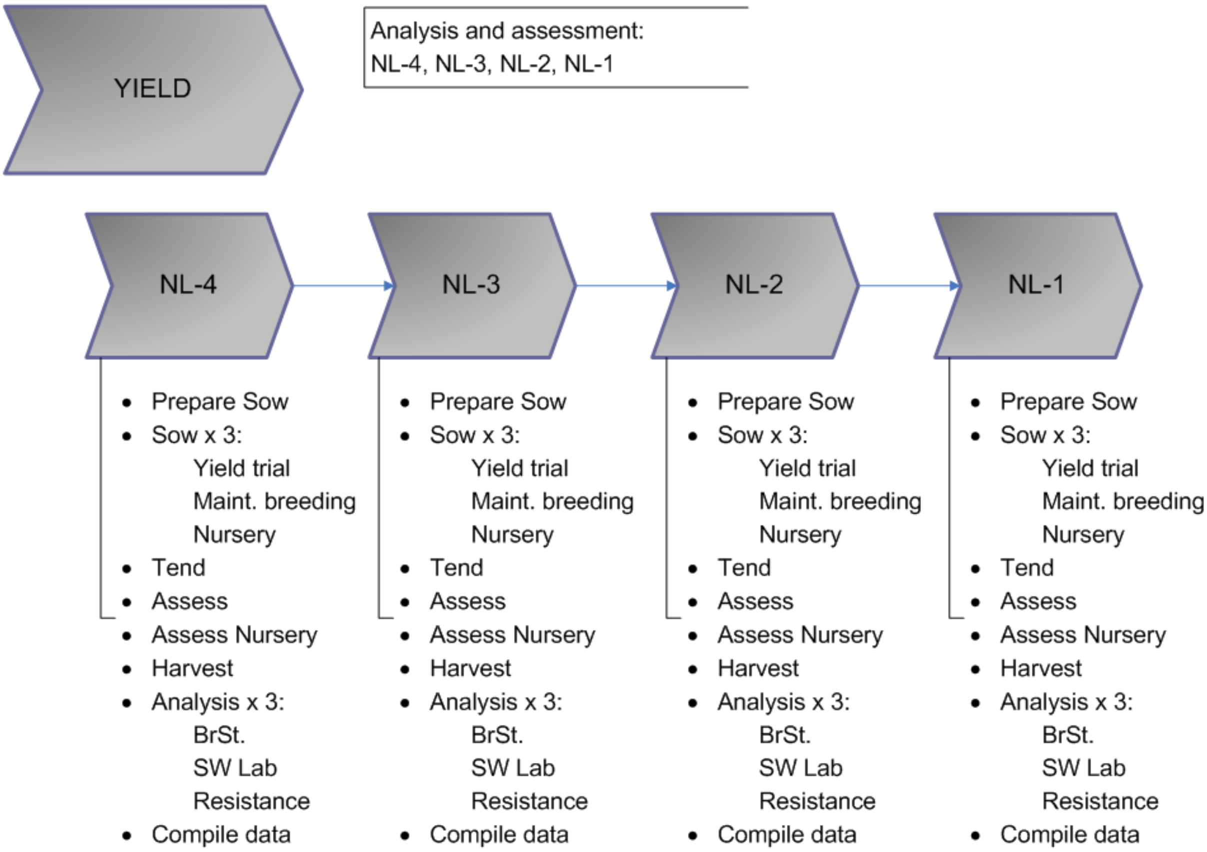


Figure 4. 11 The third stage of the BREED process; the Yield stage

After four years of yield trials, laboratory tests and elite maintenance breeding, the remaining varieties (~7000+ lines in F5 have now been reduced to less than 20 in NL-1) are up for the third hurdle – the decision on which among them to send to official trials, the NL Testing stage. Testing for NL is a rather expensive step on the way to be a launched variety proposing a thorough review of the remaining contenders. This constitutes the third decision-point in the BREED process.

Once through the needle's eye the selected varieties are sent off to two years of official tests, conducted by Swedish and EU authorities. Parallel the second part of the elite programme is initiated; the multiplication aiming to produce enough seed for the possible market launch. These years in NL Testing are described in figure 4.12 below.

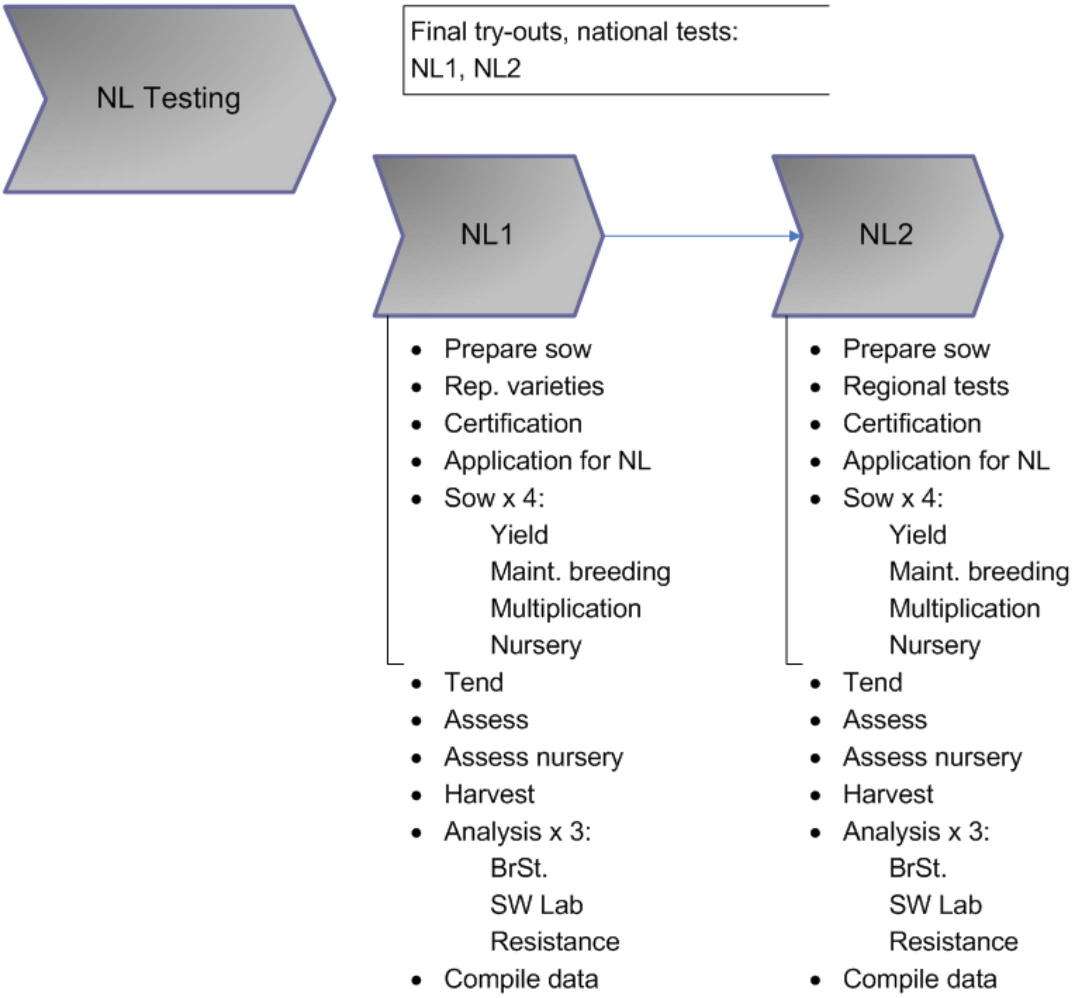


Figure 4. 12 The fourth stage of the BREED process; the NL Testing

Using the latest years as a rule for approximation shows that five varieties entering NL1 is reduced to three entering NL2. These three varieties are all up for the final review; which one (or ones) should go on to full launch in the market? Parallel to the years in NL Testing continued in-house yield trials have been conducted resulting in basis for a well-informed decision in this final BREED decision-point. Passing this final test the remaining variety(-ies) enter the Launch stage, see figure 4.13 below. There are however often an additional year of tests before the market is ready to accept any new variety; the regional tests where the variety is tested at different sites to prove it under the local circumstances.

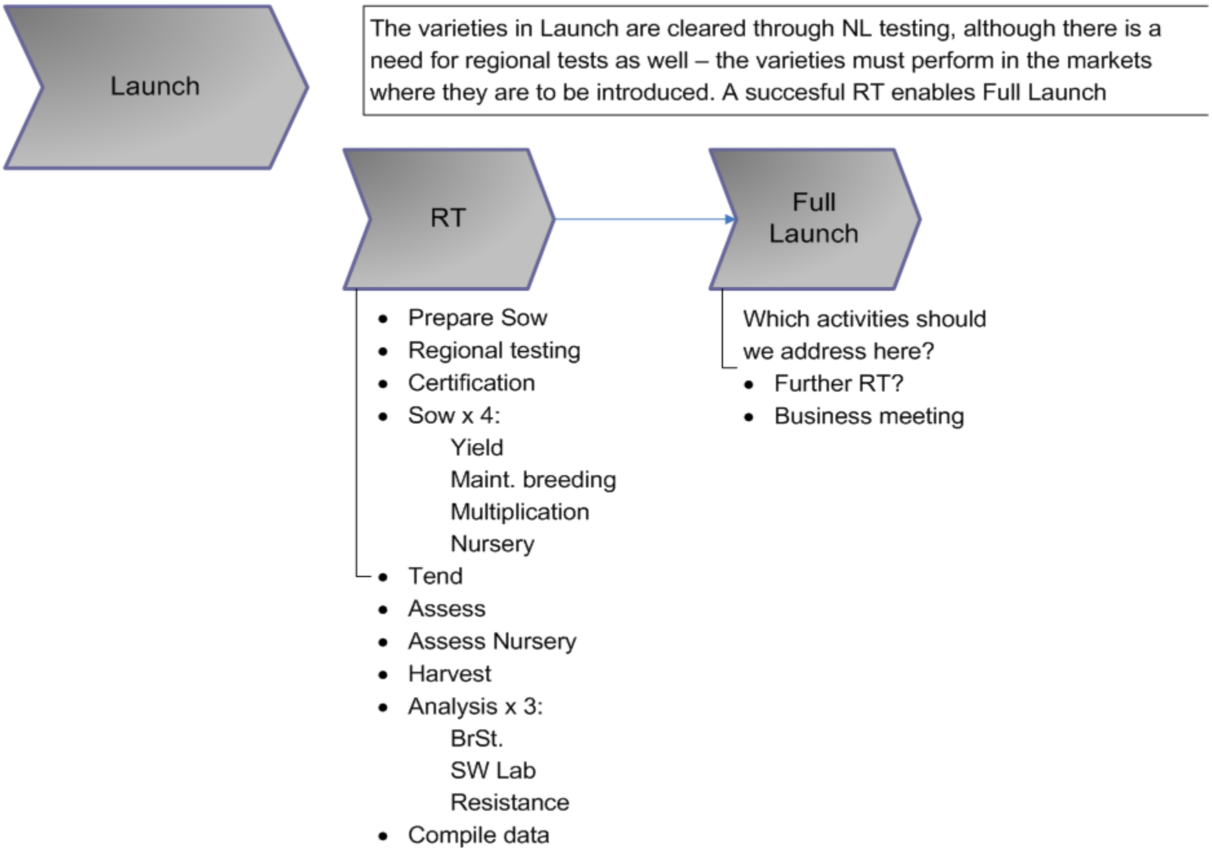


Figure 4. 13 The fifth and final stage of the BREED process; the Launch stage

The elicited PD process is described in a third level of detail as well, exemplified by F2 in figure 4.14 below. The entire process map containing all levels is presented in appendix II.

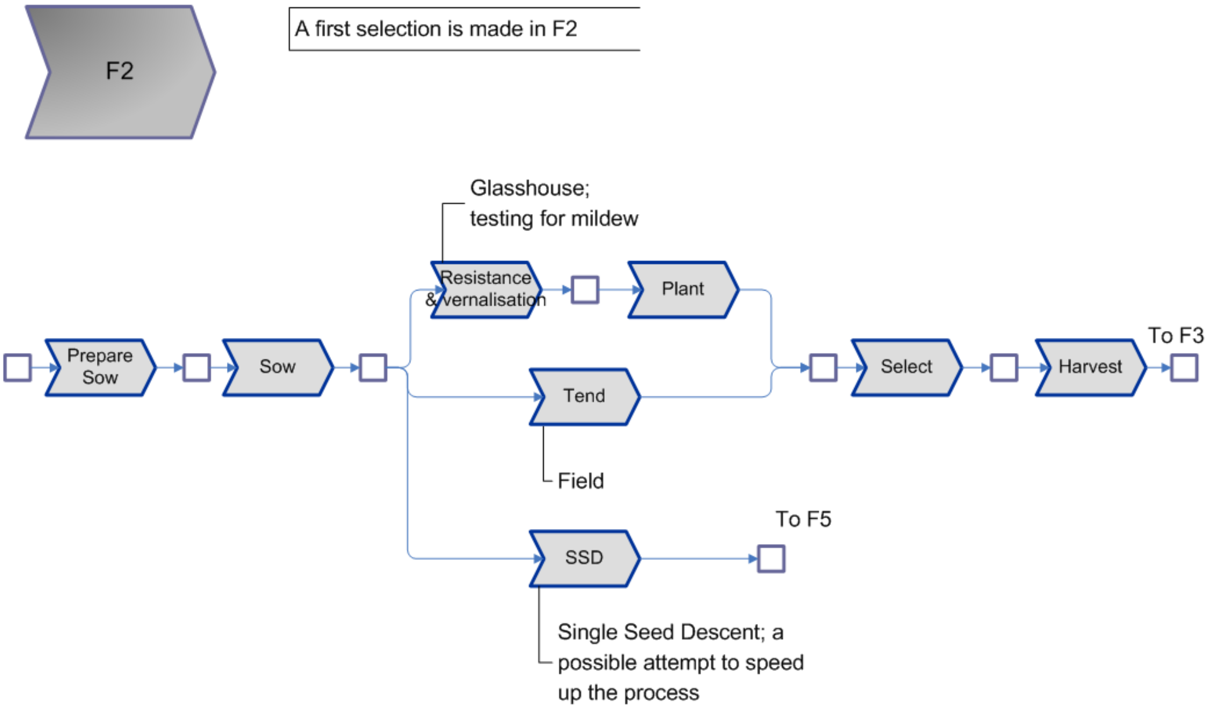


Figure 4. 14 An example of the highest level of detail in the BREED process; F2 - the third phase in the Field stage

Now that a process, described with activities, was in place the costing of it was the next step.

4.4 Costing the process

When costing the PD process there's a need to combine at least three types of information; the *description* of the process, the *activities* actually carried out, the *actual costs* incurred. The composition of the first two is the output of the process-sketching described above. Combining this with the costs incurred implies re-structuring the information available in SW Seed's accounting system.

Due to the strategic nature of the information concerning the exact cost base and its possible value for competitors the actual figures aren't presented in this section; instead the costs are expressed in percentages of the total.

Opening the company books for Winter Wheat Baltic (WWB) an early structuring is needed; separating *direct* and *indirect* costs. The allocation of indirect and overhead (OH) costs can be done in multiple ways depending on the preferences of the specific organization; some companies don't allocate them to a specific product at all. At SW Seed these costs are primarily allocated in relation to the specific crop's budget size. The OH-costs are of different kinds; some almost impossible to connect to a specific crop, some could be investigated further. In this thesis, however, the OH-costs aren't described in greater detail. The direct costs describe the costs incurred by the PD department that should support the management decisions discussed in this thesis. The allocation of the OH-costs is more of an accounting technicality that can be left out of the cost allocation below. In figure 4.15 the cost structure for WWB is presented.

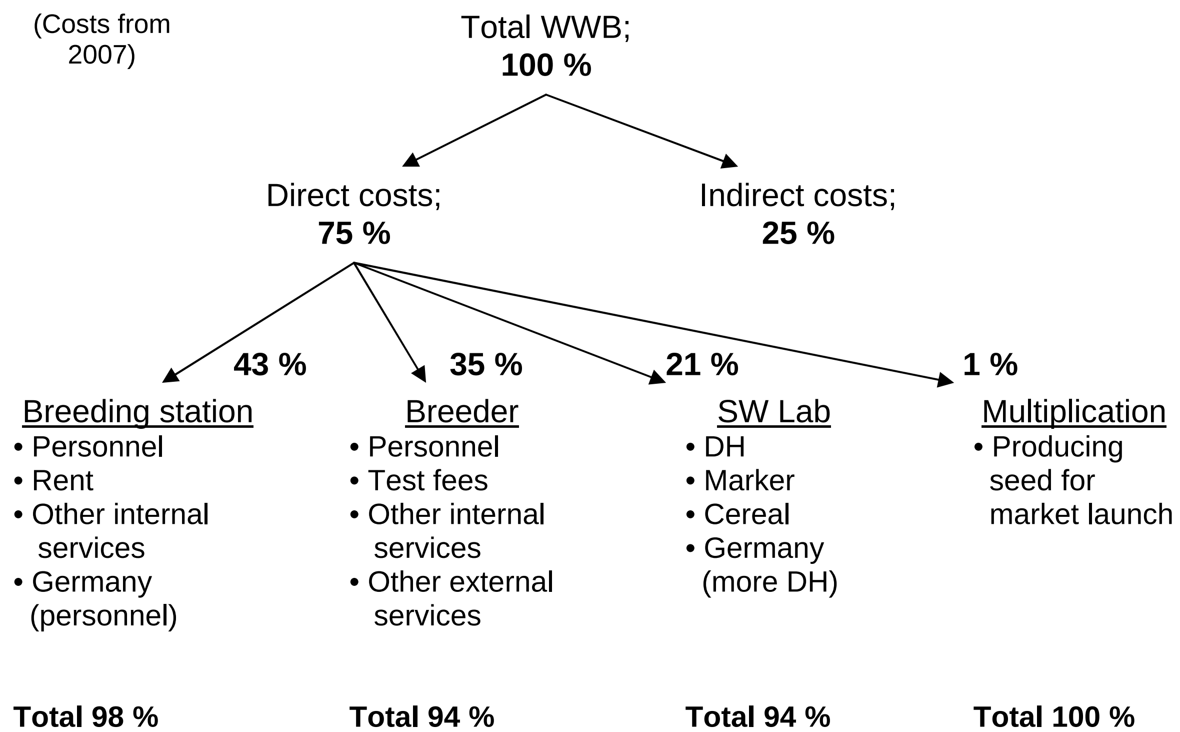


Figure 4. 15 Cost structure for Winter Wheat Baltic (WWB)

A brief note on "the company books dugout": The information concerning the cost base was collected from data on two accounting levels (business area and corporate) – these levels often provided the same figures although some direct costs (DC) weren't visible on business area level (the posts "*Germany*"). The costs for *Multiplication* were visible at business area level, but these activities weren't "tagged" to WWB in the same fashion as the other direct costs. In total the DC's (75 % of total) assigned to WWB are all (but a tiny fraction in Multiplication) incurred by the functional trinity that constitutes the PD process at SW Seed (Breeding station, Breeder and SW Lab). These functions have the major part of the costs within a few large posts, motivating the choices in the continued data collection. So, following the structure in figure 4.15 above:

- First total costs (corporate level) were increased with Multiplication-costs
- Then summarizing the total direct costs to equal the direct costs on business area level plus *Germany* (Breeding station and SW Lab) plus Multiplication
- These were divided between the four functions (Breeding station, Breeder, SW Lab and Multiplication) according to accounts on business area level, showing the ambition to find all DC's
- For each function the key costs were identified and summarized, resulting in the percentages representing their part of total DC per function

The hypothesis for the continued gathering of information was that finding and allocating these costs should provide a sufficient picture of the process. The DC's not represented in these large posts is virtually impossible to allocate to a specific activity or a specific phase; in reality meaning "allocating" them to *indirect costs*. In the following four chapters the large post costs are explained in more detail.

4.4.1 Breeding station

In table 4.1 below the four most significant costs at Breeding station Svalöv (for WWB) are presented along with their relative importance to the bigger picture and the chosen method of allocation.

Table 4. 1 Breeding station (43 % of total direct costs for WWB)

Cost	*Percentage of DC at Breeding Station*	*Allocated to phase through*
Personnel	80 %	Work description, budget and breeder
Land lease	12 %	% of used acreage
Other internal services	5 %	
Germany	1 %	Selection in F4
Percentage of total DC at Breeding station	**98 %**	
Allocated to phases	**96 %**	Some direct costs are actually indirect

Personnel: Using the budgeted person days estimated for different tasks (see Appendix III) in the current process a mapping to the BREED-activities was conducted together with the breeder (e.g. the current activities "threshing", "drying" and "transports" were mapped to the BREED-activity Harvest). In a following step the Harvest-activity could be allocated by percentages to the different stages and phases where that specific activity was conducted.

Land lease & Other internal services: These costs have been allocated to WWB by the crop's budgeted hectare usage on the fields sorting under Svalövsgården (including Möllegårdsvången, Högestorps Mitt S, Högestorps Mitt N, Montessori and Munkegårda). The budgeted usage corresponds well to the actual usage making this allocation sufficient. The mapping of these costs to the different phases in BREED has been made through the hectare usage of each phase.

Germany: These are personnel costs related to early selections (made in F4) in Germany.

4.4.2 Breeder

In table 4.2 below the four most significant costs at Breeder (for WWB) are presented along with their relative importance to the bigger picture and the chosen method of allocation.

Table 4. 2 Breeder (35 % of total direct costs for WWB)

Cost	*Percentage of DC for Breeder*	*Allocated to phase through*
Personnel	43 %	Breeder
Test fees	20 %	Invoices and breeder
Other internal services	12 %	Invoices and breeder
Other external services	19 %	Invoices and breeder
Percentage of total DC for Breeder	**94 %**	
Allocated to phases	**89 %**	Some direct costs are actually indirect

Personnel: This cost is an aggregate of two different functions; breeder (although represented by two persons in the company books) and resistance work. By addressing them separately they could be assigned to phases through discussions with the breeder on the tasks conducted.

Test fees: Four types of costs, all tied to invoices;

- Community Plant Variety Office (EU). These are fees for entering the official listing tests as well as fees for the actual testing
- Swedish Board of Agriculture. Certification costs (e.g. costs for DUS-tests)
- ”Dihaploid fast-track” (DH). Normally the DH laboratory exercises are carried out at SW Lab in Svalöv. These costs here represent a trial for comparison of results. These costs are invoices from a company in New Zeeland, promising to deliver cheaper and better results than SW Lab.
- Swedish University of Agriculture. Official Yield trials in NL Testing

Other internal services: Yield trials in other locations (Haga and Bjertorp). Haga performing trials from NL-3 forward and Bjertorp from NL-2 forward.

Other external services: Yield trials at different sites (Kölbäck, Harzhof, Denmark (2 sites), some regional sites in Sweden) mainly performed from NL -2 and forward.

4.4.3 SW Lab

In table 4.3 below the four most significant costs at SW Lab (for WWB) are presented a long with their relative importance to the bigger picture and the chosen method of allocation. The SW Lab is divided on three labs with different responsibilities; each lab is one post in the table below.

Table 4. 3 SW Laboratory (21 % of total direct costs for WWB)

Cost	*Percentage of DC for Breeder*	*Allocated to phase through*
DH lab	47 %	Numbers of DH-runs made
Marker lab	14 %	Numbers of Marker-tests made (All in IDEA)
Cereal lab	30 %	Ordered tests (from budget)
Germany	3 %	Complementing DH-runs
Allocated to phases	**94%**	

The SW Lab keeps pricelists covering their available services for the crops developed at SW Seed. The pricelists covers costs for personnel and material used and are considered by SW Seed to give a good picture of the true costs. For allocation purposes the task was to allocate the ordered services to the different phases, a fairly straightforward task generating:

DH lab: Number of genotypes times list price gives the sum.

Marker lab: These tests are all conducted in IDEA-stage, aiming to select the best suited parents to be crossed.

Cereal lab: From NL-4 (Yield stage) forward laboratory tests are conducted on the selected lines. These tests are tied to phases and end user segment (e.g. tests for baking quality are conducted on lines aiming towards the bread wheat market). The ordered tests in 2008 have been used for the allocation, using the test-distribution (over phases and segments) to split the accounted total.

Germany: Costs for personnel doing complementing DH-runs in Hadmersleben, Germany.

4.4.4 Multiplication

In table 4.4 below the four most significant costs at Multiplication (for WWB) are presented a long with their relative importance to the bigger picture and the chosen method of allocation.

Table 4. 4 Multiplication (1 % of total direct costs for WWB)

Cost	*Percentage of DC for Breeder*	*Allocated to phase through*
Elite cleansing	66 %	Costs for elite multiplication in NL2 (both potential varieties and already launched ones)
Seed cultivation	34 %	
Allocated to phases	**60 %**	Rest is already launched varieties

These costs are divided into two parts; the potential varieties (incurred by the PD process) and sustaining launched varieties (keeping the variety pure). The later costs aren't incurred by PD and are excluded from the costs allocated to phases.

4.5 Strategic agenda

In delimitating the thesis a fuzzy border was outlined towards the strategic aspects of managing the PD process. The gathering of empirics on the strategic subject isn't exhaustive due to the focus on PD activities and costs. However, in chapter 5 the possible usage of the BREED process and its decision-points are connected to the current strategic agenda at SW Seed and to facilitate such a discussion some interviews on the subject have been conducted. In chapter 4.5.1-3 below two important strategic forums at SW Seed are presented.

4.5.1 Yearly workshop

Early spring each year a strategic discussion is conducted with members from different functional areas within SW Seed, aiming to analyze and summarize the market position (and ambition) of the different crops. Although discussions on the subject have been held previous years in other forums, these workshops are new processes at SW Seed from 2008. Although some fine tuning still needs to be done, all respondents believe that the workshops have been constructive and rewarding. Before the workshop each contributory part (PD, marketing and finance) prepares information from their area of expertise with the purpose of jointly elaborate on seven strategic sections:[119]

1) Market description
   (Market sizes, values & developments, Customers & customer needs, Competitors)

2) Breeding targets and segments
   (Targeted regions & segments, Breeding targets for these segments)

3) External influences
   (Political, Climate, Competition from other crops, Area development)

4) Program evaluation and benchmarking
   (New varieties & pipeline, Methodology & tools, Programme SWOT analysis)

5) Financial evaluation
   (Key figures, Programme solidity, Variety turnover)

6) Target segments and future market share goals; 10-15 years from now
   (Targeted market shares & values, Frequency of variety introduction)

7) Key development areas and third party collaborations
   (Internal projects, External projects, Breeding collaborations)

An important outcome from these workshops is the strategic plan, summarizing the gathered information and translating the conclusions into key goals and an action plan. The focus in this plan is to describe the actions needed to reach sought objectives – to answer; where to go from now? How to get there? Needed resources to reach targets? This plan stretches over the next three years.

4.5.2 Product council

The product council is a multifunctional group consisting of personnel from PD, marketing and sales, together with specialists from specific areas of interest (e.g. a baking quality specialist and a variety specialist).

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[119] Example of discussed issues at the workshops (information from SW Seed, both documentation and interviews with involved personnel).

The council compares the products already at the market and at the products close to launch (potential varieties in NL-1 and forward). Various aspects are scrutinized such as yield and other traits compared against competitors, if the company have varieties in all segments and all markets, which up-and-coming varieties that should replace old ones etc. When the workshop deals with more strategic issues, the product council reviews individual varieties and their future presence on the market on a more tactical level.

The product council has meetings twice a year, in March for winter crops and in September for spring crops, just before a similar meeting is held with Lantmännen, who is owner of the variety once in the market.

4.5.3 Key Performance Indicators (KPI) in place

The empirical findings in this area are quite limited. Compiling the background information for the thesis the communicated situation from SW Seed was that there were hardly any implemented KPI's that continuously were evaluated. This is not to say that no measurements are conducted, rather that there isn't a metric system (related to actual costs and developed varieties) in place. Costs incurred in the PD process are captured by the accounting system, but the connections to the activities carried out are often fuzzy and the potential varieties aren't evaluated as individual projects. Instead the WWB-programme is evaluated at a programme level, measuring performance at a low level of detail.

All together the gathered information on KPI's states that discussions on suitable metrics should be based on the BREED process rather than any metrics implemented at SW Seed today.

5 Analysis

This part of the thesis discusses and analyses the theories and empirical findings presented earlier. Based on the description of the elicited PD process in the previous chapter the BREED process is presented more in depth, justifying the choices made in the structure. The disposition of the chapter follows the thesis objectives; presenting the proposed new PD process and the sought generalization as well as the costs assigned to different activities. The concluding part of the chapter connects the BREED process to the current structures for strategic discussions and proposes possible KPI's by which to measure and rate SW Seed's product development.

5.1 The BREED process

First of all; bear in mind that this thesis doesn't aim to improve, change, or for that matter, manage the actual activities conducted in the SW Seed PD department today. The aim is to elicit and cost the current process, finding ways to evaluate and manage the process as a whole. With this objective, launching a brand new "BREED" process may seem a bit too much – there are however just reasons for doing this, including naming the process as well as its parts. Virtually every aspect of the thesis objective implies the significance of the elicited PD process; the generalization issue, the description of the process and its decision-points and the adjacent areas to strategy – these are all areas that cut right through the organization. So, a "BREED" process or not, the issues discussed in relation to this subject are certainly important enough to give the process the benefit of consideration.

The proposed way of working with PD throughout every theoretical source studied in this thesis is through a structured process divided in stages and decision-points. The problems with generic processes seemingly applicable in several different industries are that they're often perceived as too bureaucratic and rigid, suggesting that a specific PD-process, based on theory, is developed. Cooper's Stage-Gate process synthesizes the contemporary knowledge, making it a suitable foundation on which to build the BREED process. Throughout this chapter the proposed BREED process is discussed and justified through different views; fit for generalization, handling uncertainty by introducing decision-points and connecting them to the cost structure of the current PD process.

5.1.1 Plant breeding PD vs. "ordinary", more technological PD

Are there fundamental differences between developing a new variety of winter wheat compared to, for example, the development of a new plasma TV-screen? There are numerous examples on developed products that undoubtedly reach a new technological level (e.g. a multitude of web-solutions in the early years of the internet; talking refrigerators, reminding the owner to buy milk; vacuum cleaners that manages themselves), but still falls short in terms of market success. Nobody understood the early web-solutions (or at least was willing to pay for them); the customers don't really seem to appreciate the benefits of a talking refrigerator or a cute vacuum cleaner that, accidentally, performs worse compared to an ordinary one. In technological PD one could almost develop anything (just add more scientists or engineers) – the problem often lies in understanding the market and the customer needs.

Cooper's theories on PD often reflect a technological viewpoint on the addressed challenges – PD is lacking in market orientation, PD suffers from too little front-end homework, PD fall short when it comes to offering enough new value to the customers. These challenges are all external – focused on the market; proposing an internal view where the PD department can develop anything just as long as they do the right things, and in the right way.

The reality for SW Seed is often (simplified) quite the opposite – they know what the market want and need; increased yield, increased yield and increased yield, accompanied by acceptable agronomical traits. The problem isn't an external uncertainty; at least not through difficulties in mapping the market needs – the problem are handling the internal uncertainties inherent in plant breeding. Where the technological companies can double the number of scientists on a given project to keep deadlines, the plant breeding company might double the breeders involved in a project without increasing the chance off success. This, of course is, a simplified picture (making ten times as many crosses, keeping more genotypes in each stage would increase the chance of success) but it puts the finger on an important difference – "ordinary" PD faces internal certainty and external uncertainty, while the situation for SW Seed is the opposite; internal uncertainty and external certainty.

Nonetheless, there is a need to find ways to work with this uncertainty and to follow Cooper's advice to keep the amounts at stake low while the uncertainties are high. Incorporating the idea of real options theory and decision trees to calculate the costs of a decision and ascribing them a time-value, the Stage-Gate process can facilitate such ambitions.

The BREED process is focused towards the development of existing products, already in the company portfolio through incremental enhancements in e.g. yield or agronomical traits. This, and the discussion on external certainty above suggests less focus on the early steps in Cooper's Stage-Gate model and more focus towards the development stage, at least in a chronological sense. SW Seed "know" that the overall product idea of a new winter wheat variety with improved yield and agronomical traits will succeed if successfully developed and launched, rendering less need for Cooper's *Scoping* and *Business Case* gates in their incremental type of development. This is not to say that these aspects of PD are left out in the BREED process; the overall structure however is somewhat tweaked compared to the original Stage-Gate. In developing a new generation of potential varieties – the "F0's" of 2008 (normally reaching the market around 2021) – the initiation of a development stage is a fairly simple decision. This meaning that in BREED there aren't paper exercise stages with discussions on product definitions and in depth market research preceding the actual crossing of the parents. Instead the viewing point of a Field stage, incorporating the Cooper's *Scoping* and *Business Case* stages is suggested. Entering Cooper's Development stage (in BREED about the same as Yield) the finalisation of the product occurs, leaving only a Test stage before Launch. At SW Seed this is a stage where some 7000+ potential varieties in F5 is reduced to roughly 15 potential varieties harvested in NL-1, knocking on the door to the NL Testing stage. This implies that tough decision-points preceding the one guarding NL Testing are necessary; waiting until now (10 years into the development of this "2008-generation") with the heavy reviewing artillery makes little economical sense according to the theories presented in chapter 3. The positioning of the decision-points in the

BREED process is discussed further in chapter 5.1.2-5 below and connected to PD incurred costs in chapter 5.3.

In Cooper's Stage-Gate, as well as in other theories, the concept of the project is central to the reasoning. In chapter 3.2 the process was defined as an empty shell, facilitating a "process-journey" for a given input; the project. In the theoretical description of the Stage-Gate process, the gates (or decision-points) are described as screening opportunities where the projects all are scrutinized rendering a tough go/kill/hold/recycle-decision. Is this doable at SW Seed? What does a "project" translate into at the PD department? As described in chapter 4 the first task in the development for the breeder is to find the suitable crosses to be made in F0. The following years in Field stage these crosses results in a growing number of genotypes; in F3 more than 40,000 genotypes (= potential varieties) exists. Each of these 40,000+ genotypes could go all the way through to Launch some nine years later – does this imply that each of these genotypes should represent a project?

Of course scrutinizing all of them in formal decision-points would prove to be an insurmountable task and another definition of a crop-project is needed. Still referring to the PD-process description in chapter 4.1.2 another possibility could be a definition based on the three large groups of end users; *feed wheat*, *bread wheat* and *special*. As described in chapter 4.5.1 these groups, or segments, are described for SW Seed's target markets in the strategic workshop, enabling a project description coupling these two factors (i.e. bread wheat towards Germany could be one project). Using this definition would however render problems in defining which genotypes that should be directed towards which markets early in the process – there are no such definite delimitations and a match made in F5 could very well prove wrong during the Yield stage or in the regional tests.

Still, without a project definition the Stage-Gate decision-points loose their significance and the theoretical approach to the new PD process would miss the target. However; using the three end user segments without trying to connect them to a geographical market could prove to be a better solution. Connecting this definition to the numbers mentioned above results in a split in percentages in the different stages (e.g. the crosses sown in F0 might be divided 40/40/20 in 40 % crosses towards feed wheat, another 40 % towards bread wheat and the remaining 20 % towards special). These broad projects are then scrutinized in the different decision-points, allowing a change of focus as the projects move through the process. Early decisions are more likely to be based on criteria selecting on an aggregate level whilst later narrows the focus towards satisfying a specific end consumer.

In reality this means reviewing each and every one of the 40,000+ genotypes in F3 mentioned above, but in a way that's possible to handle. The decision-points could be focused towards discussions on the criteria to screen on rather than scrutinizing each possible genotype. In activities where selection or assessment are made, a flexible screening process is used; allowing for decisions made on easier-to-check *must-meet* criteria early in the process, and harder, more individual, criteria late in the process.

Before going into the specifics of each decision-point (DCP) a reminder on the basic structure of the standard decision-point:

1) *Required deliverables*
   Key outputs of the preceding stage, defined for each gate

2) *Decision criteria*
   The base of the decision. Both "knock-out" must-meet and sought should-meet criteria should be used. The criteria differ between the DCP's.

3) *Outputs*
   An action plan for the following stage should be agreed upon and the deliverables in the next stage reviewed if necessary.

An important deliverable common for all DCP's is the business case, pointing out the profitable direction for PD. No detailed recommendations on the contents of the business case is presented here; it should however at least elaborate on the five areas addressed by Cooper in chapter 3.4.1, *Building the Business Case* – product definition, market research, competitive analysis, technical appraisal and business & financial appraisal.

There are significant differences in the rigour of the business case in each DCP – the business appraisal in DCP 1 will, most probably, be almost empty, while being much more detailed, and a key deliverable, in DCP 4. Here the notion of the business case as an empty shell is used. Ranging from high detail in the more financial decision-points late process (3 and 4) to low detail, outlining the grander scheme, in the early DCP's (1 and 2). When presenting the decision-points below references to this empty business case shell is given, although its content isn't discussed in further detail.

In chapter 5.1.2 through 5.1.5 the decision-points in the BREED process are discussed and described (below figure 4.8 – the top level view of the BREED process – is presented once more, now as figure 5.1, to ease the understanding in the following chapters). In a pedagogical gambol the chronological order of the decision-points are reversed in the presentation; this reflects an ambition to present them in logically appealing order.

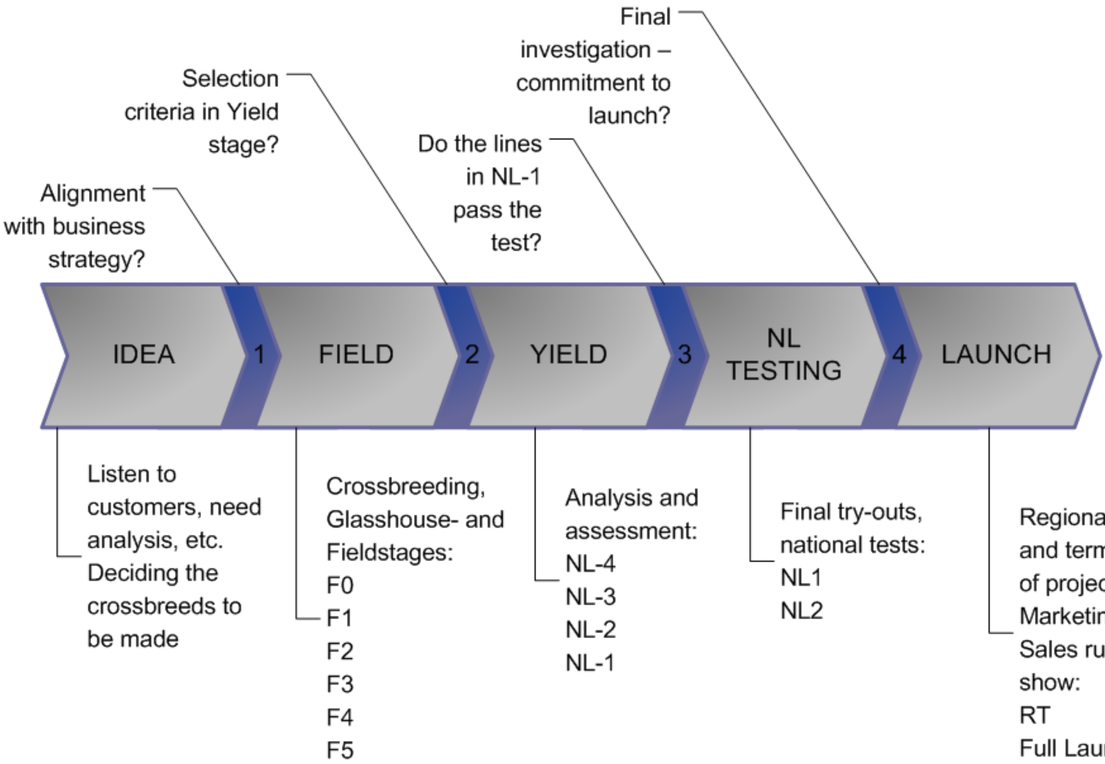


Figure 5. 1 The BREED process, top level view

5.1.2 Decision-point 4 – Go to Launch

All respondents agree on the need for a (DCP) before taking the decision to take the variety(ies) to the Launch stage. Going to Launch is in many ways a hand-over from the PD department to marketing and sales; the breeder is still involved in the decision making but in a more consulting role than before. The decisions (and cost responsibility) in the Launch stage have a tactical nature to a larger extent than earlier stages and the possibilities to affect the outcome of the stage by PD are few. Cooper's Stage-Gate model agrees with the respondents in the DCP-positioning; deciding on the deliverables from the previous stage – are the test results positive, does the market outlook still look good, do we have a positive financial return? If so, then go to Launch and implement the marketing and operations plan which should have been developed during the previous stage.

The outcome of the preceding NL Testing stage, the varieties that passed the bar, makes this DCP discussion intuitive; which one(s) of the surviving varieties should SW Seed launch? This is the decision closest to the market so it should be the most informed one. A lot of company resources and credibility goes into a launch-decision and as proposed by Cooper; high amounts at stake imply low uncertainty. This is reached by a DCP characterized by a thorough financial analysis.

Key deliverables/decision-criteria:

- The business case
  - In this DCP this should be a heavy document, compiling all available information. Key content is the business & financial appraisal; will the customers buy the product? Added content should be sensitivity analysis investigating parameters critical to success and scenario analysis.

Key output:

- The varieties selected for Launch
- An agreement on the proposed action plan on how to reach the launch objectives, including:
  - Implementation of marketing plan
  - Implementation of production plan

5.1.3 Decision-point 3 – Go to NL Testing

The respondents and theories agree on the positioning of this DCP as well. The preceding Yield stage included a large reduction in the number of potential varieties. The remaining prospects are up for a costly test stage; the NL Testing, where the costs per variety increases seven-fold (see chapter 5.3 below). The Launch stage is now only two years away and information on the match between variety characteristics and the market needs as well as the tactical decision on which segments to prioritize should enable an informed decision on the lucky varieties going on to the testing.

Key deliverables/decision-criteria:

- The business case
  - Not as heavy as in DCP 4 but considerably heavier than in DCP 2. Still having some time before launch to act on, this DCP should add a more detailed tactical perspective than earlier in the process. The competitive analysis is important; what are our competitors up to on our target markets? A management tool that should guide this discussion is the portfolio analysis; what do we *have* to launch soon? Towards which markets?

Key output:

- The action plan
  - Develop marketing plan
  - Develop production plan
  - Gather and compile information needed for the full business case discussion in DCP 4

5.1.4 Decision-point 2 – Go to Yield

As mentioned above the Yield stage includes a significant reduction in potential varieties – from the ~7,000 harvested in F5 to some 15 survivors harvested in NL-1, a whopping decrease by 99.8 %. The criteria on which this reduction is made during the Yield stage should therefore be considered carefully. During the interviews almost every respondent acknowledged the need for a DCP before the Yield stage, there were however doubts concerning the possibilities to apply a business & financial discussion this early in the process (we've got some seven years until launch in this DCP). There might be problems forecasting the market needs and the financial returns while a significant amount of uncertainty remains within the projects. An important question is however; *can we afford not to?* As stated above, 99.8 % of the potential varieties are about to be ended during this stage, and as stated below (in chapter 5.3); 40 % of the total direct cost in PD are incurred during the Yield stage (and are affected of the decisions made in it).

Another way to justify a business case discussion in DCP 2 is that after the Yield stage, in DCP 3, only 15 % of the direct costs for the development of a new variety lie ahead (again, see chapter 5.3 below). The rest; 85 %, are already incurred in the preceding stages (IDEA, Field and Yield), i.e. roughly five sixths of the direct costs are decided before a financial appraisal is made if SW Seed wait until DCP 3 to expand the business case financially.

In NL-2 (mid-Yield stage) represented varieties, if any, enters the PD process. These varieties are approved varieties developed by partner companies that SW Seed can test and launch at selected markets in a license agreement with the developing company. The decision to take onboard some represented varieties could perhaps justify a decision-point on its own, but another way to address this decision is to base it on discussions held at DCP 2. The action plan agreed upon in DCP 2 should include the targeted markets and their preferences – this guiding the selections made in Yield stage. The represented varieties or not-decision in NL-2 could then be based on the outcome of the first two years in Yield. How are we doing compared to what we set out to do in DCP 2? Any gaps in the wanted portfolio could be filled by trying on additional promising represented varieties. However, this has the prerequisite that a structured discussion on targeted markets, customer preferences and Yield stage selection criteria is held in DCP 2.

Key deliverables/decision criteria:

- The business case
    - Considerably lighter than the in DCP 3 and 4, but not too light. Seven years from launch there's a challenge in correctly estimating the potential revenues to be, but a financial appraisal is needed. This could be focused more on the cost side of the finances; which decisions should we make and what do they cost? Should we redirect some resources? Since DCP 1 (discussed below) we're now 6 years into the programme; have the customer preferences changed? The targeted markets? A mapping of the key customers and sought traits is important.

Key output:

- The action plan
    - Mid-Yield stage a status-discussion should be held on how we're doing relative the objectives set in DCP 2
    - Select according to the agreed criteria, aim breeding towards prioritized markets
    - Gather and compile information needed to support portfolio and strategic decisions in DCP 3

5.1.5 Decision-point 1 – Go to Field

This initial decision has one key output – the crosses to be made in F0. These crosses all have the purpose of satisfying a customer need, why a structured analysis of the key customers' preferences should be part of the deliverables to this decision-point. Not all respondents agreed on the positioning of DCP, arguing that the decisions are fairly straightforward anyhow; instead decisions should be made before F2 and F5 to follow up on that the sought characteristics are generated and "in" the programme. Without going into greater detail on the technicalities in plant breeding this divergence in opinion is mentioned, but not acted upon. Arguably no special information is available or needed in these phases and a DCP before the crossings are made is vital to the alignment with business strategy.

As indicated in figure 5.1, decision-point 1 should answer the question "are the chosen crossings aligned with business strategy?" by a resounding – yes! Otherwise we're wrong off from square one. This implies a formulated business strategy (on project level) as decision-point criteria. If the DCP-output is the crossings to be made in F0, they should correspond to the projects discussed above (e.g. 40 % feed wheat, 40 % bread wheat and 20 % special). Within these aggregate level projects the key traits sought by each segment should decide the actual parents selected.

Key deliverables/decision criteria:

- The business case
    - Not needed per se, perhaps used if a standard outline is tagged to the process. The areas elaborated on should at least be:
        - The strategic chosen battlefields (which markets should we compete in? Key end consumers?)
        - The portfolio composition (Should we go 40/40/20 or 100/0/0? Portfolio size; 500 crossings? 1,000?)
        - Which are the traits to look for in the parents? Which are the traits to select on in the F0 through F5 phases?
        - Which, if any, crossings are up for the DH-fast track in F1 or SSD in F2?

Key output:

- The action plan
    - Selected crossings, aligned with strategy (i.e. chosen crossings in accordance with the portfolio agreed on)
    - Decisions on the available fast-tracks; to which extent should DH and SSD be used?
    - Preparation of any alternatives available in Yield; do we still expect the target markets to be reached by going on as planned or is a change in resources allocated needed?

5.1.6 Generalization

One aspect of the thesis objective is to prepare for generalization of the results to other crop programmes than Winter wheat Baltic (WWB). This calls for a terminology common for all crops, something that's lacking today. This is often a source of confusion and misunderstandings between different functions or departments. Although more so between e.g. the PD department and the Control department than between different breeders within the PD department, the later occurs; rendering possible shortcomings through missed opportunities for synergy effects.

Using the BREED process map and terminology as modules or building blocks should provide a common platform for cross-functional discussions and understanding. Presented research acknowledges multidisciplinary work as one of four key areas of importance for successful PD. Pushing the different competences in the organisation "out of the old, familiar box" could also be a process that sparks creativity and innovation.

As mentioned earlier in the thesis, there are several differences between the PD processes of different crops; some may have longer PD cycle, others are more or less easy to multiply or test in different stages. Tweaking the BREED process, using the same structure, is of course needed to handle these differences; e.g. add a seventh year (F6) in Field, an extra year in Yield trials (NL-5) or a second year of regional testing (RT2) before launch. Or in the case of spring crops; throw out the activities for artificial winter (vernalisation) and add activities (and costs) for sowing in different hemispheres. Using the same basic structure and terminology still provides an opportunity to compare and discuss the grander schemes of things. Stating this, it's appropriate to mention that the BREED process is the result reached by interviewing a delimited part of the PD department; there could of course be key issues left out that creates difficulties when applying the results on other crops. However; hopefully, and probably, they shouldn't be insurmountable and through workshops, brainstorming sessions, further interviews or other choices of methodology a generic BREED process could be agreed upon.

However; the importance of this mission could not be emphasized enough. The theories on the subject are all explicitly clear; the PD process at SW Seed is of critical importance to the company's well-being in a longer run. The process of developing new products is at heart of the organizations financial performance and future ability to compete. Building on the thoughts of Larsson & Ljungberg this implies that the PD process is a key main process at SW Seed (i.e. a process that puts the business concept into practice), also saying that it constitutes the organization foundation; remove it and the organization will fall. Less drastic this is to say that the PD process (BREED or not) and the way it's described, is of outmost importance.

In many ways generalizing the BREED process to suit every crop developed at SW Seed is a straightforward task; finding the specifics for different crops that calls for adjustments of the process or reaching an understanding on what to name different activities shouldn't pose giant problems. Adding the economical dimension and implementing this terminology and structure in the current strategic or management activities could however prove to be a different thing. If the process is to be implemented to guide product development at SW Seed Berry's words are worth repeating (see chapter 3.2):

> "*A process is a methodology that is developed to replace the old ways and to guide corporate activity year after year. It is not a special guest. It is not temporary. It is not to be tolerated for a while and then abandoned*."
>
> - Berry, T.H., *Managing the Total Quality Transformation*

Using the concept of the process in the guidance of the organisation does indeed look promising according to theory. Analysing the activities carried out in PD through this lens or perspective ensures that every activity has a valuable need (otherwise it should be changed or thrown away), ultimately serving the customers.

5.2 Allocating the costs

In the empirical part of the thesis (see chapter 4) the cost allocation was described briefly, presenting the key costs and which activities in the BREED process they corresponded to. In this chapter focus is on discussing the allocation; how was it done? Why? Should it be done in a different way next time?

Assuming that the other crops developed at SW Seed follow roughly the same PD process, costing their respective processes should be possible using the BREED process (slightly tweaked when necessary) description and similar costing methods. When discussing the cost allocation methods below, the probable key respondents are also presented indicating where and how better information could be found if deemed necessary.

In a longer perspective an intention to cost and evaluate the PD process should be managed in a more "mechanical" way, incorporating the costing in SW Seed's financial systems. Using the information in this chapter in conjunction with the deeper understanding of the process available in-house (at Breeding station, SW Lab and among the breeders), the key personnel to chisel out this mechanical process could be found and a task force assembled.

Early on, usage of the BREED process terminology and cost allocation might call for some fine tuning, but as long as no greater change is made within a breeding programme it should be sufficient to update the costs in accordance to changes in budget (e.g. due to inflation). However, after a few years use a more thorough review of the costs should be done, even if no greater change has been performed. This review should at least include step 2-5 in the ABC methodology presented in chapter 2.7.2.

5.2.1 Breeding station

In chapter 4.4.1 the breeding station's costs for personnel were divided in *Personnel* and *Germany* to reflect how it's presented in the company books. However, these costs both represent personnel and should be presented as such, resulting in a total cost for personnel of 82 % of the total direct costs (DC) at Breeding station.

When allocating the costs for personnel the budget estimation was used, allowing for a possible miscalculation. Due to the considerable size of the cost (42 % of the total direct costs for WWB) this could be a subject to further investigation. The person day-budget (see Appendix III) is divided into "areas of responsibilities" (e.g. data, field work, glasshouse and elite programme), areas which could be used to identify interview respondents best suited to allocate these costs. This way to allocate costs was tested but later rejected due to several problems:

- The interviews with involved personnel described the activities on a higher level of detail, adding far too much complexity to the result.
- There were differences of opinions between different respondents on how to describe certain activities, where in the process (if at all) they were carried out, by who and for how long.
- Lack of key respondents (due to longer periods of illness, leaving the possible replacements with a huge prioritized work load).

However, this approach could very well prove useful in the task of generalizing the BREED process, costing other crops at SW Seed. Firstly, the involved personnel in such a task should have better insight in plant breeding (by being SW Seed personnel), thus having a better understanding of the correct level of detail. Secondly, lacking key respondents due to illness shouldn't be a long term problem and thirdly, this approach should identify the specific competencies needed if an in depth analysis of key cost areas are sought.

Nonetheless, problems such as those mentioned above made this approach impossible and further interviews with the breeder became the solution. This approach should provide a sufficient result for the purpose of the thesis:

- The budget corresponds to the actual figures in an acceptable way; comparing the end result (in account *personnel*) for 2007 with the budget estimate results in the average cost for a person hour of 99 % of what in early discussions with the control department would be suitable (averaging summer extras, blue and white collar workers).
- Almost 50 % of the budgeted person days were confirmed by interviews with the "area responsible" mentioned above.
- The breeder has great insight in the WWB-work carried out at the breeding station. Further, the breeder's insight in the PD process eliminated the differences of opinions on how the activities where carried out.

When allocating the costs to a specific phase a four-step approach was used:

1) The correctness of the budgeted activities where discussed; does the activity "threshing" amount to this and that, etc.
2) The activities were then translated to the lower level of detail used in the BREED process.
3) The BREED activities, now "containing" amounts of person days were then allocated to the different stages of the BREED process (e.g. Field and Yield).
4) Finally the activities (and person days) could be allocated to phases within the different stages (e.g. F3, F5 and NL-2).

This approach had the benefit of actually safeguarding against misunderstandings. Breaking down the cost allocation step by step put the light on mistakes made in the different steps by focusing the conversation. The following corrections of the errors were simplified as well by having levels of allocation to address rather than having to allocate from the highest level of detail once again.

Some of the personnel costs are considered overall costs in the sense that allocating them to a specific stage or phase could be misleading. For example, costs for developing the IT structure might be allocated to the WWB programme as a whole but not further, to a specific phase. The costs focused on in this thesis are to be used in decisions made within the programme, meaning that overhead costs like these are left out in the further calculation. The time for these activities sums up to ~60 person days or 4 % of the person days at breeding station.

The other costs were more straightforward to allocate. The costs *land lease* and *other internal services* represent WWB's area usage at Svalövsgården. As described in chapter 4.4.1 the current way to allocate these costs to different crops should be sufficient; the budgeted area usage result in a percentage of costs for land lease and work performed (other internal services). These costs should correlate well to the area used by the different generations in WWB, resulting in the phases' usage in hectare as the cost driver.

5.2.2 Breeder

The DC's for the breeder are mainly personnel (43 %), costs that could be allocated to the right phases by interviews with the breeder. The breeder's work is similar from year to year; the yearly time spent on sowing is fairly stable, indicating that the costs are sufficiently allocated. However, this might present a risk of lacking precision when the breeder in springtime 2008 tries to remember how the time was spent 2007. If a better precision is sought, the breeder would need a more detailed time report of how the involved personnel spend their time. In this case, the better preciseness needs to be valued against the time and effort spent on working with the time reports.

As with the breeding station, some of the breeder's time is spent on activities that are supporting the entire programme rather than just one phase. Supporting activities like these can't be tied to one or several phases in a correct way (e.g. budgeting, work with the strategy report, attending conferences and work with development of the programme as a whole). Time and money spent on these activities are left out for the rest of the thesis, decreasing the personnel costs for breeder with 11 %. One could argue that costs like these should be allocated equally on the different phases, finally reaching the activities carried out but to base decisions on such an approach – wrongly priced activities – will render defect conclusions. Costs like these are indirect by nature and should be treated as such in the decision-making as well.

Costs for *test fees*, *other internal services* and *other external services* presented a better opportunity of being allocated with precision. Test fees occur in the NL testing stage (except from DH trials on New Zealand, allocated to the DH track) and data exists on which genotype (or line) that incur which cost and in which phase this genotype belong, making the allocation straightforward. Based on invoices (available from finance) and assistance by the breeder in connecting them to a specific genotype this allocation should have high precision. *Other internal services* and *other external services* consist of invoices from partners making yield trials in the Yield and NL testing stages. The size of the invoices is correlated on how many genotypes the breeder wants to try at the different locations and thus this should be a proper cost driver. As with test fees the breeder knows how many genotypes there is in each phase and location, giving a precise allocation of costs to activities.

Represented varieties present a special case when it comes to test fees. Represented varieties are already approved in some EU country and thus they don't need to pay test fees in NL testing. However, they do need to be trialled in regional tests as described in chapter 4.1.2. These tabs (of quite significant sizes) are picked up by sales and not by the breeder and are therefore not included here. This is due to the fact that the regional testing is made mainly for marketing purposes, a necessary step to sell anything at all. Regional testing is made with both own varieties and represented varieties, but represented varieties undergo two years of regional testing while own varieties only undergo one. If a fair comparison should be made between developing a new variety at SW Seed versus representing a variety these test fees should to be included. In this thesis they're excluded however, due to early delimitations of the study and to an in-house confidence in addressing this issue in the follow up work with the thesis.

5.2.3 SW Lab

In the current budgeting process the breeder places an order for chosen tests to be conducted by the SW Laboratory. These tests come at a price, available on yearly revised pricelists. This made the allocation of these costs fairly straightforward, the only remaining difficulty was to allocate the tests conducted to different projects (not all tests conducted on bread wheat are conducted on feed wheat and vice versa) and different phases. This information was readily available by the breeder. At present time however the available information was the actual costs for 2007, and the budget for ordered tests concerning 2008 (not amounting to the same level of spending). Through discussions with the breeder the problem was solved through an allocation of the costs 2007 according to the budgeted tests for 2008, providing a sufficient picture of the cost allocation.

These costs concerned the WWB spending in the *Cereal Lab*, but didn't include the costs for *Marker Lab* and *DH Lab*. Allocating these later costs were straightforward as well. The marker tests are tests performed on potential parents, identifying the best suited ones – this justifies an allocation of all marker costs to the IDEA stage. For the DH Lab costs a price tag comes with every genotype that should undergo the DH run described in chapter 4, again making the allocation precise.

5.2.4 Multiplication

The elite programme activities *multiplication* and *maintenance breeding* has been an area of confusion throughout the work with the thesis since the terminology among the interview respondents vary significantly. A part from the many terms used to describe the same activity, the same term can be used to describe several activities. The terminology used in this thesis is described in chapter 4.1.2, and the costs for multiplication are tied to these activities. The risk of communication errors with the respondents is however not negligible and before too many conclusions are drawn from the result an internal mission aiming to agree on a terminology should be carried out.

The multiplication activity in the BREED process starts in NL1 by producing enough seed to manage the sowing of one hectare (in NL2) per potential variety in that phase (as well as some extra seed for stock keeping). Additional seed is produced in this activity – if needed – to sustain already launched varieties. This later activity is needed to keep a variety pure; every so often a fresh batch of seeds must be produced. In 2007 five varieties entered NL1 implying that these, together with any launched varieties up for "purification" should bear all costs for multiplication in this phase. The information from interviews on this matter showed marginal costs for this phase (4 person days plus some hectare usage at Svalövsgården). This is in retrospective data that should be checked with the area responsible before accepted as correct, due to possible misunderstandings in the communications, mentioned above.

In NL2 the responsibility switches from PD to *production*; here the activities concerning *multiplication* consist of the sowing of 1 hectare per variety. The varieties up for this are the ones passing NL1 as well as any launched varieties up for purification. In the RT phase a larger area is sown at partner farms to generate enough seed for the launch (these costs aren't allocated to PD). When harvested, the responsibility switches again; now away from SW Seed over to Lantmännen. In 2007 three potential, and two already launched, varieties shared the accounted costs for these activities resulting in a dividing of the costs in fifths. Three fifths charges the cost for developing new varieties (in NL2) and two fifths are excluded and treated separately. The costs for purifying or sustaining already launched varieties shouldn't be added to the PD, they should however affect profitability, perhaps as a "reduction in revenues", when calculating the future incomes from a launched variety. Launched varieties aren't up for this purification every year; the assumption in this thesis is that this occurs once every fifth year a variety remains on the market – this of course affecting the yearly revenue-reduction.

5.2.5 Cost drivers

After allocating the costs to activities proper cost drivers have been chosen (for a full list of activities and their cost drivers, se appendix I). The aim has been to reduce the number of cost drivers without losing precision. In many cases number of genotypes has proven to be a good cost driver. For example the activities carried out on the field are mainly made by hand; one person on the field one day costs a certain amount of money. The number of people needed is dependent on the size of the area needed to be worked and the area is dependent on how many genotypes the breeder has in field. However, some activities (e.g. *harvest*) aren't performed in the same way in all phases; sometimes only the ears are harvested, sometimes whole plants. From this follows that even if number of genotypes is a cost driver for most of the activities they need to be priced differently in each phase.

5.3 Using the costs

With all activities priced a better picture of where and how the costs occur can be achieved. In figure 5.2 below the costs for 2007 are presented per stage. Building the theoretical PD process implies that costs in the stages should increase during the process as uncertainty decreases and, as shown below, this isn't the case in the BREED process. However, the costs investigated are solely the ones incurred in PD. Taking marketing and sales expenses into account, a picture of steadily increasing costs should appear. In the figure the three development paths, regular breeding, DH and SSD, are presented. The SSD track is hardly noticeable, since this is a new way to develop varieties at SW Seed and further observations are needed before any certain conclusions can be drawn. Further, the costs for represented varieties are presented, this in order to investigate the costs for these separately. Allocated on this level there is an opportunity to "position oneself" in one decision-point, grasping the costs lying ahead until the next. A common belief in SW Seed is that the NL testing stage is expensive, but figure 5.2 says differently. This however, is a bit misleading; the number of years in NL testing is fewer than in previous stages and the number of varieties is much smaller, rendering a high cost per potential variety in this stage.

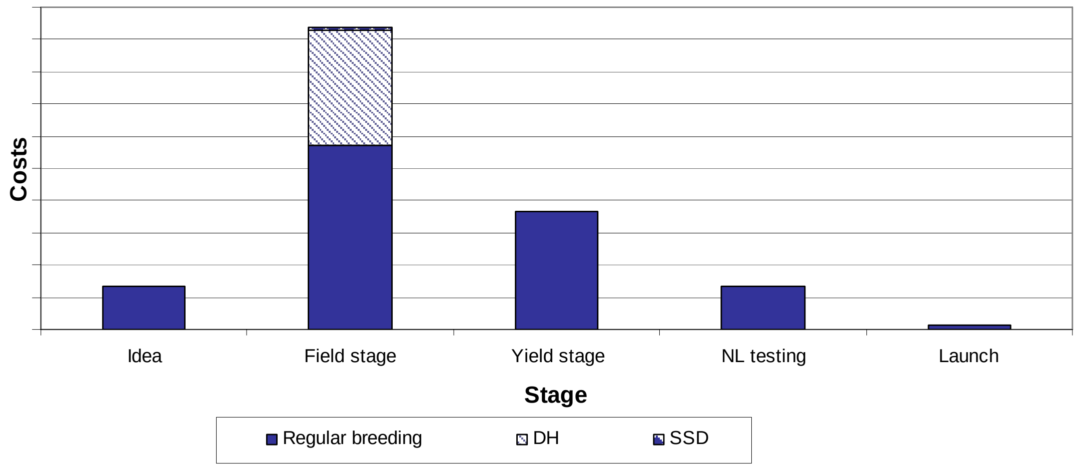


Figure 5.2. Costs per stage

The cost allocation over stages can be used to illustrate another aspect of the decisions made in the PD department. During the interviews respondents were asked were they thought key decision-points (DCP) should be positioned and what type of discussions they should consist of. As described in chapter 4.3.1 there were agreements on the DCP-positioning (matching the dividing of the process in stages as in figure 5.2 above), but the thoughts on discussions were more divergent. Is it possible to discuss the more financial dimension of business appraisal in DCP 2, before the Yield stage? Figure 5.3 below shows the implications if this answer is no; should we wait until after the Yield stage (to DCP 3) before such a discussion is held 85 % of the costs for a PD cycle are already spent. And this without doing a business appraisal estimating the financial returns on the specific varieties developed.

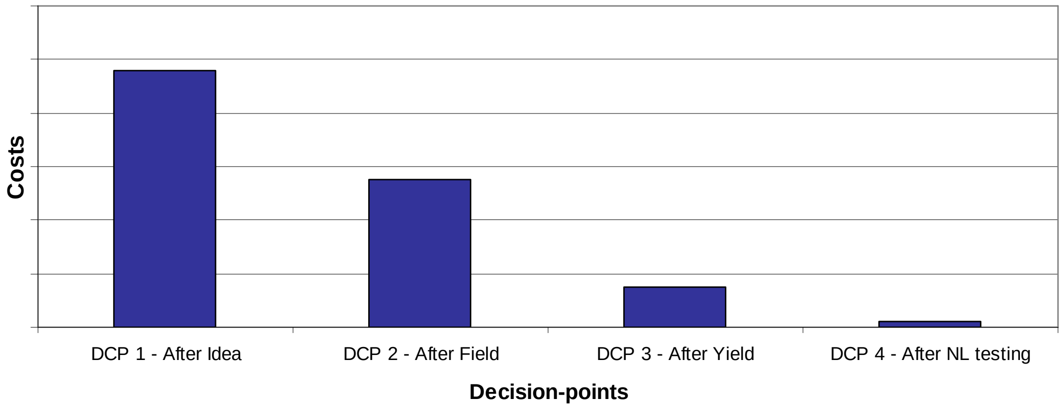


Figure 5. 3 Remaining costs in each decision-point (DCP)

It may be difficult to inform such a discussion, analysing the business situation some seven years ahead, but the alternative; not facing this task, might be worse. After DCP 1, where the crosses are decided, six years have past. Six years in which the markets may have shifted significantly. As illustrated in figure 5.3 above and in the DCP-description in chapter 5.1.2-5, the proposition is to review the market situation *and* to scrutinize, as detailed as possible, the business appraisal.

In figure 5.4 the costs for 2007 are presented on a phase level. The somewhat high costs in F1 are from the DH-runs that are initiated here. The high costs in NL-2 are due to the yield trials that are conducted on more locations than in previous phases together with the many genotypes that still are in the run of being a launched variety. The IDEA stage (only consisting of one "phase") might seem expensive. 75 % of the costs are marker tests, trying to find the absolute best parents to be.

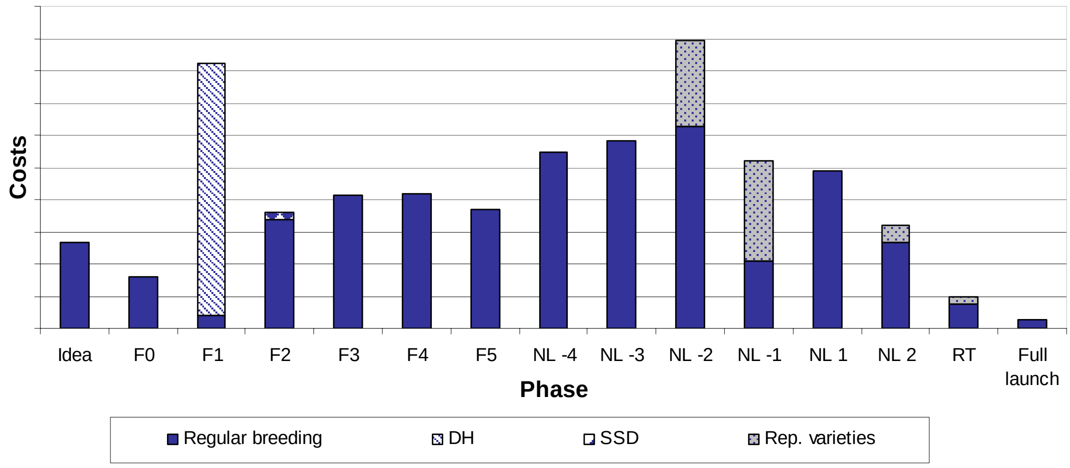


Figure 5.4. Costs presented by phase

Another way of illustrating the costs per phase is to start in a fictive year zero, initiating a new programme where no current costs exist. In figure 5.5 below such an approach is presented.

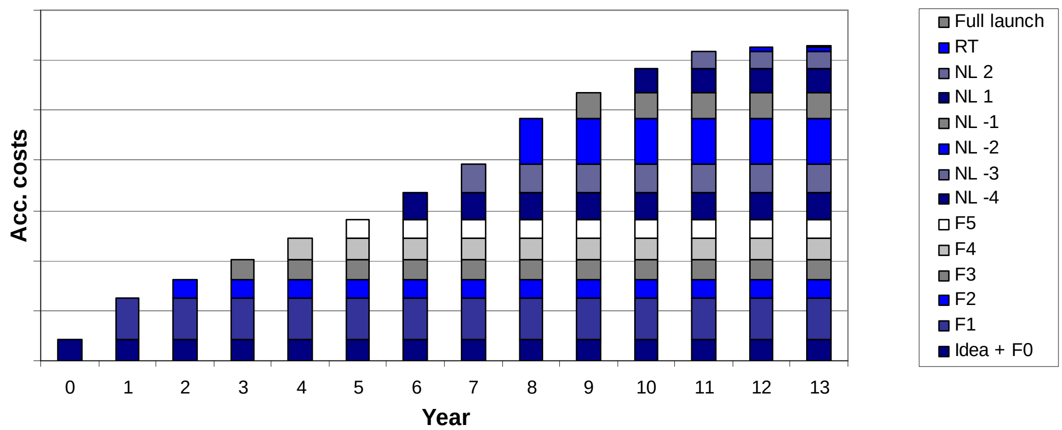


Figure 5. 5. Accumulated costs over the years

The number of genotypes is of great importance to cost picture. Looking at figure 5.4, the impression is given that F5 and NL2 cost roughly the same, but a difference lies in number of genotypes. In F5 7,000+ genotypes exists, in NL2 less than 10.

In table 5.1 below, cost per genotype is presented. As seen the costs are increasing due to more thorough work conducted on each genotype. The decrease in costs from NL1 to NL2 is partly due to tests in SW lab, not performed in NL2. Interesting comparisons can be made analyzing the different development paths. The costs for regular breeding in F1 to F4 can be compared to the DH path, which could be used to replace these four years. As seen the costs for DH are much higher per genotype. Due to the high costs per genotype only a small number of genotypes can be made. This should be put in relation to that a larger number of genotypes during the process generates a greater chance of getting a successful variety in the end. On the other hand the three year faster time-to-market is a parameter to take into account if the new variety should be successful at the market. The SSD path will be interesting when more time has gone and further conclusions can be drawn. It presents a cheaper way to gain a few years than DH but positive effect is still to be proven.

Table 5.1. Costs per genotype in each phase

Phase	*Cost per genotype* (no. of digits in the costs)	*DH* (no. of digits in the costs)	*SSD* (no. of digits in the costs)	*Represented varieties* (no. of digits in the costs)
F0*	3			
F1*	2	5		
F2*	3		3	
F3	2			
F4	2			
F5	2			
NL -4	3			
NL -3	4			
NL -2	4			4
NL -1	5			5
NL 1	5			-
NL 2	5			5
RT	5			4
Full launch	5			
*=The costs presented for F0 to F2 aren't costs per genotype but cost per population.				

As mentioned earlier, costs investigated here are the ones incurred by the product development process only. Other costs that aren't a part of the programme, such as sales and market aren't investigated in this thesis. Since regional testing is a vital part if the represented varieties are going to be a success on the market, it could be discussed if they really should be excluded. Another possibility is that the costs for represented varieties all together should be accounted to sales or marketing instead.

The presented figures so far have dealt with absolute costs incurred 2007. If the costs for developing one new variety are sought a more forward looking approach needs to be taken. In figure 5.6, the scenario is to see how much it would cost to develop a new variety standing in year 0, with a discount rate at 10 %. The assumption is made that the programme generates on new variety each year and that the costs are constant at 2007's level. In each decision-point the breeder has the opportunity to make new decisions that can affect the picture, leading to that a new calculation needs to be done at each gate.

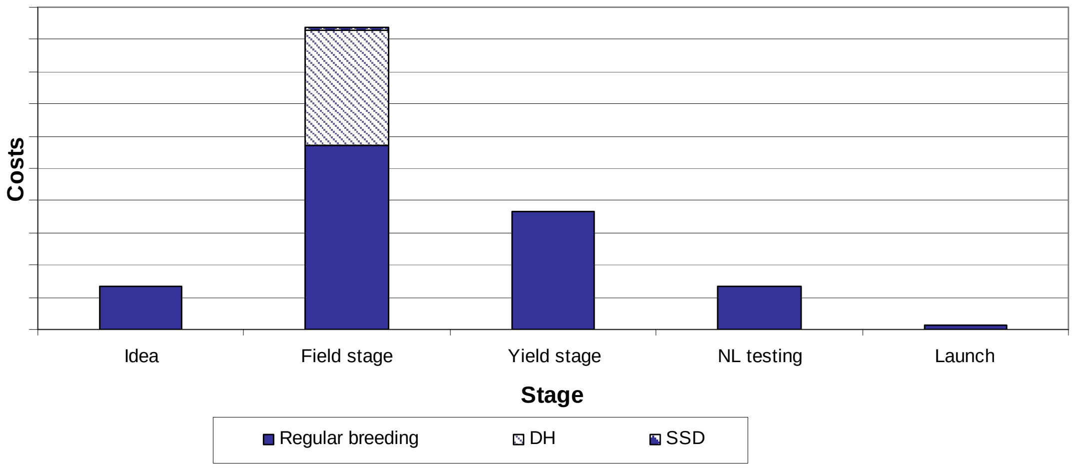
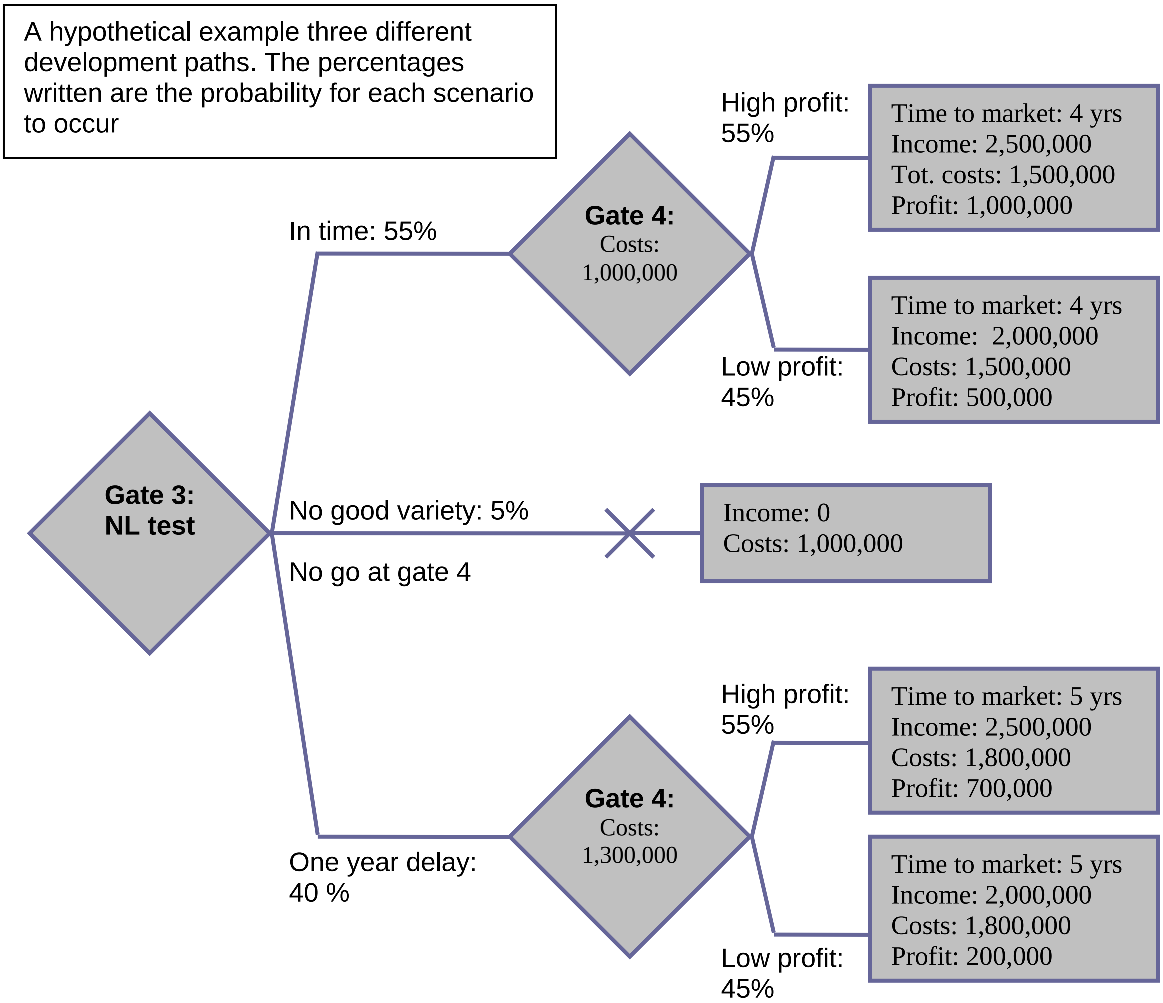


Figure 5.6. Scenario for the development costs from year zero to launch with a discount rate at 10 % and costs at a constant level

Taking this one step further a decision tree can be created. At each DCP a number of possible choices with connected outcomes are presented. In the first DCP for instance the breeder chooses project sizes; emphasis on bread, feed or special varieties? Other decisions the breeder faces are choosing development paths for a specific crossing; regular breeding, SSD or DH? In the following DCP's other choices occur, for example number of genotypes to send to yield trials.

An example of a decision tree is seen in figure 5.7 where the breeder is positioned in DCP 3. The costs to reach gate 4 is 1,000,000 if no delays occur, 1,300,000 if there is a one year delay, and another 500,000 to reach launch from gate 4. A scenario is sketched where in order to get a new variety to the market from a generation there is a 40 % probability that one extra year in NL testing will be needed, a 55 % probability to that no extra year is needed and a 5 % probability that no good variety at all will come out of the generation. If the variety reaches the market there is a 55 % probability for a high profit and a 45 % probability for a low profit. The breeder has the choice to either "kill" the generation right away in which case no further costs will incur, or a make a go-decision. The value of the go-option is the sum of the value (i.e. NPV of (income – costs)) of the three possible outcomes and in this example a go-decision should be taken. The commitment however, isn't to full launch but only to the next gate where new scenarios should be sketched up and new calculations made. The costs of the go-decision are the costs of reaching gate 4 and not launch. In gate 4 the probabilities and the value of high and low profit might have changed and new possible outcomes might have occurred, e.g. "no profit", resulting in a no-go in gate 4. The go or no go-decision should be based on the criteria discussed for each DCP in chapter 5.1.2 – 5.1.5. In this way the breeder has the possibility to make decisions based on possible end-scenarios, but the option to change path in later DCP's as more information is available.



Path	Cost to gate 4	Probability of path	Value of option from gate 4 and forward	Net Present Value of option (10%)
In time	1,000,000	55 %	1,000,000 × 0.55 + 500,000 × 0.45 = 775,000	529,000
One year delay	1,300,000	40 %	700,000 × 0.55 + 200,000 × 0.45 = 475,000	295,000
Killed in gate 4	1,000,000	5 %	-1,000,000	-826,000

The *value* of a go-decision in DCP 3 is given by the probability of the options to occur times the value of the options: 529,000 × 0.55 + 295,000 × 0.40 - 826,000 × 0.05 = 368,000

The *costs* of a go decision in DCP 3 is given by the costs committed to until DCP 4: 1,000,000 × 0.55 + 1,300,000 × 0.40 × 1,000,000 = 1,120,000

Figure 5. 7. An example of a decision tree. Please note that all numbers are highly hypothetical

The important contribution of allocating the costs on activities in phases is a way to communicate how the money is spent and if possible, discussions of how to use them better. One easy way to communicate around costs is by setting a number, say SEK 500,000, and see how much to get for this money.

5.4 Connecting the BREED process with the strategic agenda

The strategic work in SW Seed seems, partly, well aligned with the critical success factors presented in the theoretical part of the thesis (see chapter 3.3.2). All respondents state that the forums in place today are well suited to address the strategic and tactical issues that need continuous attention. The strategic workshops generates a strategy plan that guides PD in a short (three years) as well as a long (10-15 years) perspective. There are information gathered, and discussed at the workshops, on important areas such as Winter wheat Baltic's (WWB) total profitability, lifecycle analysis by launched varieties, portfolio analysis and variety turnover by time at the market to name a few. These are all key metrics presented in theory as well suited measurements to boost PD. However, there seems to be some potential for improvement in the strategy plan on translating the metrics into specific targets and objectives – what are we to aim for and, specifically, how should we get there? This is discussed further in the following chapter on KPI's.

The need for multifunctional contribution in these strategic and tactical discussions is addressed by joining forces from PD, marketing, sales and finance in these forums. The workshops are prepared by each function generating informed and effective teams at the meetings, although there might be room for improvement by standardizing the input so that each and every member "speaks the same language" and fully can contribute at the workshops. In appendix IV, some examples of possible standardized inputs are presented. These examples illustrate two things; the metrics used should include prioritizations and goals for different factors, and that they should be expressed in a standard way that everybody recognizes immediately. The standard layout could of course be tweaked between workshops, but every attendee should "know what's coming" and how to interpret it when entering that specific meeting.

As mentioned in chapter 4.5 the thesis delimitations rendered gaps in the gathering of empirics concerning the strategic areas of PD. In stating this it's implied that the run-through of the current strategic and tactical work at SW Seed isn't exhaustive. However, the impression is that there seems to be a strong foundation on which to build a metric system that generates a successful PD.

Nonetheless, SW Seed lacks one of Cooper's critical success factors to a successful PD; the Stage-Gate PD process. The BREED process could fill that void, but if so, it'll have greater chances of doing so by being connected to the company's strategic process of today. The decision-points described in chapter 5.1.2-5 needs to be addressed in suitable forums, and in figure 5.8 below, suggested connections between the strategic process and the BREED process are presented.

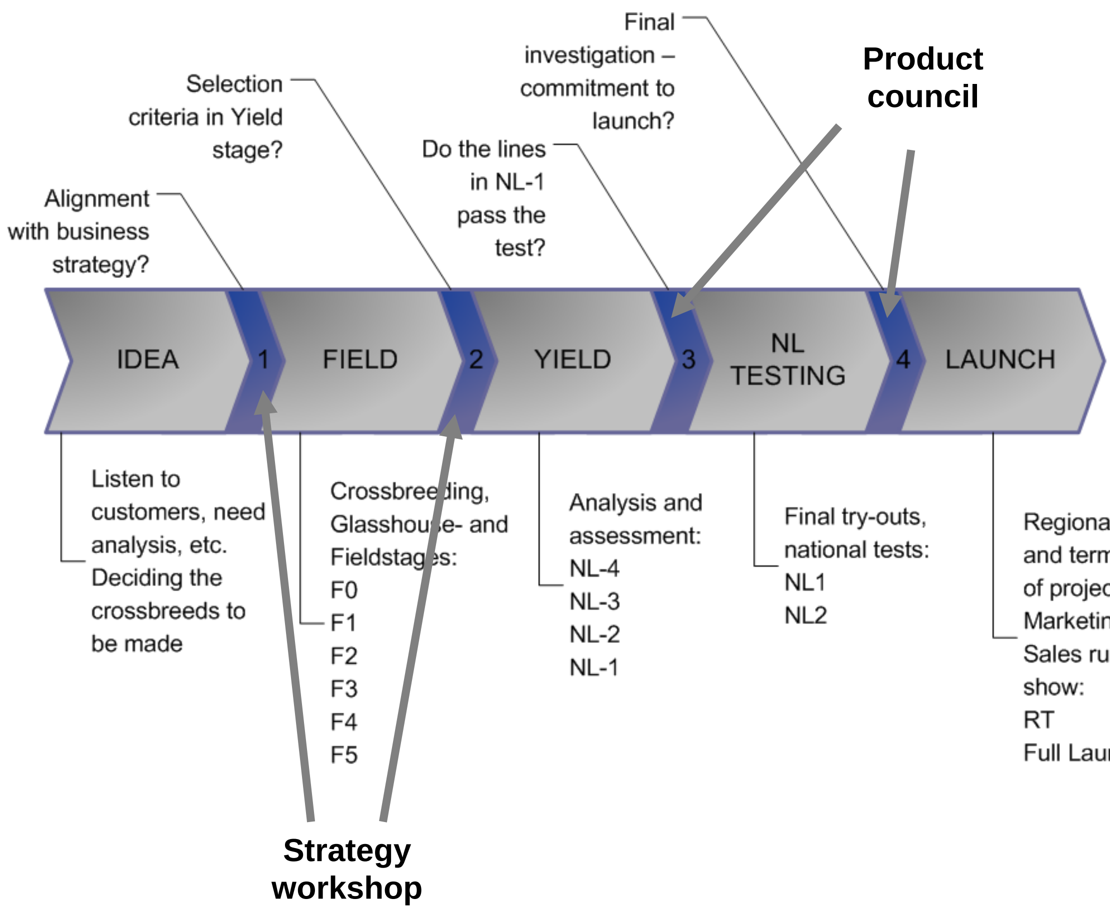


Figure 5. 8 The top level view of the BREED process; added are the proposed forums for the different decision-points

Following the same reversed chronological order as in chapter 5.1.2-5, the later decision-points (DCP) 3 and 4 are discussed first. The reason is the same; towards the end of the BREED process the decision parameters are easier to address and describe in detail, the decisions made have a more tactical (and therefore precise) nature than the strategic ones with longer time horizons discussed in DCP 1 and 2.

The internal uncertainty (greatly affecting what'll actually be the outcome of the PD process) is significantly reduced in DCP 3 and 4. The decision on which potential varieties to send through to the NL Testing is made reviewing some 15 varieties, all described extensively through conducted tests in the Yield stage. In DCP 4 even more information on the varieties exists, parallel with newly compiled market data and financial analysis. The tactical decisions made in these DCP's have more of a business appraisal character then earlier DCP's making the Product council a well suited forum for the discussions.

The discussions at the current strategy workshops concerns most of the information that's connected to DCP 1 and 2, making it natural to (if necessary) extend or tweak these to include more formal DCP-discussions. As mentioned above, the long term discussions spanning 10-15 years should address many of the DCP 1-areas suggested by Cooper perfectly. In DCP 2 six more years have elapsed and the external environment may have changed considerably; a refined strategic outlook seems in order. Internally focus should be kept on the upcoming Yield stage. Have customer preferences changed or have our competitors raised the bar on what's saleable, affecting our future Yield-selections? Both DCP 1 and 2 should fit the strategic workshop setting perfectly as indicated in figure 5.6 above.

In the following chapter a more detailed discussion on possible KPI's – both within and after the PD process – is presented.

5.4.1 KPI's

As mentioned in chapter 4.5.3 the background information to the thesis gave that the use of KPI's at present are limited. The interview material on the subject gave little new information on specific metrics sought for by the respondents. However, in chapter 5.4, praise was given to the strategic work at SW Seed, specifically the strategic workshops and thereby connected strategy plans. These contain a lot of information that could be translated into useful KPI's. A discussion on the specifics (metrics as well as their proposed levels) is left out of this thesis due to earlier delimitations, presented is however a more theoretical discussion, trying to structure a qualitative discussion of possible metrics and KPI's that SW Seed *could* use, rather than giving normative guidelines to what they *should* use.

Larsson & Ljungberg and Cooper have somewhat different ideas on what to measure, although not contradictive they propose slightly different emphasises. Larsson & Ljungberg takes a holistic view to metrics stating that any set of metrics should consider their three types of demands on a process; the end customer, the sub-processes and the organisation. The proposed idea is that no organisation can be successful in a long run if they neglect to deliver results in any of these areas. In figure 3.9 (see chapter 3.5) the organisational demands are translated in critical success factors, which in turn are translated in process goals, aiming to fulfil demands from sub-processes and customers. This translation is often a difficult enterprise leaving the users of a certain process more puzzled than motivated. An example might be a programme loosing money on a yearly basis, rendering a strategic goal to close the gap between revenues and costs. How should this be translated into a process goal? Which critical success factors hold the key to the solution? Enhance everything and sell more? The critical success factors (CSF) in PD proposed by Cooper in chapter 3.3.2 (and discussed again in chapter 5.4 above) could structure this translation. The foundation is a sound *product innovation & technology strategy* addressing the grander schemes affecting PD:

- What are the goals for PD as a whole? In relation to the overall business strategy? What does this mean for WWB? The return on invested capital may differ considerably between different crops short term. If that's the case so should the goals.
- Which are the strategic arenas where winning is crucial to long term success? The markets and technologies? And again; what does this mean for WWB? Would doubling the DH efforts reduce the development time enough to capture important market shares? Or would it just mean not loosing more? Or are SW Seed's DH capabilities too weak and the resources better spent elsewhere?

Structuring this information with the ambition to prioritize and translate the overall strategy into process goals is what strategy is all about; where should we spend our money? The split between different strategic arenas, or on a lower business level, different projects is Cooper's second CSF; *portfolio management*. As described in chapter 3.3.2 the thought of a portfolio could be analyzed on different levels; e.g. a business level portfolio could be the composition of the crops developed by SW Seed while a project level portfolio might judge projects within a crop programme against each other. Using the analogy of the BREED process this might be a question addressed in decision-point (DCP) 2; have the markets changed since DCP 1 where the crosses where decided? Should the project sizes be tweaked in any direction? A recent example of this is the drop in profitability for ethanol production from wheat, a few years ago considered key to success, today more or less a dead market. Portfolio discussions could be viewed at yet a lower level, within the projects (projects defined as in chapter 5.1.1, e.g. percentages of the "2008-generation" towards key end customers such as bread wheat). In DCP 1 focus for bread wheat might have been the Danish market, and in DCP 2, 6 years later the Russian market seems a lot more interesting; the "bread wheat project portfolio" might then by tweaked a bit, shifting focus from Denmark towards Russian key customers. Potential KPI's focused towards these decisions could be in the line of; assuming that Russia is a key strategic arena and that SW Seed aims for this and that market share, five new varieties tailored for the Russian market should enter NL Testing within three years. The KPI's could address the percentages (and outcome) of the projects in NL-3, NL-2 and NL-1 focused towards the Russian market.

Cooper's third CSF is acknowledging that PD is a multidisciplinary enterprise. The teams running the projects should consist of personnel from different functions to use all the expertise available within the organisation. PD should also be an innovative and creative adventure where transparent feed-back within and between different PD programmes enhances the learning through candid evaluations. As Cooper put it – celebrate failures, it means we're learning. KPI's for this CSF is less focused towards the process output and more towards the process itself. Aiming to create a multifunctional environment where everyone can contribute measuring the strategic workshops could be such a KPI. How do the members rate the workshops? The input and the discussions specifically? Do the workshops create the empowered teams sought by Cooper?

Process KPI's such as the one above could also illustrate the fourth and final CSF; the Stage-Gate process. Metrics for the PD process should however measure in-process performance as well as post-process performance. Using a structured PD process has the benefit of focusing the discussions on the decisions made rather than on the outcome of the decisions. In figure 5.9 below an example of a possible KPI is presented. These attrition curves illustrate the results of different phases that might generate rewarding discussions on the decision criteria used in selections throughout the phases. Or put the spotlight on lacking resources; say that a significant increase in attrition rates during some phases relates to a shortage of personnel rendering bad selections in earlier years. Further it can be compared against costs incurred to see what we get for our money. If more money is spent, does the attrition curve raise? However, curves like these might propose that there's a norm value to aim for and render flawed management signals to the PD department. Nonetheless, illustrative measurements like this should spawn interesting and rewarding discussions in the different decision-points.

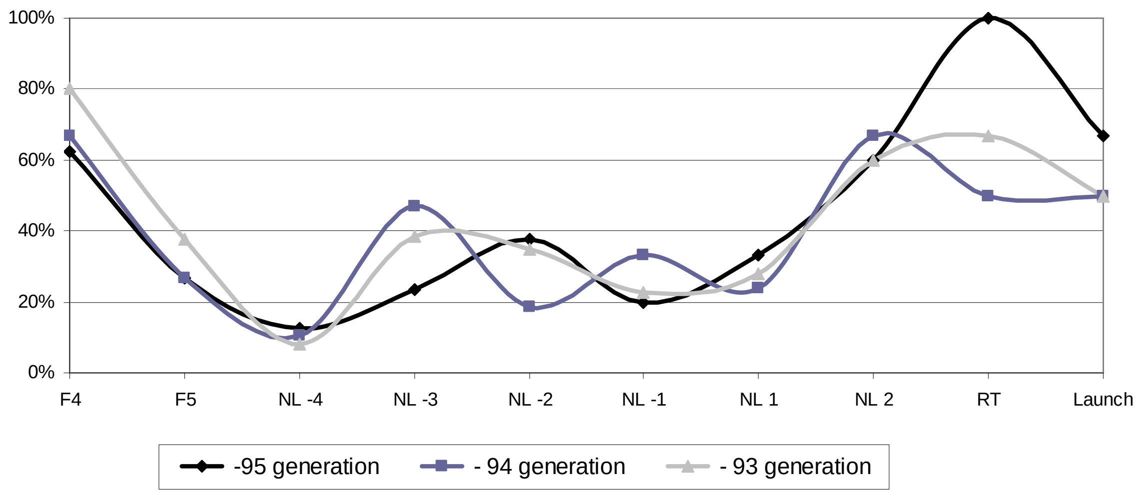


Figure 5. 9 Attrition curves illustrating the outcome of different phases and generations (hypothetical percentages)

This example of a possible KPI addresses three important "facts" in the selection of metrics:

- What you measure is what you get. The KPI's sets the ruler by which performance is judged by, resulting in a focus to perform well on what's measured and neglecting what isn't.
- All measurements should aim to provide basis for an action or an adjustment, otherwise why measure? If possible measure as early as possible in the process; it leaves more room for the adjustments.
- Metrics creates knowledge that creates understanding – use the possibilities that measuring creates in the strategic discussions.

While Cooper is more straightforward in his suggestions Larsson & Ljungberg gives broader guidelines on how to do and what to think of in selecting KPI's (see figure 5.10 below). Using this model as a starting point should render a complete set of metrics for an organisation if successfully implemented (the model is described in a bit more detail in chapter 3.5).

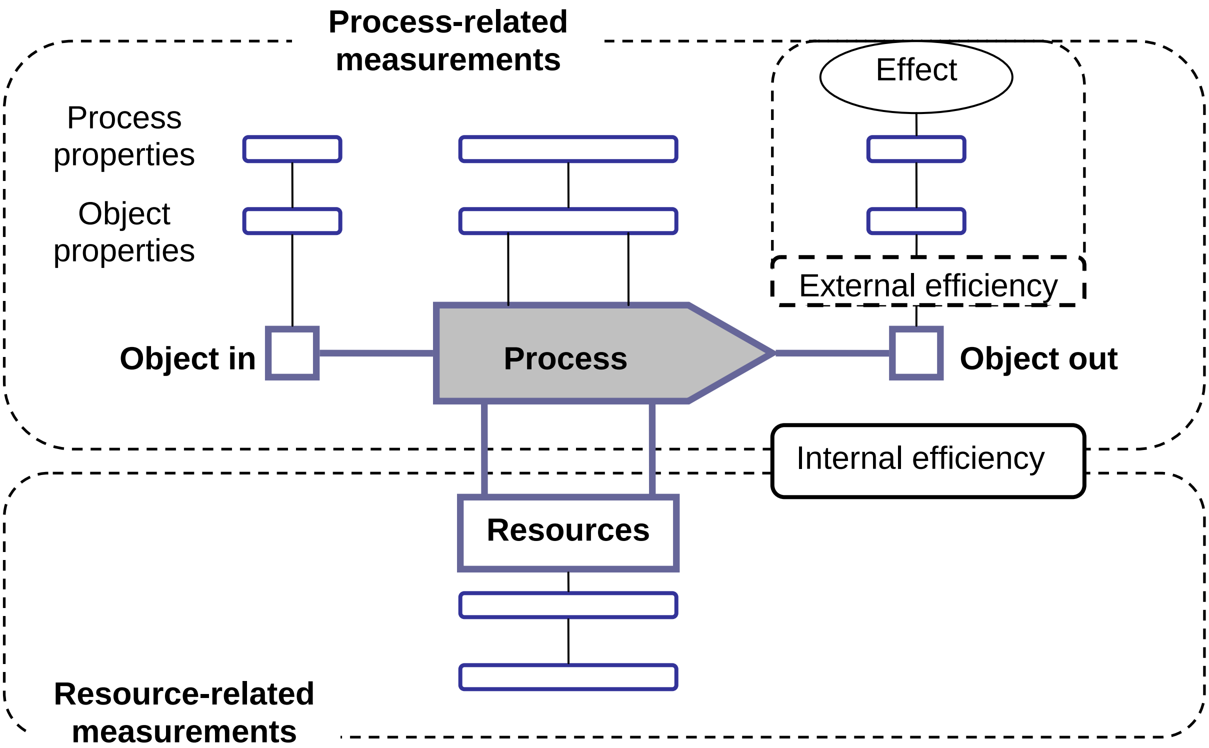


Figure 5. 10. Model for measurements of processes (Source: reworked from Larsson & Ljungberg (2001), p.244-245)

The internal efficiency is closely related to the question; how much do we get for the money spent? This thesis have spent a considerable number of pages on "money spent", but a value analysis of the activities performed aren't discussed here, this would require further investigations to elaborate upon. Although an interesting subject the internal efficiency is therefore left for SW Seed to address in other forums. The external efficiency, measuring the short and long term result of the object out, is what Cooper describes as post-launch metrics. The measurement of process and object in figure 5.8, the in-process metrics are the ones that can be proactive, i.e. it's with help from these KPI's that there's a possibility to correct a project before all costs are incurred.

However, going the Larsson & Ljungberg-way could be a bit chewy initially and Cooper's focus on monetary post-process metrics might seem appealingly easy to choose. Figure 5.11 below illustrates an attempt to connect the holistic approach of Larsson & Ljungberg with Cooper's suggested metrics. The idea is to present a way to spot any gaps in the KPI's discussed, or according to theory often the case – to identify areas where too many metrics are in use. In this matrix of possible KPI's no difference is made between the process results in terms of *what* and *how* proposed by Larsson & Ljungberg in figure 5.10 above. This distinction, discussed with a precision worth mentioning, demands greater insights in plant breeding and SW Seed than possessed by the thesis writers.

Stakeholder	In-process metrics	Post-process metrics	
		Short term	Long term
Customers	1	4	7
Organisation	2	5	8
Sub-processes	3	6	9

Figure 5. 11 A tool for gap analysis on the current set of implemented metrics; do we actually measure everything we should? Do we measure too much?

The in-process metrics are by nature hard to generalize, significant variations between organisations in different industries should be normal and this is reflected in Cooper's suggestions. Quality of gate meetings, deviation from PD process and timeliness to reach gates are all connected to a generic Stage-Gate process. However, measuring the ability to stay within budget and timeliness to complete certain activities should be directly translatable to SW Seed. Below follows a brief discussion on which metrics in the different groups (identified by number) that could be interesting for SW Seed

1) How are we doing on traits important to key customers? Measurements concerning yield, resistance and other important characteristics are already in place and this area should be well covered today.

2) The organisations demands on the process were thoroughly discussed earlier, an example being attrition curves. How are we faring in the NL Testing stage? A high attrition rate might suggest increased tests beforehand.

3) Do we measure timeliness in processes or the deliverables between involved parties? Deviations from the normal pace in the PD process could be another interesting metric. The interviews indicated that the in-house DH-technology often doesn't keep the promised performance, reducing the benefits of this procedure. Implementing KPI's to watch over such sub-process results may render changes in the chosen product innovation & technology strategy.

4) Development over different segments; can we retain the key customers or are we loosing ground to competitors?

5) Are we keeping budget? One way of using this is to if there are some projects, i.e. bread, feed or special, that constantly misses the budget. At present bread varieties are considered slightly more expensive to develop due to tests performed in SW Lab. After looking at the budget performance over some time this might however need to be revised, possibly leading to discussions on what to focus on in the future.

6) Sub-processes post-process performance, short term, could be deliverables in the form of input needed by sales or marketing to complete their tasks.

7) Difficulties to retain key customers on short term will inevitably show on longer term metrics such as changing market shares. Another key KPI in this area is the success rate of launched varieties. What’s “successful” and what’s not is of course a matter of internal definition; it could be to reach a certain level of revenues, to stay in market for a specific number of years etc.

8) The long term demands from the organisation are closely connected to the profitability of each crop programme. As discussed earlier in this chapter these demands and derived goals preferably should be translated into goals within a shorter time horizon. An often suggested KPI is the percentage of sales/profits generated by new products (e.g. products launched within five years).

9) Examples of long term sub-processes goals could be management initiatives such as increased spending in DH-technology. What should we strive for, and is this money well spent?

These are all just examples of what could be measured and the purpose isn’t to provide a complete list. For further illustration of the KPI’s, see appendix IV. The KPI’s most suitable for SW Seed should stem from industry know-how, and preferably, the critical success factors discussed earlier. As stated several times above; there seems to be many metrics in place at SW Seed, if they’re not yet implemented as KPI’s, this should be a fairly easy task although of course needing a discussion on desired KPI levels.

6 Conclusions

In this final chapter of the thesis the most important parts of the analysis are summarized; aiming to deliver on the thesis objectives presented in chapter 1.4. A brief discussion on what's next and possible ways to further improve SW Seed's PD through complementing projects and initiatives ends the chapter.

6.1 Key findings

The most important part of the first thesis objective was to cost the PD process currently in place at SW Seed (delimited to Winter wheat Baltic (WWB)). Costing the process should provide a foundation on which to build a generic metric system for PD, guiding management in directing PD towards a more sound resource allocation within SW Seed's crop programmes. Understanding the cost allocation had the prerequisite of mapping the PD process for WWB in order to tie costs to conducted activities. Through the elicited BREED process (Breeder's Roadmap to Efficiency and Excellency in product Development); confirmed through interviews with key process personnel, this prerequisite was achieved. The elicitation was conducted through two different process-mapping methodologies – the *walk-through*; following the trail of process activities interviewing key personnel along the way, and the *process design*; adding new elements, such as formal decision-points, to the elicited process.

A dugout in the company accounting system provided the costs to allocate and doing so rendered an opportunity to confirm the elicited BREED process; could the key costs be allocated to the elicited activities? Identifying the most significant direct costs – the costs that drive the sought decisions, the resource allocation – showed that 87 % of the direct costs (DC) could be allocated to the BREED activities in different stages and phases. The remaining DC's are to a large extent in fact indirect costs in the sense that they can't be allocated to a certain PD phase. An example of this is breeder time put into programme development and attaining conferences, gathering knowledge that gain each and every phase in WWB development. However, the 87 % should provide a stable base on which to build decisions that drive DC's, such as potential shifts in resource allocations between different stages. As presented in the analysis chapter the key costs for the main activities in each PD phase is described through cost drivers indicating how and why costs accumulate over the stages. This, in combination with the decision-points introduced in the BREED process puts the spotlight on the four most significant strategic discussions in the PD process and the possibilities they withholds when used properly. Adding management tools such as scenario and sensitivity analysis, the inherent internal uncertainty in plant breeding can be reduced or at least incorporated in the key decisions needing attention.

In chapter 5.1.1 differences between plant breeding and more technological PD were discussed and although simplified, an argued difference is that where technological PD faces internal certainty and external uncertainty (we can develop almost everything, just add more scientists, the problem lies in understanding the market and customer needs), SW Seed's challenge is quite the opposite. In plant breeding there's an external certainty when talking about market and customer needs; just increase yield, resistance and other agronomical traits and the market will buy the new variety. The problem is the internal uncertainty; SW Seed doesn't know if they're going to succeed in doing this. By the introduction of decision-points the 13 year PD cycle can be broken down into shorter time-spans, allowing for formal adjustments of decisions made at the initiation of the cycle. The decisions made in these DCP's have two elements; firstly they relates them to the costs incurred in the different stages (as shown in figure 5.3, 85 % of the costs are incurred before DCP 3) and secondly they addresses the need for formal, more forward looking, discussions on the financial appraisals by the projects conducted. These both elements of the decisions could be supported by the analogy of the decision-tree as discussed in chapter 5.3. Doing this acknowledges the time-value of money and incorporates scenario and sensitivity analysis in the financial appraisals. It also addresses one important shortcoming of the often used Net Present Value or Internal Rate of Return-method when calculating the actual cost of a PD project. A decision made in a fictive year zero, could be altered several times along the way when new information is compiled. This time-value of an option is supported to a further extent in decision-tree analysis.

During the interviews needed to map the sought process obstacles in the use of divergent terminology often became apparent. The mixing of Swedish, English, German and occasionally home-brewed names for the same activities sometimes made the compiling of found information feel like a Sisyphean challenge. The interviews showed that these feelings were present within SW Seed as well; different functions used different terminology, leaving room for misunderstandings and missed opportunities for synergies. Applying the BREED terminology and activities might facilitate a multifunctional platform for understanding between these different competences at SW Seed today. A common language was just one part of the second thesis objective; the other being to prepare the elicited process for generalization to the other crops developed at SW Seed as well. In this thesis to BREED process' ability to cover the processes of development of other crops haven't been tested. Nonetheless the module-based structure should allow tweaking of the process to describe crops with slightly different processes as well. If needed an extra year in e.g. Field or Yield stages could be added without changing the underlying structure of the BREED process. Activities must be altered to some extent (e.g. spring crops don't need vernalisation) but none of these changes alter the positioning of the sought key discussions in decision-points 1 to 4. When discussing generalization and the potential application of BREED all over PD at SW Seed, it's critical to acknowledge that the PD process is perhaps *the* most vital process in place at the company today. This implies that implementing a new terminology, tweaking the strategic discussions or addressing resource allocation in new ways will affect the way SW Seed conduct businesses on a day-to-day basis. As discussed in the analysis chapter no single task in such an implementation should prove insurmountable, but all together it would truly be a significant project, affecting all functional departments.

The overall impression is that the information in the strategy plan covers many of the theoretical strategic aspects addressed in this thesis, but that there might be shortcomings in the transformation of this information into critical success factors and process goals. The proposed way for SW Seed to solve this possible problem is to generate this translation in a step-by-step method. The first task is to formulate the overall SW Seed business strategy in implications and key objectives for the four critical success factors (CSF); *Production Innovation & Technology Strategy*, *Culture & Leadership*, *Portfolio Management* and *the BREED process*. These objectives must be translated once more to actually mean something for the PD personnel in the day-to-day work; what implications will the CSF-objectives have on the different stakeholders' demands on the PD process? Addressing the demands of *customers* as well as the *organisation* and the different PD *sub-processes,* measuring performance *in-process* and *post-process* (both short and long term) should result in a complete set of KPI's. In chapter 5.4.1 a comprehensive model for a gap analysis on the chosen set of metrics is introduced (see figure 5.11). Once having these metrics in place a fine tuning of the metric system should be the next step. In this task the more detailed model proposed by Larsson & Ljungberg should prove to be a good starting point.

6.2 Recommendations

Adopting the proposed BREED process at SW Seed has the prerequisite that it gets acceptance by the people working closest to it. Firstly, *it isn't* a new PD process in the sense that any activities have been changed. Formal discussions (that in many cases already exists) have been named and structured, but they're, in essence, carried out today so they shouldn't seem all that strange. Secondly, *it is* a new PD process in the sense that the ambition is to replace the old terminology and structure strategic discussions based on a generic process throughout all crops. This second aspect of the BREED process is important and something that should be considered before, if any, significant conclusions from this thesis are drawn. If the proposed process is to be implemented this task should be preceded by a project addressing its possible (and likely) shortcomings in different areas. Time and resources should be assigned for key personnel to discuss its structure in workshops with the goal to agree on proposed layout and terminology.

Adjust the strategic workshops and product council to incorporate the essence of the BREED decision-points. As mentioned several times throughout the thesis, PD is a multifunctional discipline. At SW Seed, this cross-functional work is largely conducted through the described workshops and councils, together sketching the strategic and tactical roadmap for PD to follow. For BREED to work, the decision-points must be addressed in the same manner; structured discussions within empowered groups with members from all involved departments. These forums already exist and tweaking them to handle decision-point discussions shouldn't prove impossible. The suggested way to handle projects (based on segments) might need adjustments to work in an appropriate way. However, the proposed way to use the decision-points to address selection-criteria and enhanced matching of potential varieties and prioritized, key segments and markets should be implemented. The theoretical framework paints a distinct picture on this issue.

Although the allocated costs to the BREED should provide a significantly better picture of the relations between activities, cost drivers and results there could be important areas where room for improvement and enhanced accuracy exists. One area that could prove useful to analyze in the near future is that of disease nurseries. The costs allocated to the nursery activities today is solely personnel and although the other costs should be rather small they accumulate along with the number of lines analyzed. If improved disease resistance is a fairly important process goal, costs for nurseries could very well be an interesting decision parameter when deciding how to allocate resources in e.g. the Yield stage.

Using ABC to allocate costs to a generic standard process also renders an interesting possibility for initiatives in Value analysis; could SW Seed get more value out of the activities conducted if their were changed in any way? The process or activity analogy (described in chapter 3.2) suggests that no activity should be performed without a sought *object out*, justifying it. Could there be a better way of getting those objects out than implemented today?

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Appendix I

Activity	*Main tasks performed*	*Main cost driver*
Choose crossbreed	• Performing studies on possible parents	Time/person days
SW Marker	• Marker tests, judging potential parents	Number of tests
Prepare sow	• Loading trays • Treat seeds against diseases • Preparing field books and printing labels	Number of Populations/Lines
Sow	• Sowing on field and in glasshouse	Number of Populations/Lines
Resistance & vernalisation	• Resistance tests made in F0 to F2 • Work connected with the vernalisation chamber	Number of Populations/Lines
Plant	• Planting into the ground after vernalisation chamber	Number of Populations/Lines
Crossbreed	• Emasculation • Pollination	Number of Populations/Lines
Tend	• Weed control • Other activities performed during the growth	Number of Populations/Lines
Select	• Selection in field	Number of Populations/Lines
Harvest	• Harvest by hand and machine	Number of Populations/Lines
Analysis Breeding Station	• Analysis performed on the breeding station	Number of Populations/Lines
Compile data	• Compiling results from the analysis	Time/person days
Sow nursery	• The sowing of nurseries	Number of Populations/Lines
Assess nursery	• Travels to nurseries • Inspection of nurseries	Number of places
Sow yield trials	• Sowing of yield trials	Number of Populations/Lines
Sow maintenance breeding	• Sowing of maintenance breeding	Number of Populations/Lines
Analysis resistance	• Analysis of the resistance tests	Number of Populations/Lines
Analysis SW Lab	• Analysis performed in SW Lab. Treated as a black box activity, priced according to pricelist	Number of Populations/Lines & tests performed
Application for NL	• Filing applications for NL • Test fees	Number of varieties
Regional testing	• Filing applications for regional trials • Test fees	Number of varieties
Compile results	• Compiling results from NL testing • Deciding varieties to launch	Number of varieties
Certification	• Certification and official yield trials	Number of varieties
Business meeting	• Preparing and attending meetings for marketing purposes	Time/person days

Appendix II

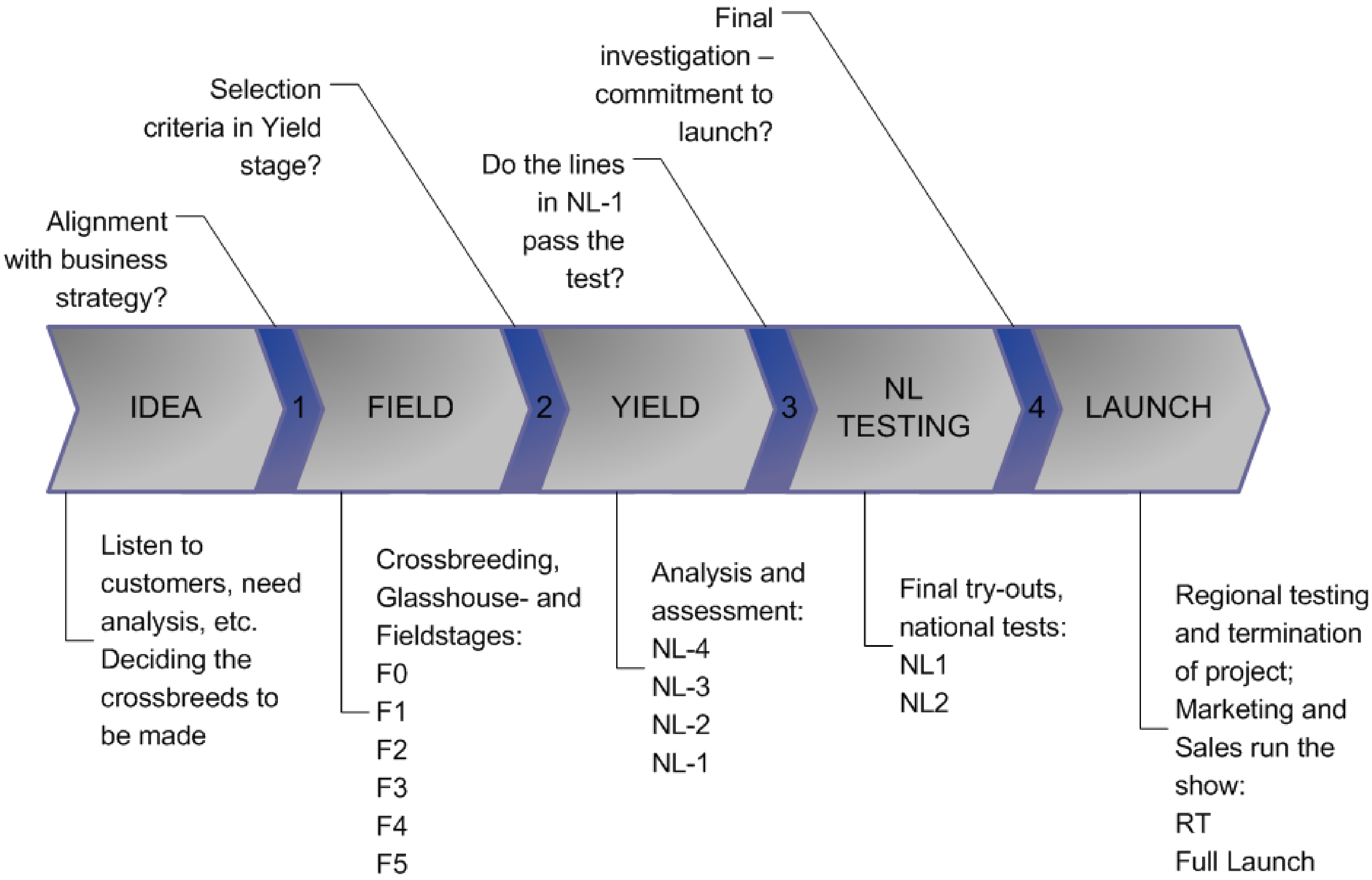
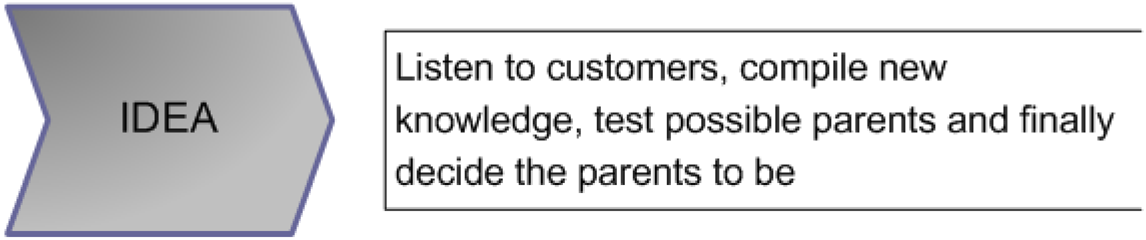


Figure Appendix II. 1 Top level

Appendix II, The BREED process; all levels of detail



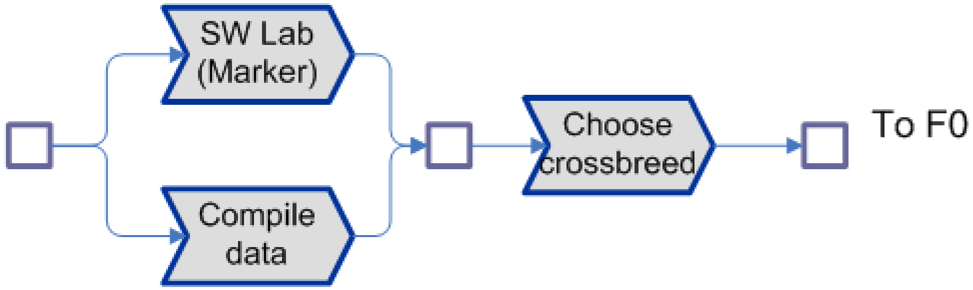


Figure Appendix II. 2 IDEA

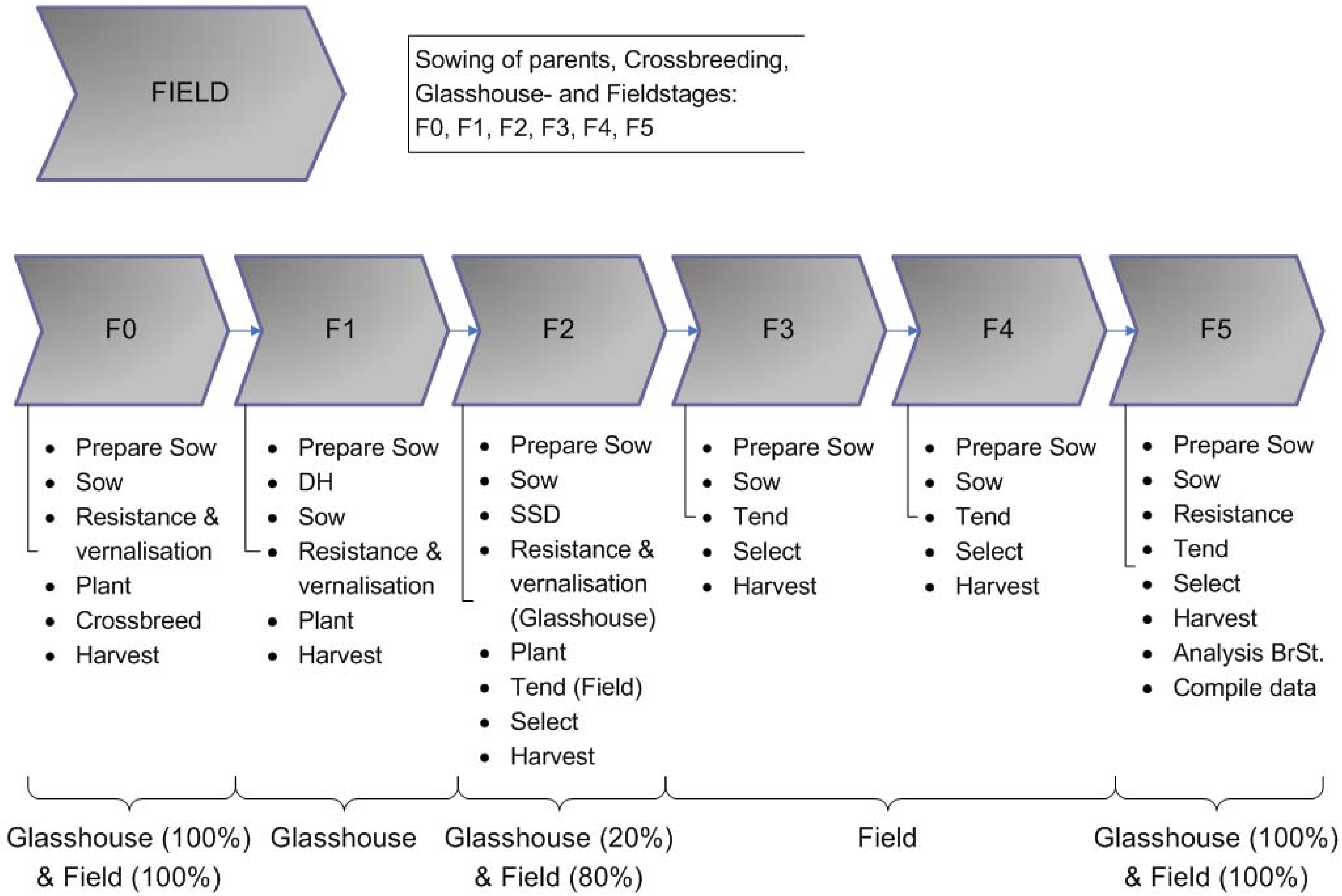


Figure Appendix II. 3 Field

Appendix II, The BREED process; all levels of detail

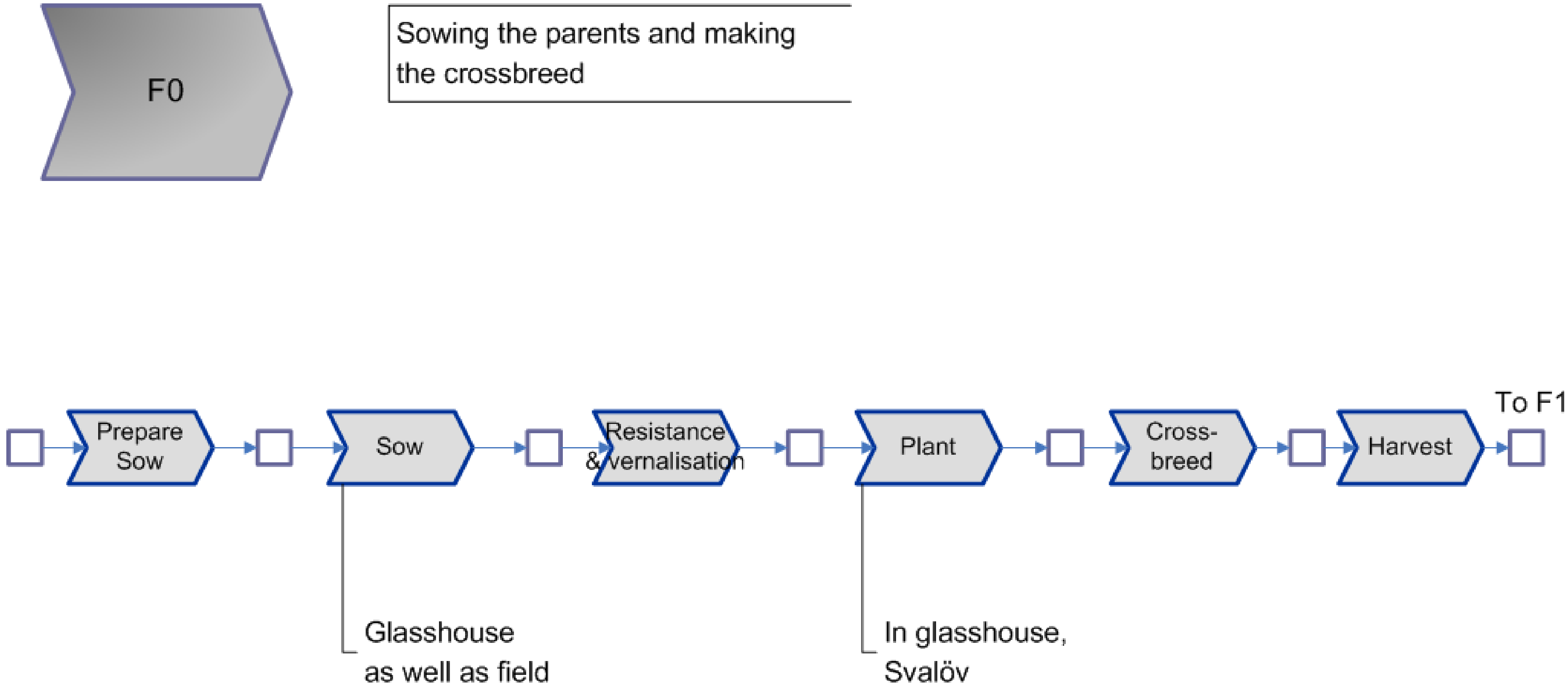


Figure Appendix II. 4 F0

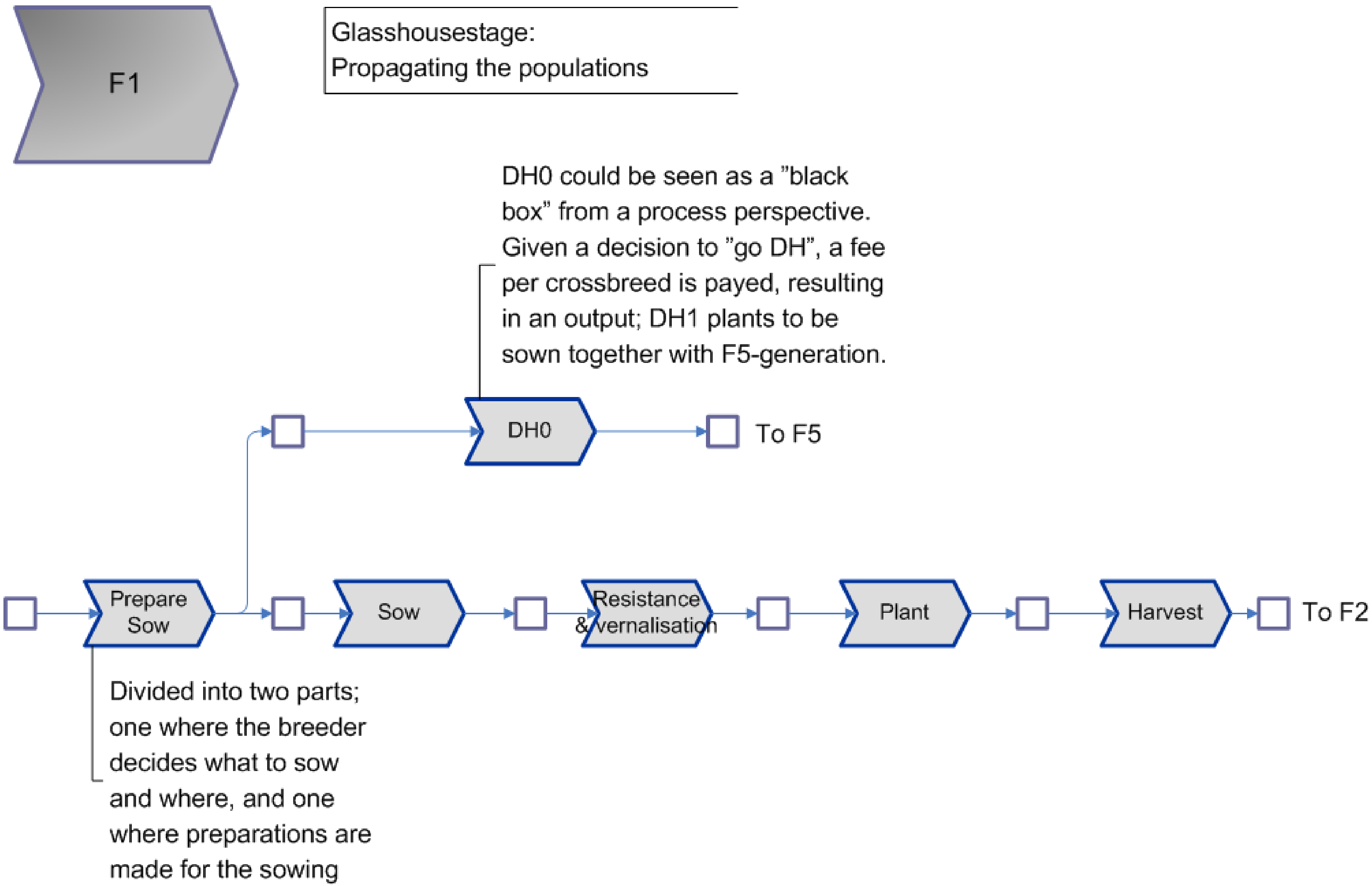


Figure Appendix II. 5 F1

Appendix II, The BREED process; all levels of detail

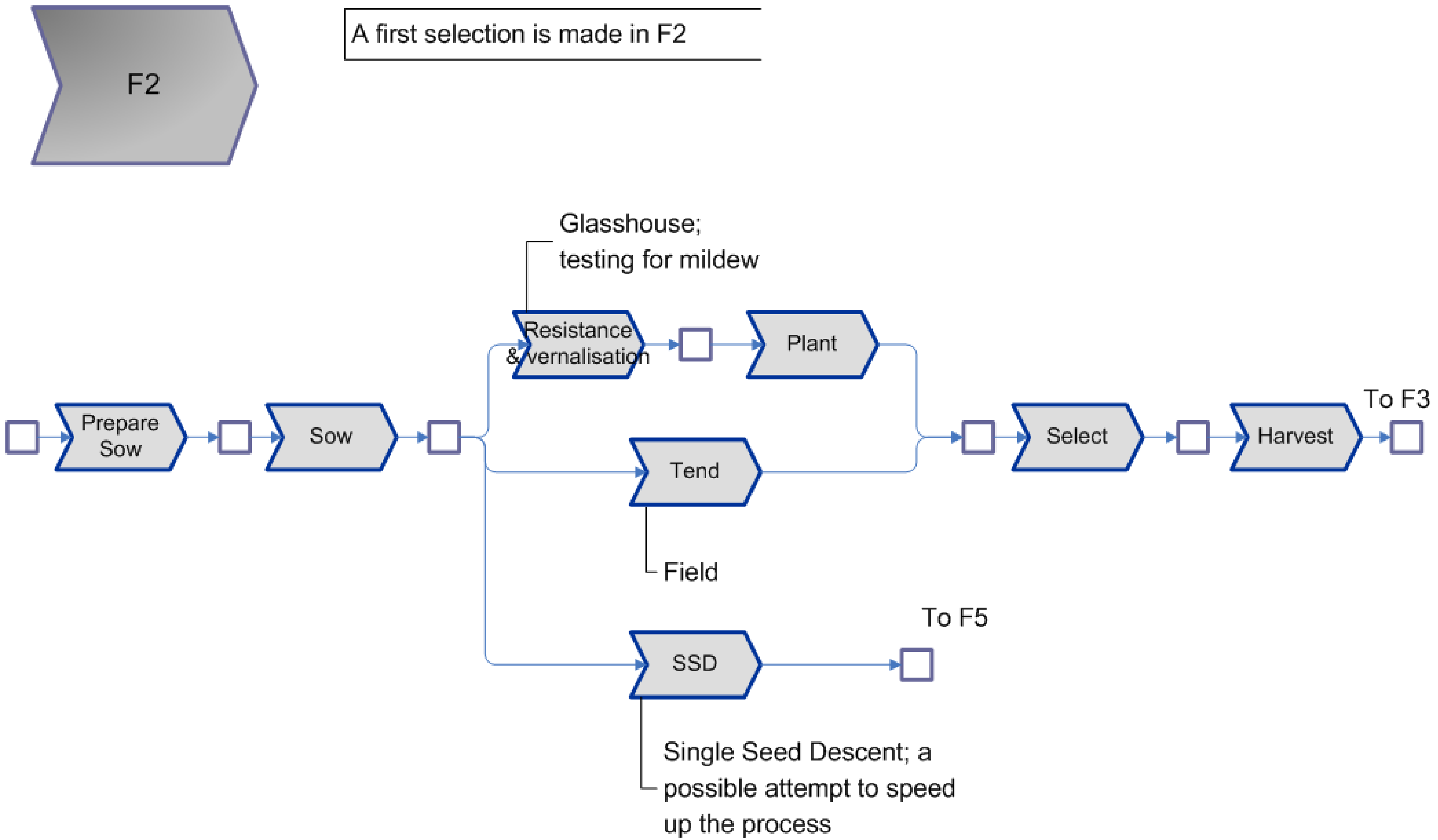


Figure Appendix II. 6 F2

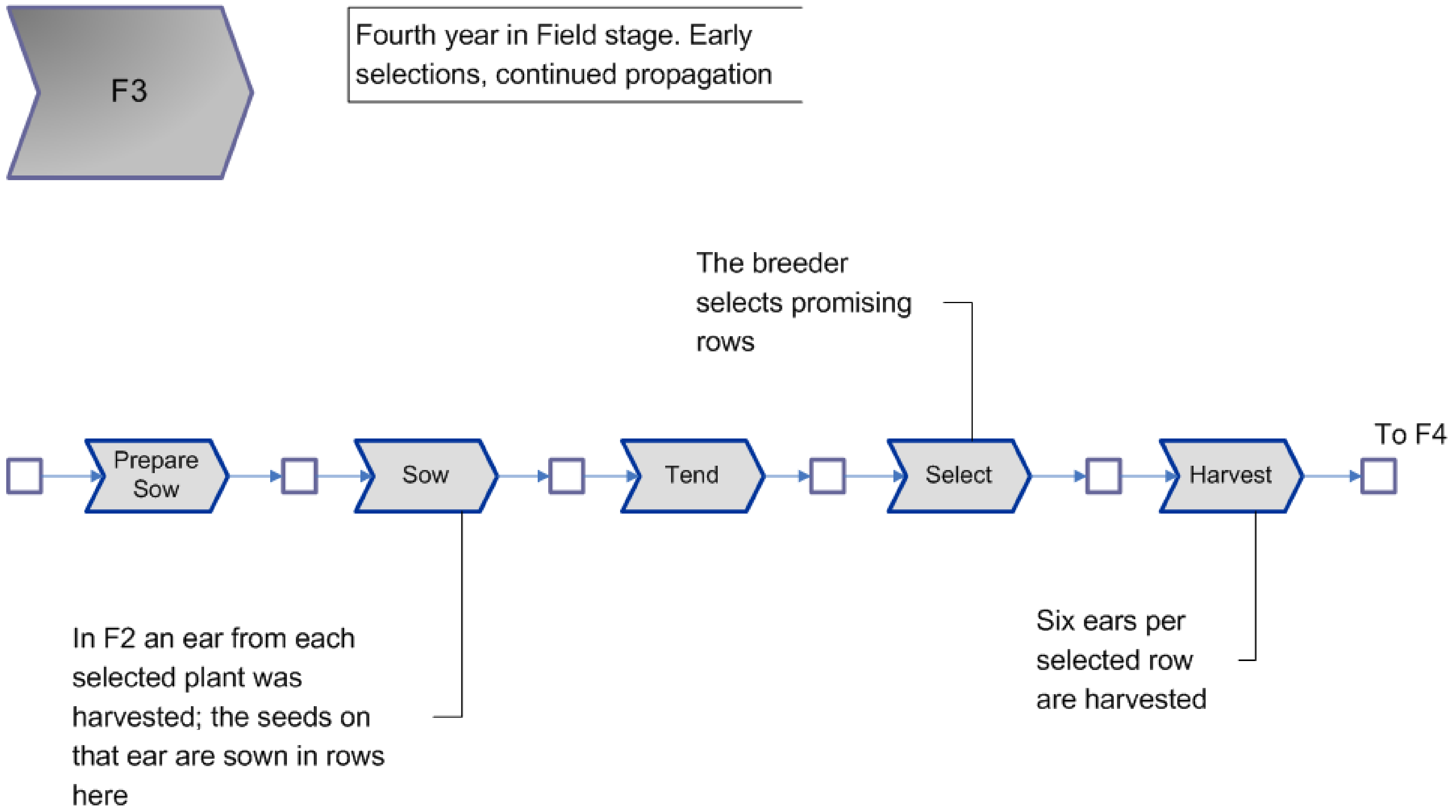


Figure Appendix II. 7 F3

Appendix II, The BREED process; all levels of detail

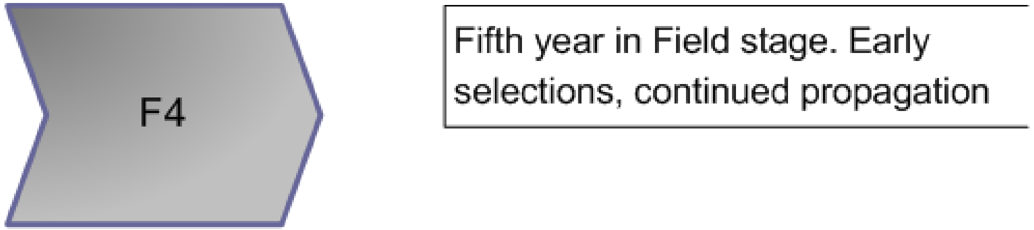


Figure Appendix II. 8 F4

Final Field phase before Yield stage

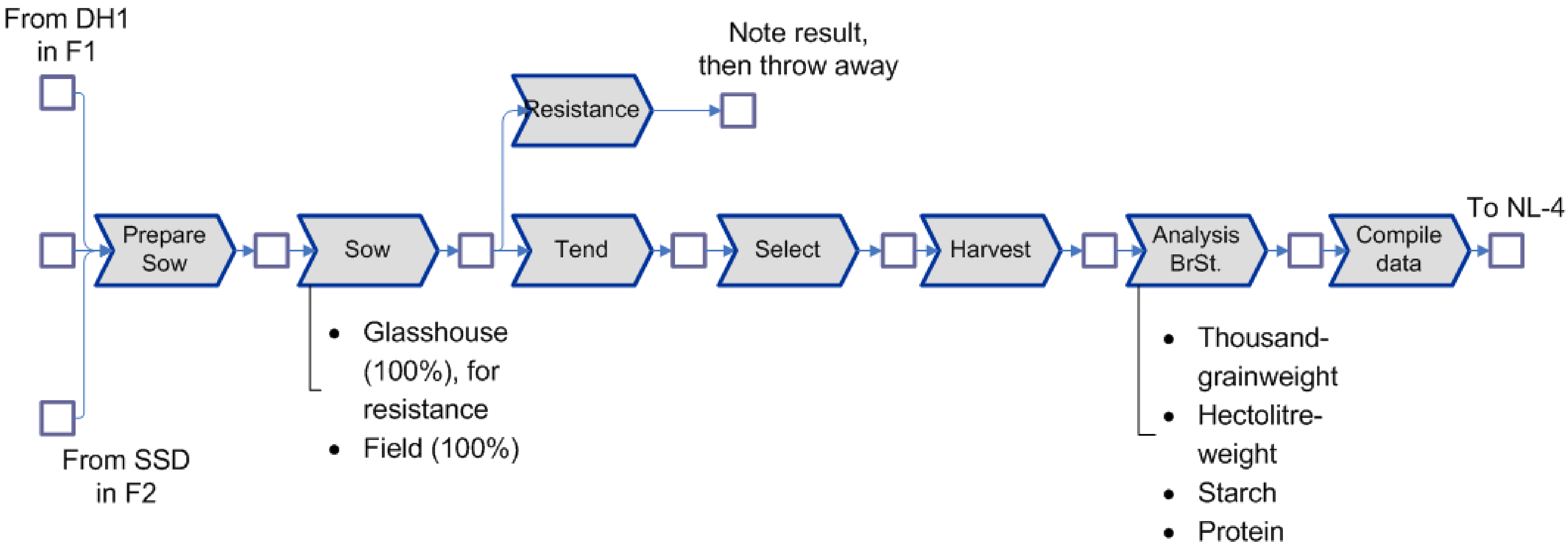


Figure Appendix II. 9 F5

Appendix II, The BREED process; all levels of detail

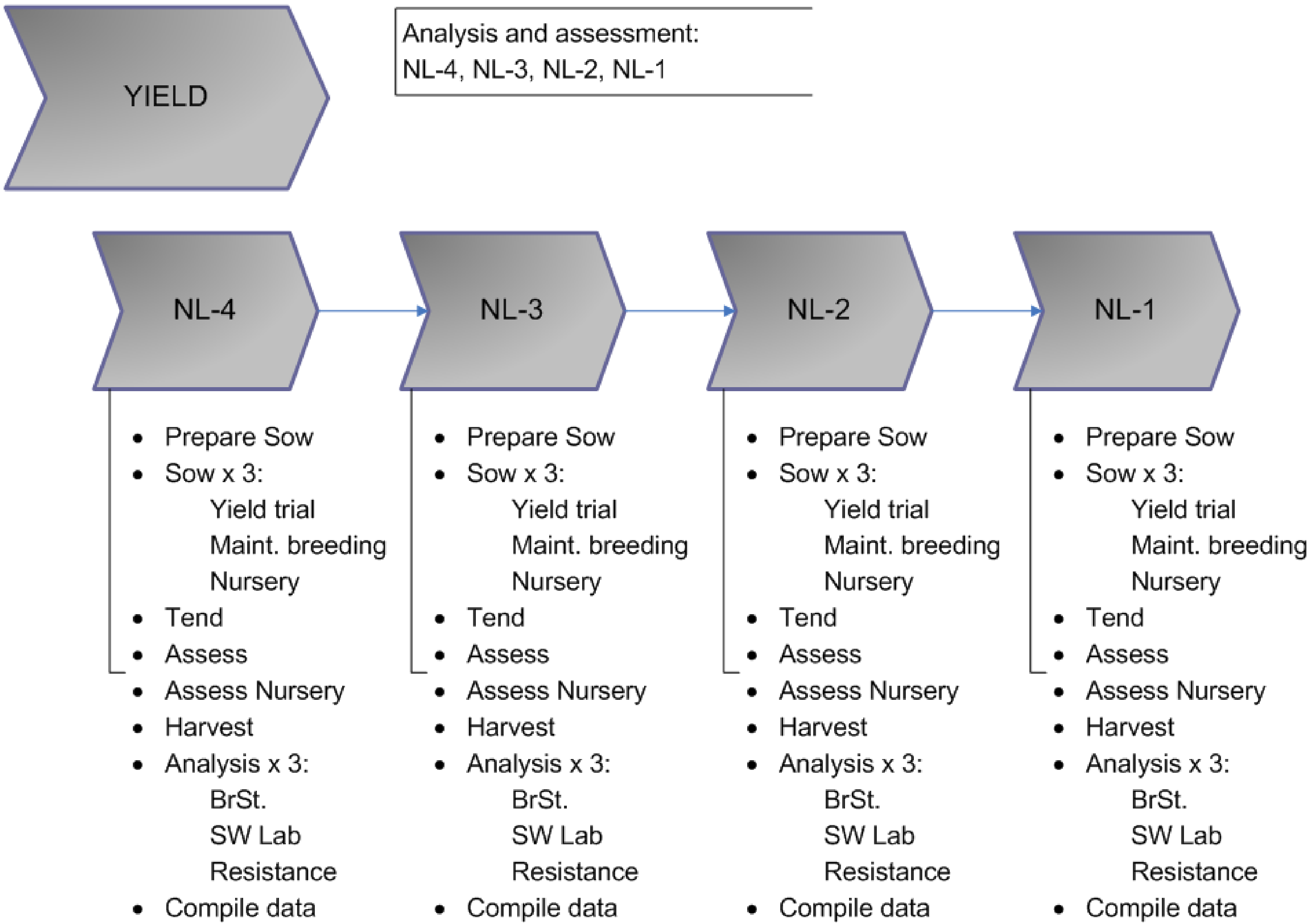


Figure Appendix II. 10 Yield stage

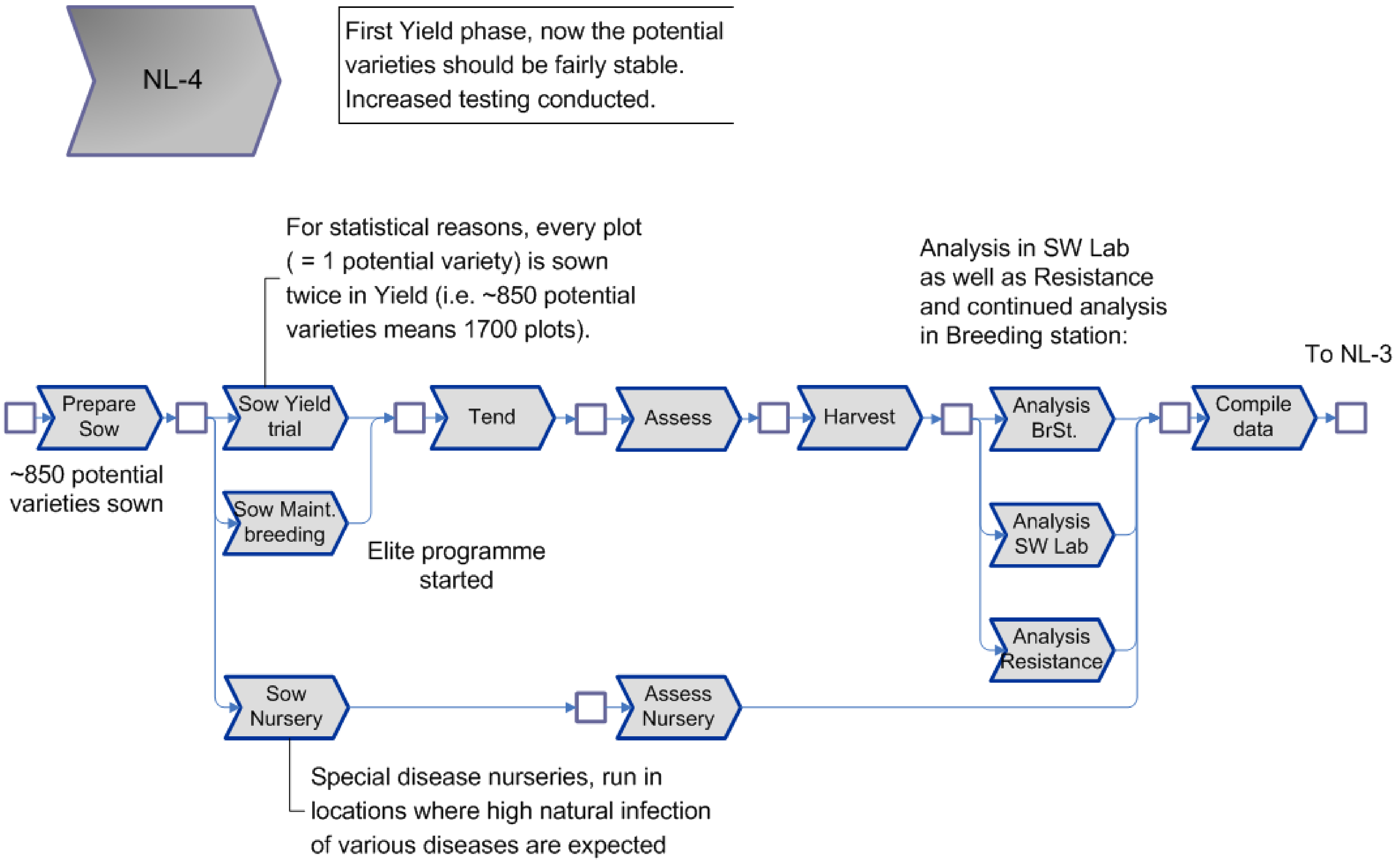


Figure Appendix II. 11 NL-4

Appendix II, The BREED process; all levels of detail

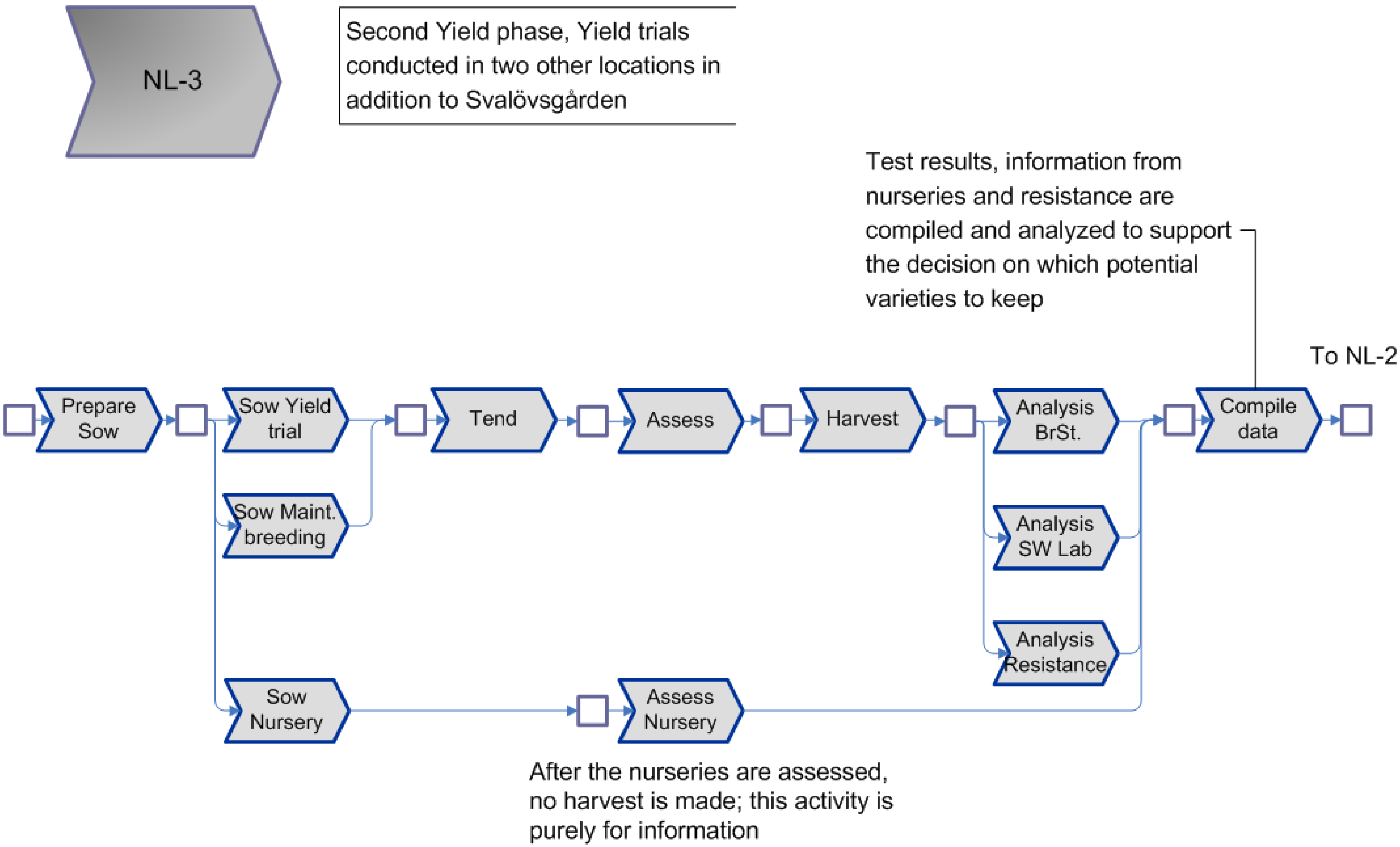
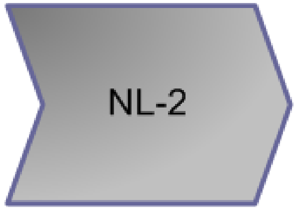


Figure Appendix II. 12 NL-3



Third Yield phase, now Yield trials in other locations are increased to eight.

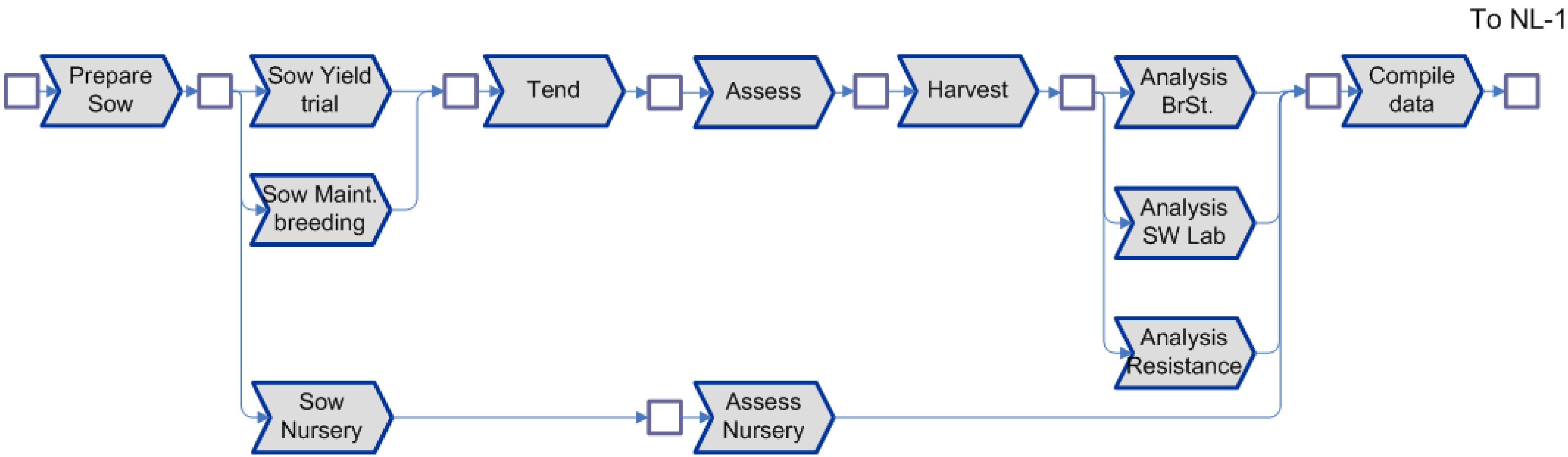


Figure Appendix II. 13 NL-2

Appendix II, The BREED process; all levels of detail

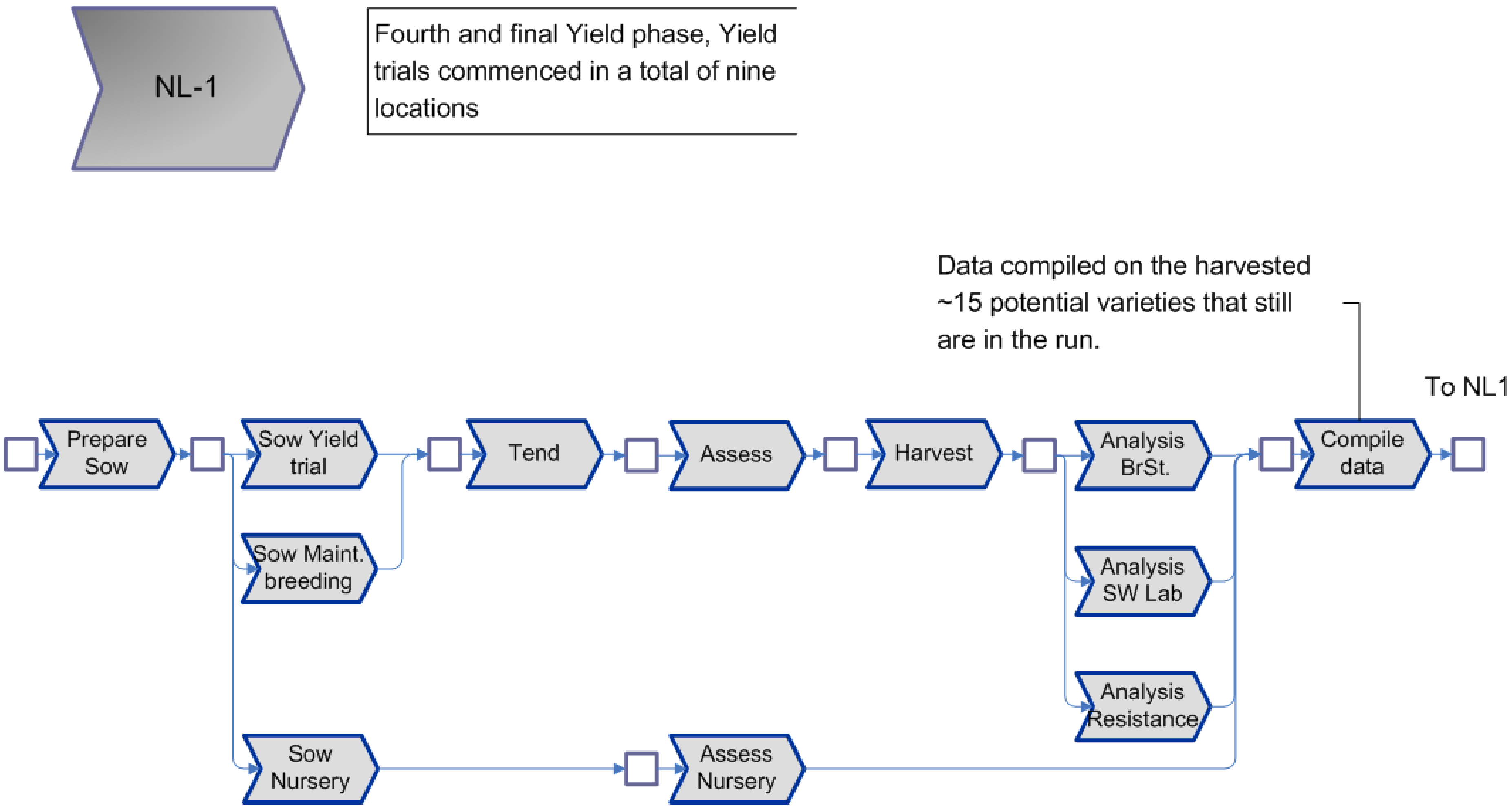


Figure Appendix II. 14 NL-1

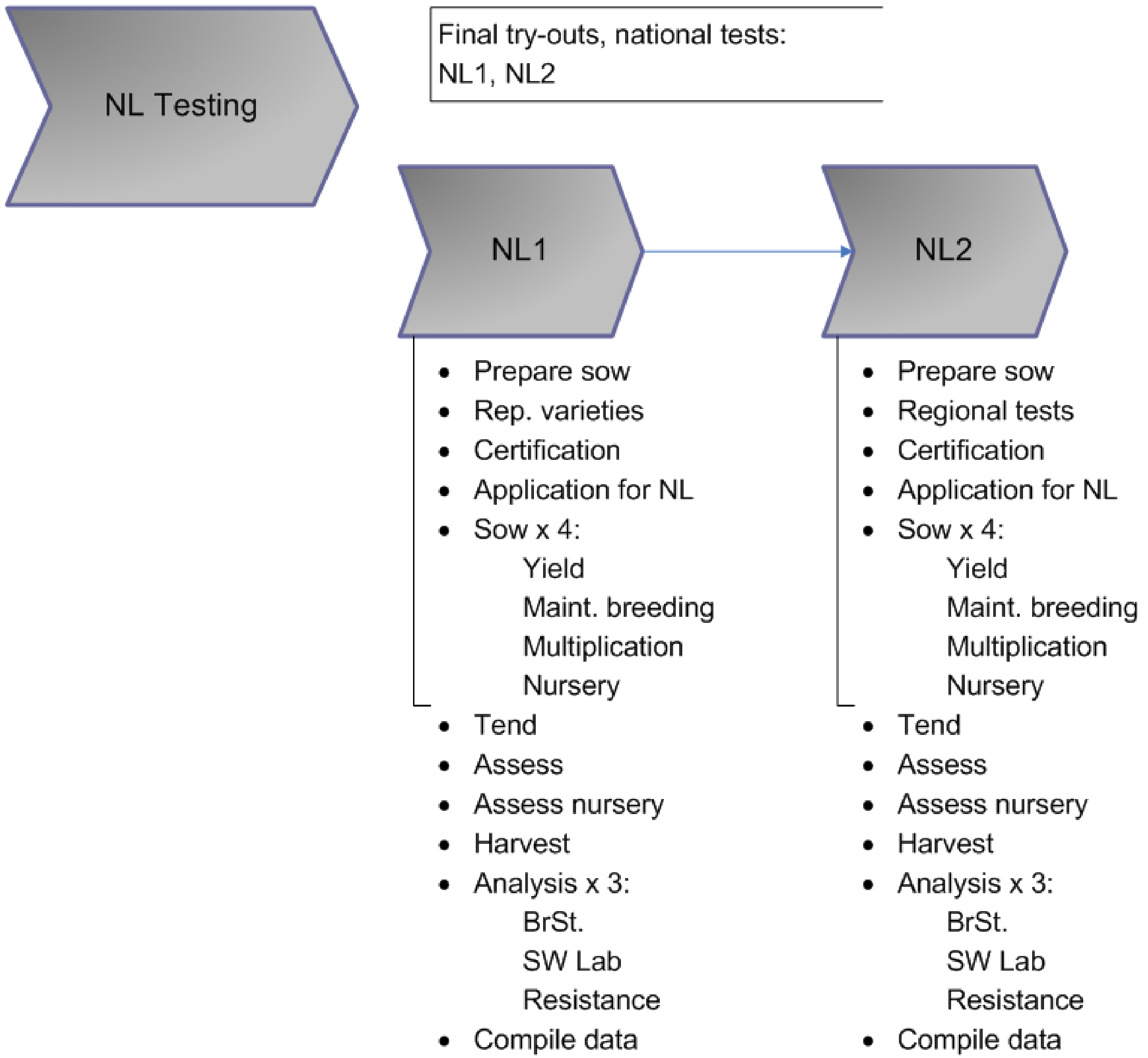


Figure Appendix II. 15 NL Testing

Appendix II, The BREED process; all levels of detail

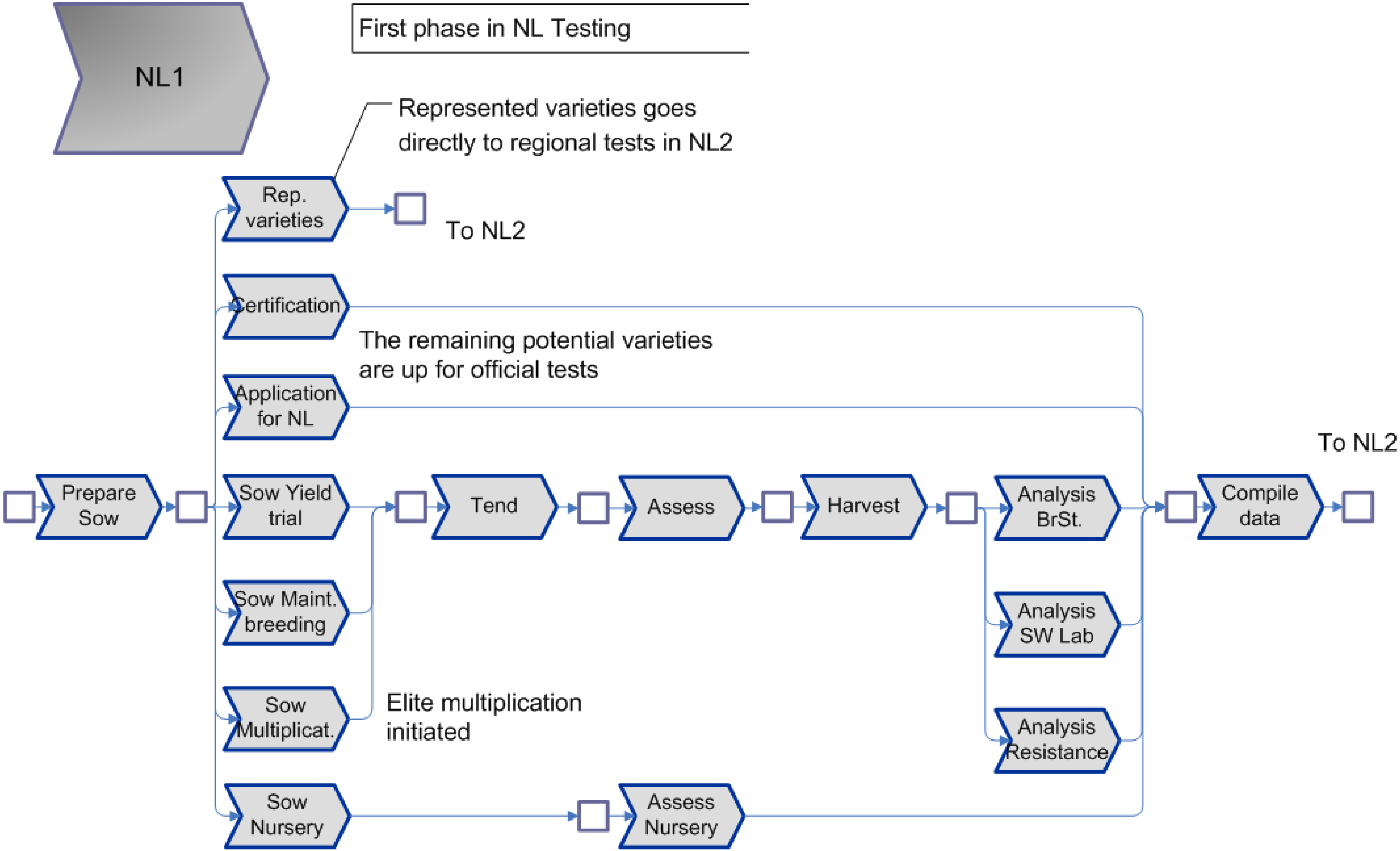


Figure Appendix II. 16 NL1

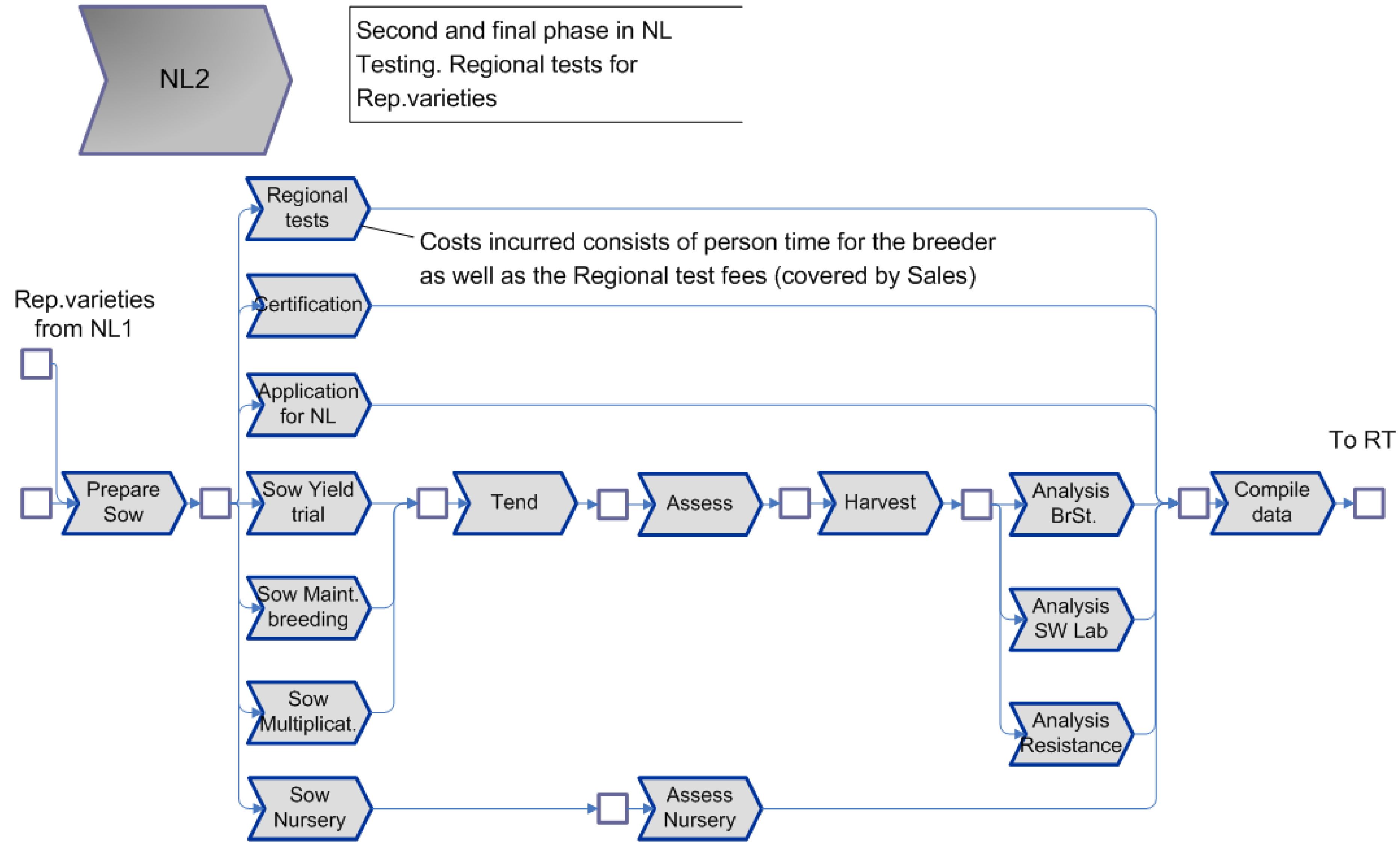


Figure Appendix II. 17 NL2

Appendix II, The BREED process; all levels of detail

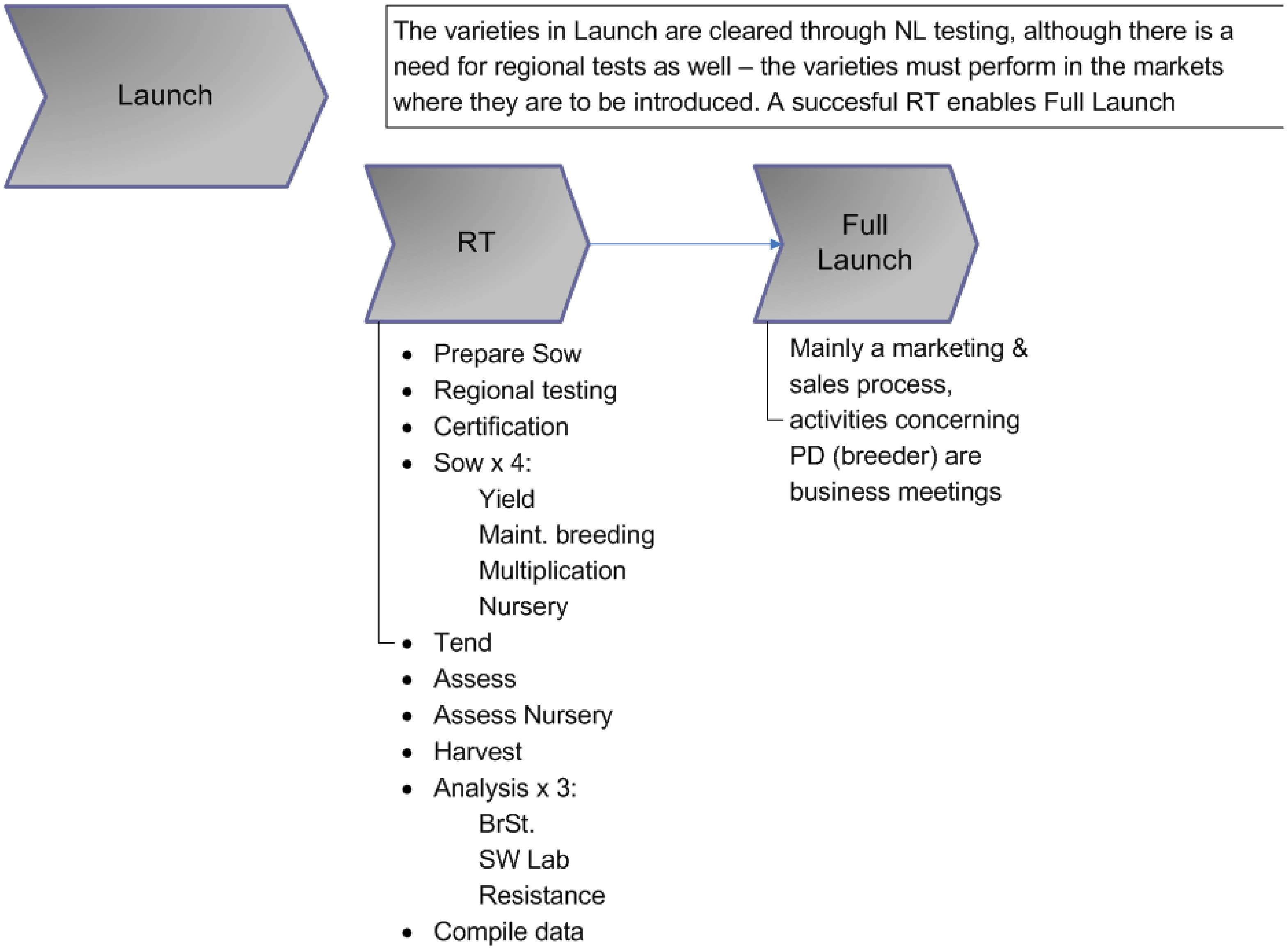


Figure Appendix II. 18 Launch

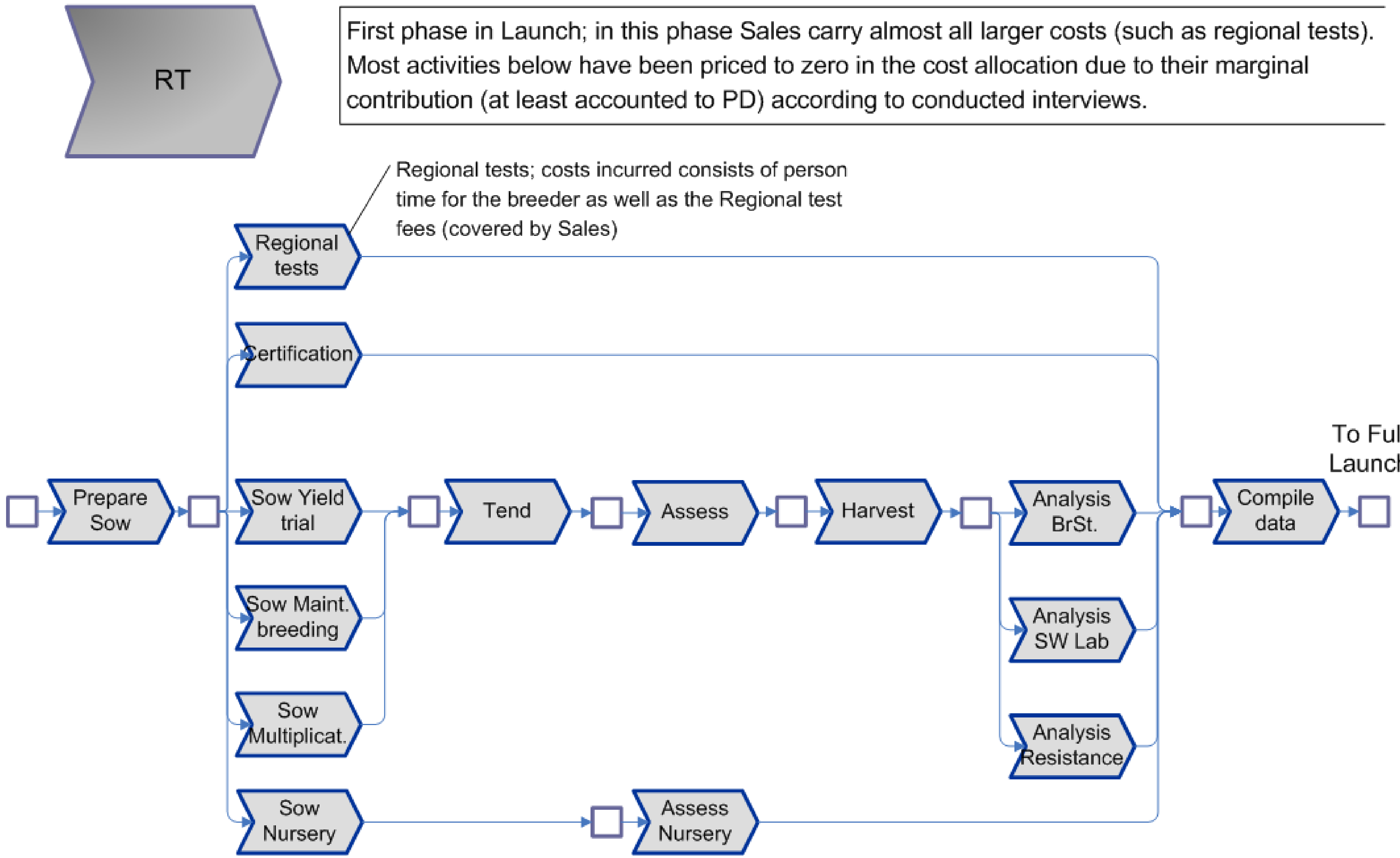
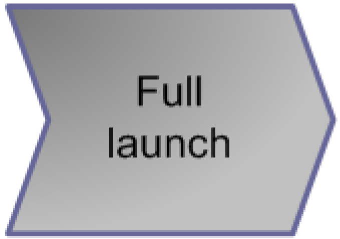


Figure Appendix II. 19 RT



The second and final phase of the Launch stage. The activities concerning Launch are mainly run by marketing and sales, leaving little room for contribution by PD. However, costs (personnel time for breeder) have been allocated here; these costs might be more correctly viewed as a supporting process (and an indirect cost)

Figure Appendix II. 20 Full launch

Appendix III

			Januari				Februari					Mars				April				Maj				Juni				Juli
	Arbetsuppgift	mandagar	v.1	v.2	v.3	v.4	v.5	v.6	v.7	v.8	v.9	v.10	v.11	v.12	v.13	v.14	v.15	v.16	v.17	v.18	v.19	v.20	v.21	v.22	v.23	v.24	v.25	v.26
KJL	datasystem, underhåll, utvekl	23	2				2					2				2				2								
KJL	etk o påsar utskrift	6				2	2	2																				
KJL	fältböcker, utskrift	8					2	2	2	2																		
KJL	graderingar	31																						1	1	1	1	3
KJL	försöksdatabearbetning	18																										
RHE	arbetsledning				1							1		1		1	1	1	1	1	1	1	1	1	1	1	1	1
RHE	uppvägning försök/förökningar	60																										
RHE	sådd	60																										
RHE	ogräsbek	3																1										
RHE	fältunderhåll	27													2	2	2	1	1	2	2	2				2	2	1
RHE+ABL	sticksättning, etk	32																				5	5	10	10			2
RHEtillägg	höjdmätning,graderingar	45																								5	5	5
RHE	tröskning	120																						10				
RHE	fälttransporter	8																										
RHE	torkning	12																										
RHE	rensning	45																										
RHE	analys, hlv, tkv, Corona	65																										
RHE	utskick	15																										
RHE	slopning/lagerhållning	35	2		2															5	5	5						
RHE	maskinunderhåll etc	15		3				3					3															
BTU	byggnader och arb miljö	20				2					2				2				2				2				2	
ABL+RHE	ladda magasin	105																										
ABL	skörd korsningar	0																										
ABL	tröskning	80																								5	5	5
ABL+RHE	ax/plant skörd fält	215																										
ABL	lagerhållning/slopning	8	1														1				1				1			
ABL	isolat underhåll/uppförökning	8		1												1				1				1				1
ABL	växthus tillsyn/vattning	3			1														1				1					
ABL	Växthustester	109	5			5	5	5	5	5	5	5	5	4	5													
ABL	Plantering i växthus	20		10	10																							
ABL	Fusarium, förökning av inokulum	3									1	1	1															
ABL	Korsningar i vxh	30															10	10	10									
ABL	Skörd i vxh	30																						10	10	10		
ABL	Korsningar, fält	45																									15	15
ABL	Sådd av vxh-generationerna	15																										
ABL	Urval i brätten	6																										
AWI	Ladda magasin	15																										
AWI	Sticksättning	10																						5	5			
AWI	Fältbesiktning	15																								5	5	1
AWI	Dra Ö.skjutare	18																										3
AWI	Urval	10																										
AWI	Skörda ax/pl	9																										
AWI	Skära 500ax	2																										
AWI	Tröska fält	2																										
AWI	Klippa falltal	3																										
AWI	Tröska inne	6																										
AWI	Mtrl till SUK	4																										
tillägg	behandling/sammanställning																											
		0																										
	Summa mandagar	1 485	10	14	14	9	11	12	7	7	8	9	9	5	9	6	14	13	15	11	9	13	9	38	28	29	36	37

						Aug				Sep				Okt					Nov				Dec				
	Arbetsuppgift	v.27	v.28	v.29	v.30	v.31	v.32	v.33	v.34	v.35	v.36	v.37	v.38	v.39	v.40	v.41	v.42	v.43	v.44	v.45	v.46	v.47	v.48	v.49	v.50	v.51	v.52
KJL	datasystem, underhåll, utvekl				5					2				2					2				2				
KJL	etk o påsar utskrift																										
KJL	fältböcker, utskrift																										
KJL	graderingar	3	3	3	3	3	3	3	3																		
KJL	försöksdatabearbetning									3	5	5	5														
RHE	arbetsledning	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	2	2	1	1	1	1	1	1	1	1	1
RHE	uppvägning försök/förökningar										20	20	20														
RHE	sådd											20	20	10	10												
RHE	ogräsbek																	2									
RHE	fältunderhåll	1	1	1	1	1	1	1	1																		
RHE+ABL	sticksättning, etk																										
RHEtillägg	höjdmätning,graderingar	10	5	5	5	5																					
RHE	tröskning					20	30	30	30																		
RHE	fälttransporter					2	2	2	2																		
RHE	torkning					2	2	2	2	2	2																
RHE	rensning										10	10	10	10			5										
RHE	analys, hlv, tkv, Corona							10	10	10	10			5		5		5		5		5					
RHE	utskick								5	5	5																
RHE	slopning/lagerhållning																	5		5		2		2		2	
RHE	maskinunderhåll etc																				3				3		
BTU	byggnader och arb miljö												2					2				2				2	
ABL+RHE	ladda magasin			10	10				10	10	10	20	20	15													
ABL	skörd korsningar																										
ABL	tröskning					10	15	15	15	10																	
ABL+RHE	ax/plant skörd fält				40	45	40	45	45																		
ABL	lagerhållning/slopning	1				1				1				1													
ABL	isolat underhåll/uppförökning				1				1				1														
ABL	växthus tillsyn/vattning																										
ABL	Växthustester															5	5	5	5	5	5	5	5	5	5	5	
ABL	Plantering i växthus																										
ABL	Fusarium, förökning av inokulum																										
ABL	Korsningar i vxh																										
ABL	Skörd i vxh																										
ABL	Korsningar, fält	15																									
ABL	Sådd av vxh-generationerna											5	5	5													
ABL	Urval i brätten														2	2	2										
AWI	Ladda magasin													3	3	3	3	3									
AWI	Sticksättning																										
AWI	Fältbesiktning	1	1	1	1																						
AWI	Dra Ö.skjutare	3	2	2	2	3	3																				
AWI	Urval		2	2	2	2	2																				
AWI	Skörda ax/pl							5	2	2																	
AWI	Skära 500ax								1	1																	
AWI	Tröska fält								1	1																	
AWI	Klippa falltal								1	1	1																
AWI	Tröska inne											3	3														
AWI	Mtrl till SUK											2	2														
tillägg	behandling/sammanställning																										
	Summa mandagar	35	15	25	71	97	101	116	132	51	66	88	91	54	18	18	17	24	8	16	9	15	8	8	9	10	1

Figure Appendix III. 1 Budget over person days, Breeding station. The areas of responsibilities; KJL=data, RHE=field work, ABL=glasshouse, AWI=elite programme

Appendix IV

The table below shows an example of an in-process metric measuring yield on varieties in the pipeline. This information is gathered today and its importance is well known. An easy compiling and comparable KPI is however not implemented yet.

Yield (above varieties in market)				
	- 0 %	5 -10%	10 – 15%	15% +
NL -4				
NL -3				
NL -2				
NL -1				
NL 1				
NL 2				
RT				

Conclusions:
The early NL selections look weak; an increase in rep. varieties might be needed

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The table below shows an example of an in-process metric, with a top three chart of most important traits to improve (apart from yield) and with there target goals. Information for this KPI could today be found in the strategy report, however not quantified for all traits. If comparing this to figure 5.10, this metric should be a metric in field number one.

Top three traits			
Trait	Present level	Yearly increase	Goal
1. Fusarium			
2. Starch			
3. Septoria			

Conclusions:
The varieties in market have all been affected by Fusarium, causing this to be the number one trait to develop

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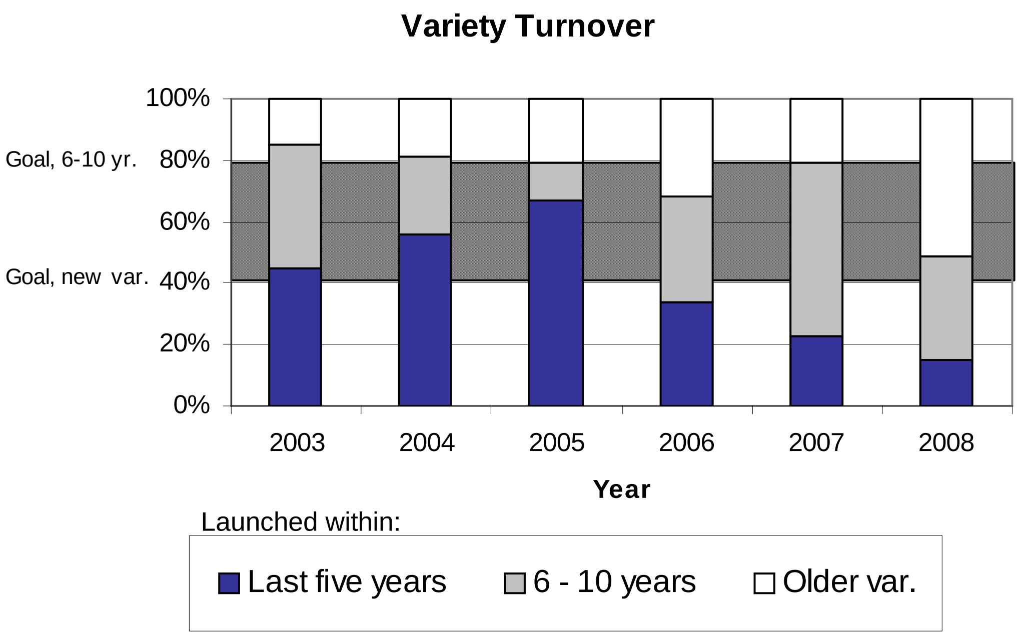
On-budget performance is one suggested KPI that satisfies the organization's demand, measured in each gate and at launch. A similar table can be set up for timeliness.

On-budget performance												
	DCP 2			DCP 3			DCP 4			Launch		
	Bread	Feed	Spec	Bread	Feed	Spec	Bread	Feed	Spec	Bread	Feed	Spec
-94 generation	+20	0	0	+35	-10	0	+85	+5	-	+150	-	-
-95 generation	+35	+15	+10	+75	+20	+10	+105	+30	-	-	+25	-
-97 generation	0	0	0	+15	0	0	+20	+10	0			
-99 generation	-25	-30	-10	-15	-25	0						
-03 generation	-35	-20	-									

Appendix IV, Examples of KPI's and how they could be summarized

The variety turnover, a post-process metric, is at present looked upon, even though target goals aren't set. In the example below, a need for a new variety that succeeds at the market is clear.



Without prioritized markets and segments, the breeder has no goal for the breeding programme. The chart below gives the breeder information of which crosses should be made. The priorities in the chat also gives the percentages of how the crosses should be made (e.g. 34 % of the crosses should be to get feed varieties, preferably with characteristics demanded in Denmark, 24 % for the Swedish feed market where winter hardiness becomes more important).

Segments			
Prio	Market	Present M-share	Goal
34	Dk – feed	45 %	95 %
24	S – feed	45 %	95 %
17	S – bread	45 %	95 %
12	N – feed	25 %	75 %
8	D – feed	25 %	75 %
5	S - special	25 %	75 %
=100