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# Defining Equipment Purchasing Concept for R&D Organisation

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Finally we are here. It has most certainly been an interesting journey. Starting from having no idea of what the subject of my thesis could be and ending with a book to demonstrate of what I have learned.

At the case company, I am grateful for this opportunity to do this thesis and I thank everyone who participated to it either directly or indirectly. I am proud of what I achieved during this time and also a little surprised how smoothly this thesis proceeded. Massive thanks goes to Jukka Sillanpää, my instructor and the Site Quality Manager in the case company, as he deserves special thanks for being not only supportive and instructive, but also for pushing me to reach high; and not to mention his great insight of the topic.

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<p>This thesis explores approaches to purchasing laboratory equipment for an R&amp;D organisation of the case company. The case company is going through a transition due to the ownership change. New testing laboratories are built and new equipment will be purchased to these laboratories. The equipment purchasing process for the R&amp;D organisation of the case company is defined based on the findings from the current state analysis, literature and benchmarking.</p> <p>The purchasing process is described from the perspective of R&amp;D test equipment purchasing that involves test engineers and internal customers. To be able to form more in-depth understanding of the purchasing process, other stakeholders such as Quality Engineering and Supplier Quality are taken into account. The purchasing process is approached through the current state analysis. Best practice was found through literature search and benchmarking, which was done against two other companies that have established their equipment purchasing processes.</p> <p>The current challenges were strongly related to the lack of the process description that would be tailored to the R&amp;D organisation, partly because of the transition process the case company is going through. Therefore, by producing a process description and a workflow accompanied with list of roles and responsibilities of each process step, this study helps to identify the factors of the equipment purchasing process.</p> <p>The visualised conceptual framework helps outlining the purchasing process and the final purchasing concept can be used as a job aid when new test equipment needs to be purchased.</p>	
Keywords	Laboratory equipment, purchasing, vendor selection

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**Acronyms**

AHP	analytical hierarchy process
ASL	Approved Supplier List
ASTM	American Society for Testing and Materials
CAR	Capital Agreement Request or Capital Appropriation Request
CO <sub>2</sub>	Carbon dioxide
ECG	electrocardiogram
EIP	Equipment Investment Process
ERG	Equipment Review Group
ERP	Enterprise Resources Planning
FAR	Fixed Asset Request
FDA	The Food and Drug Administration; an agency within the U.S. Department of Health and Human Services
IQ	Installation Qualification
MOLP	Multiobjective Linear Programming
NDA	Non-disclosure Agreement; a legal contract A contract between the case company and a vendor or vendor that protects the confidential information of one or both parties
OQ	Operational Qualification
PO	Purchase Order
QE	Quality Engineering, Quality Assurance
QPL	Quality Policy
R&D	Research and Development
SSP	Self Service Purchase; a process and method to allow employees to execute certain types of purchases that have no Quality Affect and does not require supplier/vendor set-up.
TCO	Total cost of ownership

## 1 Introduction

Purchasing is usually related to the procurement function in companies which occurs when purchasing materials, equipment or finished goods or services. This thesis explores the approaches to purchasing laboratory test equipment for an R&D organisation which goes through transition due to the ownership change.

Quite often, new equipment is bought in companies independently, by their staff, and often the purchasing process is not clear for those who are usually not involved in procurement directly, and function outside of the procurement activities. Procurement professionals know that there might be several different ways to purchase equipment and there may be more than one established way; but those occasional buyers may not know how to approach this. Moreover, there might not be any guidelines to help with the task. When there is no systematic way of doing purchases, the process becomes time consuming and cost ineffective. It also may result in purchases of low quality items. All this leads to the interest from the case company, which does not have procurement professionals, to develop a concept for the purchasing process to fit its current needs.

### 1.1 Case Company Background

The case company is operating in the medical industry field. It currently employs 40 persons in Finland of which there are 30 persons working with research and development (R&D). In total, the company employs 16 500 people globally. The Finland based R&D team concentrates on supplies and accessories such as ECG leadwires, breathing tubes and filters, and CO<sub>2</sub> absorbers for breathing systems.

The case company's vision is to improve the safety of healthcare equipment as well as lower the cost of healthcare in hospital pharmacy, nursing floor, operating room and patient bedside. The product families include medication and supply dispensing, infusion, ventilators, respiratory diagnostic instruments, interventional procedures, surgical instruments, and skin antiseptic. The latest acquisition widened the portfolio to disposables, or supplies and accessories. This medical equipment is typically used with one patient only in the hospital operating room, intensive care

unit or emergency room, but there also can be reusable equipment which may require, for example, sterilisation. Typically the disposables are used together with anaesthesia machines and patient monitors.

R&D team's task is to develop new products as well as ensure the installed base by for example continuous improvements and responding to functional customer complaints. In case of these functional customer complaints, there often are tests to be performed to find out the reason for malfunctioning. The tests may include functional testing simulating the actual usage of the product or other tests such as locating the source of malfunctioning. The tests that are performed within new product development vary vastly and can be, for example lifetime tests in humid conditions or material testing such as pull tests. Improvements to the products may come as result from customer complaint but also they are natural steps in the product's life cycle. The customers in this context are the end users, for example hospitals. The other way to see customer is the customer of the laboratory services and those customers are R&D projects. Usually the tests are defined by industry standards.

## 1.2 Business Context

The case company works in the field where new product development follows tight design control procedures which are part of quality management system. The quality management system is a collection of policies and procedures of how to execute business. In this field, quality management system refers to various standards, such as ISO 15223 or IEC 60601-1, which give the precepts for medical equipment.

When new product is under development, the new design has to be verified and validated. Design verification ensures that the product is built according to the requirements defined in product specifications and it meets the user requirements. Design validation evaluates whether the product is performing as it is intended. Verification and validation activities are part of the quality management system. Especially verification activities usually require a set of tests defined by standards. These tests are performed in R&D laboratories. The tests may be functional tests to see that the product performs as intended or they may be checking something, for example if the intended material is compatible with manufacturing processes. The tests may be done to prototypes or finished new design. The validation activities are usually done in the environment the product is used in.

R&D laboratories also perform the tests after improvements to the currently sold products. These tests also follow the design verification procedures but they may be performed to explore new ideas such as new design or changed material to check if it performs the same way or better than the currently used material. Thus, there are multiple needs for R&D laboratories, one of which is to acquire the equipment to fit to the needs of various testing environments.

### 1.3 Business Challenge

Presently, the R&D team of the case company is in transition phase and moving to the new premises. As a result, it needs to build three new laboratories for product development and testing purposes: gas laboratory, electrical laboratory and technical/prototyping laboratory. These laboratories require among other things a multitude of new equipment to be purchased and installed. In the future, new equipment is needed when existing laboratories are updated or expanded. Currently, however, there is no systematic way for new equipment purchasing which makes it time consuming and cost ineffective.

Purchasing anything can be difficult if one does not know what to purchase and how to do it. This applies when purchasing everyday items for everyday life but also when purchasing professionally, for example, laboratory equipment. When mistakes are made in everyday purchases, the outcome often is not very drastic because the items are consumables and relatively cheap. But when purchasing equipment, the amount of money to be used is considerably more and the equipment is expected to be in use for much longer than everyday items, for years or even decades. The investment for most expensive equipment can be tens of thousands of euros and other costs such as training, validation, installation, maintenance and calibration services also ought to be considered. If a mistake happens, for example a wrong type of equipment is bought; the whole R&D laboratory can get paralysed because certain tests cannot be done and product development suffers, and in the worst case scenario, a new piece of equipment cannot be purchased. There are also other things to consider when purchasing equipment, such as delivery times and warranty periods. In total, the equipment purchasing appears as not an easy and simple task.

#### 1.4 Objective and Outcome

The objective of this thesis is to establish, on a conceptual level, the way of systematic laboratory equipment purchasing in R&D organisation. The expected outcome of this study is the description and guidelines of this new equipment purchasing concept, specifying what factors ought to be considered and how the purchasing should be carried out on a conceptual level.

The scope of the study includes the purchasing process for laboratory equipment for R&D laboratories. The training, equipment validation, installation, maintenance and calibration are left out of its scope as well as other equipment purchasing. This is because the purchasing concept itself is wide enough for one study and adding other areas of purchasing to this thesis would increase it to massive proportions.

In R&D laboratories, there is a wide range of equipment to be purchased including the wet area testing equipment, anaesthesia machines, fume hood and other testing equipment. There also are different types of bottled gases such as oxygen and carbon monoxide, and the gases that are used when putting a patient in hospital operating rooms under anaesthesia. The laboratories are also used to test numerous kinds of products that are usually connected to patient ventilation but not limited to it. To address these multiple purchasing needs, this study is commenced.

This study is performed by analysing the current equipment purchasing process in the case company as well as exploring purchasing practices in general. Equipment that the company is planning to purchase is inventoried, and the important equipment selection and performance criteria are analysed based on the key internal stakeholders' opinion. Data for benchmarking is collected from other companies than the case company. This is done before gathering the existing knowledge in order to get insight of what kind of questions should be asked from the interviewees. The existing knowledge is gathered by interviewing experts and exploring the company specific processes and procedures. The theory of purchasing practices in general is searched from literature. When discussing these topics, the equipment performance criteria are based on the view of internal key stakeholders.

This study is written in seven (7) sections based on logic that answers the following questions: what is the problem, how does it occur, what can be done with it and how was it solved: Section 1, Introduction, gives background information and overview of

this thesis. Section 2, Method and material, explains how this research is done. Section 3, Current state analysis, clarifies the current purchasing practices and challenges in case context. Section 4, Best Practice of Professional Equipment Purchasing, dives into different purchasing practices in general and suggests conceptual framework based on them. Section 5, Building laboratory equipment purchasing concept, explores the conceptual framework and proposes purchasing concept for the case company. Section 6, Utilising Proposed Concept, shows how the proposed purchasing concept works in a real-life situation by testing it in one pilot case. Section 7, Discussion and Conclusions, summarises the study and ponders its reliability.

## 2 Method and Material

This section presents the research method and material that utilised in this study. Firstly, the research approach and research design are described. Secondly, the data collection and analysis methods are overviewed after which the reliability and validity plan of the study is explained.

### 2.1 Research Approach

When choosing the research approach, it is best to choose an approach that works for the problem at hand and takes into consideration the context of a given challenge. Every approach has its strengths and weaknesses. (Denscombe 2010:163.) For this study, the case study approach is selected because of empirical nature of the study and its high dependence of its specific context: for example internal company specific documentation.

A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and the context are not clearly evident. In this study, the unit of analysis refers to equipment purchasing process which starts from the need for new equipment and ends to receiving and installing the equipment. The case study inquiry copes with the technically distinctive situation in which there will be many variables of interest that data points and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis. (Yin 2003: 13-14.)

According to Gillham (2010), a case study investigates a phenomenon to answer a specific research question and seeks a variety of evidence to support the answer. There are various dimensions for the case study: qualitative, quantitative, exploratory, explanatory, multiple case study and other dimensions. The research question of this study is that how the testing equipment should be purchased to the R&D laboratories. This study concentrates on the qualitative methods for data collection and analysis because the data targeted is difficult or even impossible to obtain, measure

and compile as statistics, as is done in quantitative methods. Qualitative methods concentrate on evidence that help understanding the meaning of what is going on, for example, the input from the interviewees and as such fit into this study (Gillham 2010: 10).

Gillham (2010) also suggests that one source for evidence is not sufficient but using multiple sources is a key characteristic of case study. Therefore, the approach utilised in this study aimed at triangulating the sources i.e. by interviewing several people, employing observation and reviewing the company specific documentation. This study fulfils these case study characteristics by answering questions such as *who, what, when, how* and *why*. Therefore this study is also started with empirical inquiry instead of the literature review to avoid a possible distortion of perspective and manipulating the interviewees by leading questions which might have otherwise appeared. This is visible in the research design of the study which is described in the next sub-section.

## 2.2 Research Design

The research design of this study is illustrated in Figure 1. This illustration shows the steps that are taken within this study and presents the outcome of each step. It also points out the data collection stages.

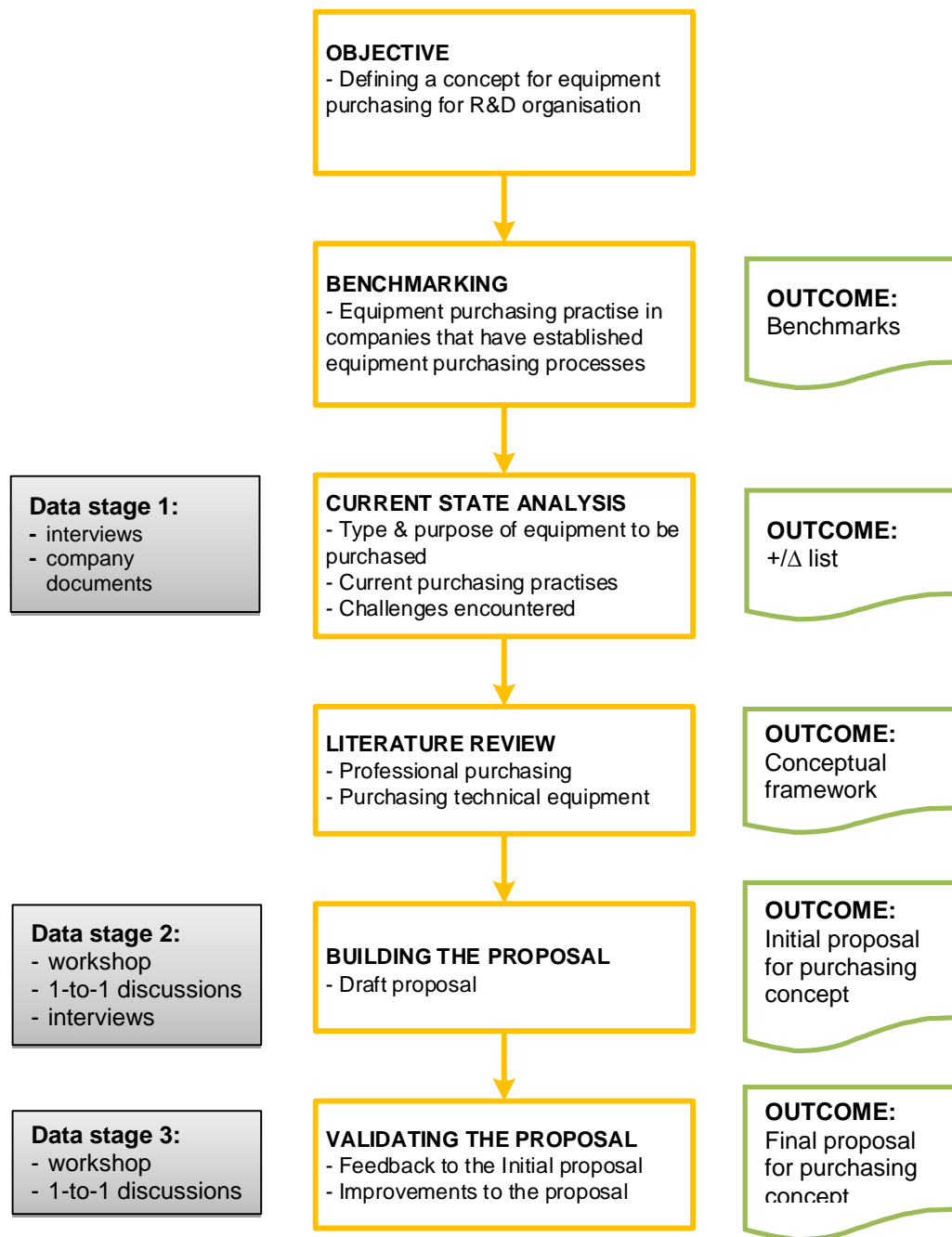


Figure 1, Research design and outcome of each step.

As seen from Figure 1, this study aims to build a solid concept for equipment purchasing in R&D organisation. Before conducting the current state analysis, benchmarking is done in order to find out how others do the equipment purchasing activities. Current state analysis is conducted at the start to map how the purchasing of equipment currently takes place in the case company. Outcome of this stage is the “pros and cons” list, i.e. the findings indicating what is evaluated as good with the current practices and could be retained; and what needs further development. After

the current state is mapped, the foundations for good practice are searched in in the literature review.

The best practice for purchasing is found in the literature and is exercised by excellent companies as well as it has been analysed by excellent researchers. Based on the best practice and findings in the current state analysis, the first version of the proposal is built. The first proposal is then validated in workshops and discussions with the internal key stake holders and internal customers (R&D engineers) as well as the management. The proposal is subsequently revised according to the feedback and the final proposal of the purchasing concept is defined.

### 2.3 Data Collection and Analysis

This study used a number of data sources utilised in three rounds of data collections: Data 1, Current state; Data 2, Proposal building, and Data 3, Proposal validation.

The data collection rounds included different focus groups as can be seen in Table 1, 2, 3 and 4. This is because different functions had their specific view over the current ways of purchasing equipment and the assumption was that each type of function sees the purchasing from different angle than other functions, and therefore the multiple data collection rounds ensure that the whole picture is formed.

To get an insight of how others practice equipment purchasing, professionals from other companies were interviewed. The interviewees were chosen based on their functions in their companies and also because these companies were known to have established ways for equipment purchasing (Table 1). Data for benchmarking was collected before Data 1 because they gave insight and hunch where to take the Data 1 interviews. The data collection order was decided in the beginning of the study based on the researchers urge to understand the practical side of equipment purchasing.

Figure 1 shows the details of data collection used for benchmarking the purchasing processes in two external companies.

Table 1, Data collection for benchmarking.

Participants	Data Stage	Date and Duration	Documented as	Topics Discussed
Equipment Control Manager	Benchmarking	18.2.2015 1,5 h	Field notes (appendix 1)	<ol style="list-style-type: none"> <li>1. Description and illustration of current equipment purchasing process</li> <li>2. Strengths of current equipment purchasing process</li> <li>3. Weaknesses of current equipment purchasing process</li> <li>4. Summary of strengths and weaknesses of current state</li> <li>5. Improvement opportunities.</li> </ol>
Buyer of Incoming Goods	Benchmarking	18.2.2015 30 min	Field notes (appendix 1)	<ol style="list-style-type: none"> <li>1. Description and illustration of current equipment purchasing process</li> <li>2. Strengths of current equipment purchasing process</li> <li>3. Weaknesses of current equipment purchasing process</li> <li>4. Summary of strengths and weaknesses of current state</li> <li>5. Improvement opportunities.</li> </ol>
Clean Room Manager	Benchmarking	19.2.2015 30 min	Field notes (appendix 1)	<ol style="list-style-type: none"> <li>1. Description and illustration of current equipment purchasing process</li> <li>2. Strengths of current equipment purchasing process</li> <li>3. Weaknesses of current equipment purchasing process</li> <li>4. Summary of strengths and weaknesses of current state</li> <li>5. Improvement opportunities.</li> </ol>

Table 1 shows the topics that were discussed to benchmark purchasing processes. The four themes were basically the same as in current state analysis (Table 2). The original questions were formalised in a way that they could be utilised in both benchmarking and Data 1, but at that time it was not quite clear yet whether they actually could be used for Data 1 as well. Once the questions were used in benchmarking interviews, it became obvious they can be used in Data 1 too.

The interviews were conducted face-to-face in Finnish language, recorded and transcript, and translated into English for the field notes. The questions were sent to the interviewees beforehand and field notes were checked afterwards by them before utilising in this study. The questions and field notes are documented in Appendix 1. Data 1 collection details are in Table 2. In this collection round, the focus is in current state of equipment purchasing in the case company.

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Table 2, Data 1 collection.

Participants	Data Stage	Date and Duration	Documented as	Topics Discussed
Principal R&D Engineer	Data 1a	25.02.2015 15 min	Field notes (appendix 2)	Description and illustration of current equipment purchasing process
Principal R&D Engineer	Data 1b	05.03.2015 1 h	Field notes (appendix 2)	<ol style="list-style-type: none"> <li>1. Description and illustration of current equipment purchasing process</li> <li>2. Strengths of current equipment purchasing process</li> <li>3. Weaknesses of current equipment purchasing process</li> <li>4. Summary of strengths and weaknesses of current state</li> </ol>
Engineering Director	Data 1c	11.03.2015 1 h	Field notes (appendix 2)	<ol style="list-style-type: none"> <li>1. Description and illustration of current equipment purchasing process</li> <li>2. Strengths of current equipment purchasing process</li> <li>3. Weaknesses of current equipment purchasing process</li> <li>4. Summary of strengths and weaknesses of current state</li> </ol>
Sr Specialist, Customer Order Management	Data 1d	12.03.2015 15 min	Field notes (appendix 2)	Description and illustration of current equipment purchasing process
Principal R&D Engineer	Data 1e	13.03.2015 15 min	Field notes (appendix 2)	Description and illustration of current equipment purchasing process
Site Quality Manager	Data 1f	17.3.2015 1 h	Field notes (appendix 2)	<ol style="list-style-type: none"> <li>1. Strengths of current equipment purchasing process</li> <li>2. Weaknesses of current equipment purchasing process</li> <li>3. Summary of strengths and weaknesses of current state</li> </ol>

As seen in Table 2, six individuals were either interviewed or discussed with to get up-to-date information about current equipment purchasing practice. As some of the individuals were reluctant to participate a formal interview, the discussions were short and put on records as short notes during and after the discussions. The interviews were conducted in the same manner than the benchmarking interviews and the questions accompanied with field notes are documented in Appendix 2. In addition to the discussions and interviews, case company specific documentation that considered purchasing and sourcing actions was reviewed. In order to maintain the anonymity of the informants, the interviewees were given identification from Informant 1 to Informant 6. For confidentiality reasons, the respondents are neither identified in Tables nor later in this study.

Based on the data collection from the current state, the literature review was done concentrating on the topics relevant to the case company challenges. In this study, this search focused on finding different models and practices to find out how weaknesses of the current state could be overcome. Together, Data 1, literature and benchmarking formed the base for the proposal, which at this point was a draft version of Equipment Purchasing Concept. The proposal draft was presented to the key stake holders to get feedback, which formed Data stage 2. The details of the data collection are in Table 3.

Table 3, Data 2 collection.

Participants	Data Stage	Date and Duration	Documented as	Topics Discussed
Site Quality Manager	Data 2a	17.3.2015 1 h	Field notes (appendix 2)	Building the proposal draft and initial proposal.
1. Principal R&D Engineer 2. Principal R&D Engineer 3. Principal R&D Engineer 4. Supplier Quality 5. Site Quality Manager	Data 2b	16.4.2015 1 h.	Process map with corrections and handwritten field notes	1. Building and testing the proposal draft 2. Summary of strengths and weaknesses of current state
Principal R&D Engineer	Data 2c	16.4.2015 15 min	Process map with corrections and handwritten field notes	1. Building and testing the proposal draft 2. Summary of strengths and weaknesses of current state
Engineering Director	Data 2d	16.4.2015 30 min	Process map with corrections and handwritten field notes	1. Building and testing the proposal draft 2. Summary of strengths and weaknesses of current state

As Table 3 shows, Data 2 collection was done in a workshop with key internal stakeholders and some one-to-one discussions so there were four interactions in total. The workshop was held as a free-format session in which the participants discussed openly about the strengths and weaknesses of the current state as well as the proposal draft, or more specifically the content of the proposal draft and furthermore how to improve it. The participants also provided their suggestions, i.e. what was good in the proposal and what needed improvements or further development. The one-to-one discussions were also free-formed discussions with the proposal draft.

After the proposal draft was refined to the initial proposal, it was presented to the management and quality assurance in order to get feedback to form the final proposal. This presentation imitated implementing and testing the proposal and the ideal would have been testing the concept in real-life situation. Unfortunately there was not one at hand at the time when this part of the study was made. The data collection for data stage 3 is presented in Table 4.

*Table 4, Data 3 collection.*

<b>Participants</b>	<b>Data Stage</b>	<b>Date and Duration</b>	<b>Documented as</b>	<b>Topics Discussed</b>
Site Quality Manager	Data 3a	14.4.2015 20 min	Process map with corrections and handwritten field notes	Building and testing the final concept
Engineering Manager	Data 3b	21.4.2015 30 min	Process map with corrections and handwritten field notes	Building and testing the final concept
1. Principal R&D Engineer 2. Principal R&D Engineer 3. Principal R&D Engineer	Data 3c	22.4.2015 15 min	Process map with corrections and handwritten field notes	Building and testing the final concept
Site Quality Manager	Data 3d	24.4.2015 15 min	Final process map with corrections	Building and testing the final concept

In addition to the interviews, discussions and workshops, the study also utilised the results of observations and the analysis of the internal documents. Grouped details of the internal documents are given below in Table 5. About 350 pages of company documents were reviewed in order to get thorough understanding of company policy for purchasing equipment. The complete and detailed list of the reviewed documents is in Appendix 3.

Table 5, Case company internal documentation groups.

Group	Description
A	Decision trees
B	Forms and instructions
C	Guideline Documents
D	Job aids
E	Lists
F	Procedures
G	Process descriptions
H	Records
I	Standard work instructions
J	Standard operating procedures

In addition reviewing the documents listed in Table 5 above, a synopsis was written about how the purchasing should be done according to the company policy. The current ways of purchasing were then reflected to the company policy and strengths and weaknesses pointed out. The analysis of the data was done by comparing the practices from the available knowledge to the company publications. The qualitative data was analysed by using the Content Analysis method.

The observations were gathered from researcher's own experiences when purchasing equipment for the case company.

#### 2.4 Validity and Reliability Plan

When producing an academic study, the reliability and validity of the research have to be evaluated. *Validity* of the study means an estimation of how well the study measured what it is supposed to measure and whether the results are consistent with the goals and done with the suitable tools. Therefore the research questions and methods have to be connected to the outcome of the study. (Jha 2008: 100-111.)

Since the research method chosen to this study is qualitative case study, the research interviews, observations and company specific purchasing documentation help in understanding and mapping the current situation in the case company. Informal and semi-structured conversations and interviews consist of list of themes and questions to be covered and they are discussed in informal conversation. The questions also may vary from interview to interview especially when there is a

change to explore the research questions and objectives in more details or depending on the expertise of the interviewee. The order of questions also can vary depending on the flow of the conversations. As the research questions reflect the reality of the time they are collected, this method is not necessarily repeatable. (Saunders et al, 2007: 320-323, 327-328.) To prove the validity of this research, the outcome of this research matches with the objective of the study. As for validity, the process from Data 2 to the outcome is transparently and explicitly reported.

*Reliability* of the study describes the consistency of the study and whether it can be repeated. Especially when there are only few key informants where the analysis is based, the reliability can be compromised. (Quinton & Smallbone, 2006:129-131.) There are only few key informants in this study, so various data sources are used: company specific internal documentation, interviews, benchmarking, workshops and discussions with multiple stakeholders. The proposed solution details are discussed in point by point with relevant parties.

Reliability in non-structured interviews is also related to issues of bias. Firstly, there may be bias from the interviewer when the comments, tone or non-verbal behaviour may affect the responses. This may occur for example when interviewee imposes his own beliefs or in the way how he construes the responses. Secondly, there may be bias related to interviewee when the bias may be caused for example by perceptions about the interviewer. Third kind of bias may occur when there is a lack of willingness of key persons to participate. (Saunders et al, 2007: 326-327.) The issue of bias is tackled in this study by asking same questions from all interviewees, recording the entire interviews and conducting the interviews before the literature review.

The interviews are transcript and added to this study. In addition to the key stakeholders, other functions beside of R&D engineering are also interviewed. These functions include Quality Assurance, Supplier Quality and Customer Order Management. The observations that are made during this study are documented in logs.

### 3 Current State Analysis

This section discusses the results of the current state of equipment purchasing in the case company, and more specifically within its R&D organisation. It is based on the findings from interviewing those R&D engineers that currently purchase equipment as well as key internal stakeholders, and it is also based on the company internal documents. Firstly, this section explains the types of equipment need, which makes a vast selection of equipment to be purchased, with some of it already purchased. Secondly, this section analyses the current purchasing practices. Since there is no existing process, the current state is explained in detail in order to have a comprehensive picture of equipment purchasing in the R&D organisation today. Thirdly, this section analyses the strengths and weaknesses in the case context.

#### 3.1 Forthcoming Project: Equipment to Be Purchased

The case company is a big, international organisation with an R&D department in Finland. Since the company is going through a transition state (new premises and new owner) during this study and building complete new R&D laboratories, there is a vast selection of test equipment to be purchased. The equipment purchasing is done by four of the R&D engineers and because of the transition state, there are no fixed purchasing practices tailored for the Finnish R&D team.

The equipment need is identified by listing the existing equipment database and comparing it to the needs of the R&D team. This is done within team meetings. The type of equipment is defined by exploring previous premises and mapping the needs of R&D team by hallway and email discussions. The populated list of necessary equipment is divided to categories in order to be able to make further decisions about how to proceed. The categorisation is based on the purchasing value or physical dimensions, or if the equipment is so called “quality affect”, so that there are two equipment classes: Type 1 and Type 2. These classes are called *types* from now on in this paper, in order to avoid mixing up the terms between this study and company documentation.

Table 6 clarifies the classification and criteria of these equipment types. The “quality affect” is defined in the internal company documentation and with help of a decision

tree given in that documentation. “Quality affect” means the application of material or service which may directly or indirectly impact the quality of products and/or Quality System if the case company. Typically “quality affect” equipment is used for verification and validation activities and records are kept of their calibration and maintenance.

*Table 6, The equipment to be purchased divided in categories by physical dimension or purchase price.*

Type	Equipment type	Price/size group	Example
1a	Big sized equipment or expensive equipment - quality affect or not - require PO - may require CAR/FAR	≥limit specified in the company (\$ or €) not portable	Microscope, anaesthesia machine, patient monitor, oil bath, material tester, weather chamber
	Medium sized equipment or medium price equipment - quality affect or not - require PO - may require CAR/FAR	≥limit specified in the company (\$ or €) portable	Moisture- and thermometer, scales, flowmeter, ISO Gauges
1b	Small sized or cheap equipment, or tools, quality affect - usually does not require CAR/FAR	<limit specified in the company (\$ or €) portable	Manometer, tape measure
2	Small sized or cheap equipment, or tools, non-quality affect - usually does not require PO, CAR/FAR	<limit specified in the company (\$ or €) tools etc.	Screwdriver, reference thermometer

As can be seen from Table 6, there are three types of Type 1 equipment, from which Type 1a equipment is either big in physical dimensions or big in purchase price. The common factor for them is that usually they are not portable. There are exceptions to this, though: Patient monitors are portable but they are expensive. Anaesthesia machine is movable if it is not connected to the gas lines but they are such in size that they cannot be picked up and carried away not to mention the high purchase price. 1a equipment can be either “quality affect” type equipment or not but because of their price range, they require some kind of investment planning and they may require capital asset request (CAR) or fixed asset request (FAR). Regardless of that, they always require purchase order (PO).

Type 1b equipment is usually portable, as thermometers and flowmeters are, although also they can be desk top models. They also are medium priced. 1b equipment can be, like the 1a equipment, either “quality affect” type or not. Equally, they require some kind of investment planning and they may require CAR and in all cases, they require PO.

Type 2 equipment is usually small in size and low in price, such as tools and small, hand sized thermometers. Type 2 equipment also are not Quality Affect or do not require supplier set-up.

Section 5.2.1 explores the equipment classification in details in relation to the proposed purchasing concept.

### 3.2 Analysis of Current Equipment Purchasing Practice in the Case Company

Majority of the company specific documentation concentrates on purchasing materials, services or manufacturing equipment. They also are made from the main company site point of view and the scope is for the United State premises only. Since this study is made to find out how to purchase laboratory equipment for testing purposes in the Helsinki R&D laboratories, the company guidelines cannot be applied as such at the time being. The lack of overall view of purchasing process came up in all of the discussions with the internal key stake holders as well as when exploring the documentation. For example, the company documentation describe in very details how information is inserted to system and by whom (computer programme called ERP) but does not explain when. The company guidelines are not inclusive either so they give freedom to operate outside of those guidelines. There are many forms and checklists that reference to other forms and checklists that are either obsoleted or non-existent.

After the current process of purchasing was mapped based on company documentation and interviews, it was compressed into an illustrative flowchart by the researcher in order to comprise a full picture of how the equipment is purchased (Figure 2). There were two so called “showstoppers” found in the process. The showstoppers are points where the whole process can stop if not handled.

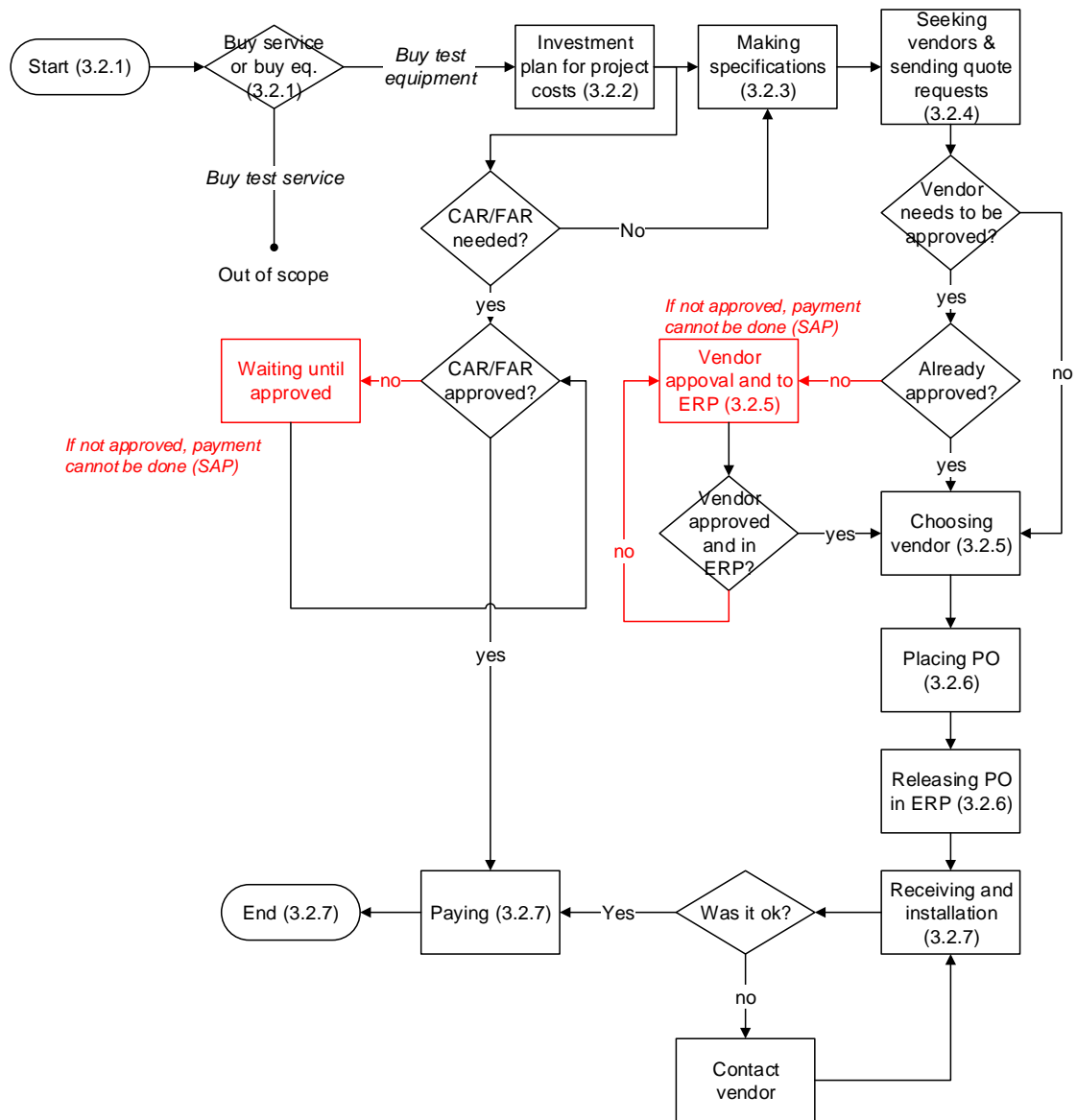


Figure 2, Current way of equipment purchasing. The numbers indicate the subsections where these steps are discussed. The showstoppers are marked with red.

As can be seen from Figure 2, the current purchasing process looks simple. However, it may be simplified too much as explained in details in the following subsections, to which the numbers in Figure 2 refer: each number in the box is a subsection following this section. There are two showstoppers marked in red. Even if the showstoppers are identified, the current process allows proceeding right to the end (paying) without stopping the process. If the showstoppers are not solved at this point, the project encounters problems: the invoices cannot be paid.

As the equipment to be purchased is divided to two categories (1 and 2) based on their value or dimensions, the current purchasing process does not differentiate them. This means that the same process as shown in Figure 2 is used regardless the equipment classification.

### 3.2.1 Starting Point

When the R&D project proceeds, there may become certain need for testing that cannot be performed with the current equipment. When this need occurs, first there is an evaluation whether the test is performed at the case company's R&D laboratories or testing services are purchased. The function that decides how to fulfil these project needs is the engineering director if the decision cannot be made within the project team (Appendix 2: 3). If the decision is, that the testing is done in case company's own premises, new equipment is required and the equipment purchasing process starts.

*“The process starts from, that we know what we want: service or equipment. The need can become due to a project: when it goes further, we think “this kind of thing has to be done” and then we evaluate whether we buy it as a service from somewhere else or do we do it ourselves and from there we continue.”*

(Appendix 2: 2)

Currently, there is no actual “kick-off meeting” or similar to establish the start of the equipment purchasing process. Related to this, there is poor transparency over the project leader or the purchasing team:

*“There is one that has the whole responsibility, project manager, and this person is seeking for vendors and requests quotes and orders [the equipment]. But it can be also so that some people get parts of it i.e. some equipment and deal with the entire process for them and the whole responsibility of the entire project is with the project leader.”*

(Appendix 2: 2)

According to the sources, the project leader can be chosen based on who is available at that point of time. According to the observations, the project leader divides the equipment to other engineers based on their job functions, if there is abundance of equipment to be purchased.

### 3.2.2 Investment Plan for the Project

Once the decision of new equipment purchasing is made, an investment plan is needed. The project leader starts the new equipment purchasing with estimation of how much the whole project costs. This includes every related cost and a Capital Appropriation Request (CAR) or Fixed Asset Request (FAR) is made for this sum of money, i.e. it is an evaluation and justification for each penny used in the project, and of how it would affect the project if the money is not available. Additionally, the future affect for taxation is evaluated. The approvers of the CAR are in high management level. Company guidelines and work instructions define in which situations CAR or FAR is made. For simplification, and because it is the most common case, only "CAR" is used from this point. By definition, "CAR is a document and approval expenditure guidelines per the Corporate Authorisation Policy MAM" (e.g. Appendix 3: E).

*"Bigger investments are done with CAR. Single small purchases are rather done as expenses and each one of them are not done as CAR because of the heaviness of the process. CAR is made by someone that is free in the team at that moment of time. (...) Basically, CAR is an application to the management to commit capital. Assumption is that these kinds of investments have long life. Investments against CAR are added to company assets and their value is re-evaluated annually within removal programme. This is to differentiate the expenses and investments in the book keeping."*

(Appendix 2: 3)

According to the company guidelines, the CAR approval should be waited until proceeding. According to the sources, the practice is that the purchasing process furthers without waiting for the formal approval which may cause problems later: if the CAR is not approved by the time of placing purchase order (PO) in ERP, the PO cannot be placed.

The purchasing team is gathered from R&D and the following roles can be identified: project leader, vendor seeker, quote requestor, purchaser, payer and order follower. These roles are described in detail in Section 3.2.8. Usually there is no specific role distribution but the purchases are divided into smaller entities and one person is responsible for all of the tasks except paying the invoices which are paid by the upper management.

### 3.2.3 Specifying the Equipment to Be Purchased

The one who purchases the equipment is also responsible for checking that the equipment purchased fulfils the specifications. The specifications are made together within the whole R&D team based on the knowledge of what kinds of tests are planned to be done now and in the future.

*“He who orders the equipment also has responsibility over that, so that the equipment is capable of doing what it is supposed to do.”*

(Appendix 2: 2)

The specifications can become from the existing equipment base and new equipment may be updated models of the same or from different vendor. In the end, the information lies within the R&D team and only needs to be gathered. Currently, there is no formal way to gather this information and it can be scattered, for example, within emails, conversations and project plans.

### 3.2.4 Seeking the Suitable Vendors and Requesting the Quote

Vendors are often found from documentation of previous equipment purchases or by conducting specialised searches in the internet. Colleagues may also recommend vendors or equipment for certain types of testing purposes. Sometimes customers can recommend vendors for some specific type of equipment.

Quote request is sent to the best 2-3 candidates that are found. Based on the quotes and additional questions asked from the candidates, one vendor is chosen. When exploring the company documentation, it soon became clear that there is no

systematic way of choosing the vendor and despite of vast selection of document templates, a quote request template could not be localised. The interviews did not reveal such forms either.

### 3.2.5 Choosing and Approving the Vendor

Once the vendor is chosen based on the expertise of the purchaser, the vendor status and classification criteria is checked. According to the company purchasing controls, vendor classification is applied to each vendor at the time of selection to drive controls based on the type of material or service being provided. This classification can be made with help of a decision tree that is described in the purchasing controls. However, this guideline did not describe how the classification is actually done and what the outcome of the classification is and furthermore, what is done with this classification. Other document describes how to evaluate the vendors based on what kinds of material they provide, or whether they affect quality system requirements. There is a decision tree to help with the task and following that decision tree, the conclusion is that it cannot be applied to Helsinki R&D equipment purchasing at the moment this study is made.

According to the company guidelines, the vendors have to be approved and found in ERP system. Approving vendor happens in Helsinki R&D team so that there is a form that is filled in and approved by the local management, and then sent to Global Procurement for further handling.

There also is a decision tree to help to decide whether the purchase can be self-service purchase or not. Self-service purchase is typically something small, Type 2 tools that has no direct or indirect effect on quality systems and can be done with company credit card although it is strongly advised to do all purchases with PO and ERP if possible. Other types of purchases require purchase order (PO) which is clarified in Section 3.2.6.

### 3.2.6 Placing the Purchase Order

Once the vendor is approved, the purchase order can be placed. According to the case company policy, the purchase should be made in the ERP system. Since this

study is made at the transition time, the purchase orders are made manually and attached to the paper invoice afterwards. According to the sources, this is identified as a weakness, because there is a risk to place multiple purchase orders for same event.

Purchase order is a legal document that describes the items or services that are ordered. According to the company policy, all vendors are governed by the terms and conditions contained in the purchase order (PO), unless specified otherwise. The PO should be approved by the engineering management, but the interviews and observations revealed that this did not happen in every case. At the time when this study is made, there is no uniform way to make a PO, for example there are no ready-made forms to use for equipment purchasing but the ones that are found on the company database are considering either components or they are for internal use only. According to the sources, there is no proper guidance of what the purchase order should cover, and furthermore what are the parts of a purchase order. This reflects as a training need for the R&D team.

The purchase orders made by R&D engineers are currently basically the same in content between each other and they are based on the quotes. The quotes are attached to the purchase orders. They consist of the parts of the purchase, for example a microscope, camera and light source are listed in the PO. Services such as installing or training are not included in the POs. According to the sources, some engineers send the POs to their manager for approval but this is not a common practice. This can be identified as another weakness, because if the management is not aware of purchases, how can they have a clear picture of all expenses of the R&D organisation.

### 3.2.7 Receiving the Equipment and Paying the Invoice

When the ordered equipment arrives, it is checked against the purchase order. If the equipment that arrived does not match the PO, the vendor is contacted. Otherwise, the receiving is marked in the Excel tracker that is maintained within R&D team only. One observed weakness is that not all incoming equipment is inspected after arrival.

The invoice is checked and PO and quote are attached to it by that person who ordered the equipment. Then this package is checked by the Engineering Director and sent to the Accounts Payable team to be paid. According to the sources, the CAR and vendor have to be approved at this point latest or otherwise the invoice cannot be paid. According to the observations, not all engineers check the vendor status beforehand which may cause problems in the invoice paying stage.

### 3.2.8 Roles and Responsibilities Involved in the Current Purchasing Process

The resources involved in the current purchasing process include four clear roles that are visible at various stages of the current practice: (a) Engineers, (b) Engineering Manager/Director, (c) Accounts Payable team, and (d) Global Procurement which includes at least Global Sourcing and Genpact team. The roles and responsibilities are shown in Table 7, Current roles and responsibilities.

*Table 7, Current roles and responsibilities.*

<b>Role</b>	<b>Tasks and Responsibilities</b>
R&D Engineers	<ul style="list-style-type: none"> <li>- identify the need</li> <li>- specification making</li> <li>- vendor seeking and comprising</li> <li>- quote requests</li> <li>- placing POs to vendors</li> <li>- receiving the equipment</li> <li>-</li> </ul>
R&D Engineering Manager/ Director	<ul style="list-style-type: none"> <li>- decides between bought service or new test equipment</li> <li>- approves POs in ERP or manually with signature</li> <li>- approves new vendors with signature</li> <li>- approves invoices</li> </ul>
Accounts Payable team	<ul style="list-style-type: none"> <li>- pays the invoices</li> </ul>
Global Procurement	<ul style="list-style-type: none"> <li>- approves new vendors</li> <li>- adds vendor to ERP</li> <li>- further vendor handling related tasks</li> </ul>

As seen from Table 7, the R&D Engineers are currently responsible of the process of equipment purchasing for the laboratories, when the management has the approving role. The visibility to other functions beyond that is currently not clear. This is problematic since there is no formal training of purchasing practices for the R&D engineers. Since the case company was going through transition time whilst this study was made, some of the roles and responsibilities do not reflect the company

policy, for example adding vendors to ERP is usually done by the engineers and/or Global Procurement depending on the type of the vendor (“quality affect” or not) but because the engineers did not have access to ERP yet, it was done by the Global Procurement.

Moreover, this the lack of a specific training and sourcing function leads to the lack of negotiation experience and power with the vendor. It goes hand in hand with lacking of thorough equipment (purchasing) specifications and uniform purchase order format. When the purchase is not specified thoroughly, there also is uncertainty of what the purchase actually included.

*“There are so many things to consider: is the installation included [to the purchase price]? Validation activities? Are maintenance services available? Is the warranty period defined? What are the accompanying documents? Drawings, circuit diagrams? Manuals in which languages? Are we ready to receive the equipment? Is there a place assigned? Are the spare parts easily available? All these need to be considered when doing the purchase.”*

(Appendix 2: 7)

According to the sources (Appendix 2), there are lots of open questions that should be answered during the purchasing process. Especially when purchasing those Type 1 equipment that require more than just receiving and paying. Type 1 equipment is big in dimensions and also expensive, and they often require specific conditions such as validation activities: Operational Qualification, Installation Qualification and/or Process Qualification (Appendix 2: 7). Currently, it is not specified, which activities are needed and which are not.

### 3.3 Analysis of Strengths and Weaknesses of the Current Purchasing Practice

This section discusses the strengths and weaknesses revealed in the current equipment purchasing practice. The results are summarised in Table 8 and include five points of strengths (the main strengths are marked green) and nine points of weaknesses. The three main weaknesses are marked pink, although they are linked to the other weaknesses that are listed as well.

As can be seen in Table 8 on the next page, there are not so many strengths found. The most important strength is that there is established purchasing controls existing and they only need to be clarified for R&D equipment purchasing. Secondly, important finding is that there are decision trees made to help in decision making. Other strengths are related to support and flexibility. Since the case company is going through a transition time, support from other functions is essential; for example invoices could not be paid without ERP support. There also is flexibility and co-operation between the purchaser and vendor as well as amongst the R&D team. This enabled bold decisions such as changing the vendor in the middle of negotiations or purchasing something that is not planned in the beginning.

*Table 8, Strengths and weaknesses of the current state.*

Strengths (+)	Weaknesses (Δ)
	Lack of process description; the process is vague
Support from other functions	Manual process
Flexibility and co-operation	No clear roles & responsibilities; no assigned sourcing function, lack of negotiations
Established purchasing controls	High level procedure for purchasing controls that does not offer guidance in detail
Decision trees made to help determining if Self Service Purchase or PO Purchase; decision tree made to help determining if the vendor is so called quality affect vendor or if it is not	
	No actual “kick-off meeting” or similar to establish the start of the equipment purchasing process
	No formal way to make the equipment purchasing specifications; lack of thorough (equipment) purchasing specifications and uniform purchase order format; uncertainty of what did the purchase include
	Lack of purchase training; one person may know a lot but others are not aware of it
	Obsolete or non-existing documents

\*PO stands for Purchase Order. The key findings are highlighted.

As can be seen in Table 8, there are quite many weaknesses identified in the current purchasing practice. The weaknesses are marked as deltas (“Δ”) to implicate

improvement opportunity rather than negativity. The most important finding is that there is no over-all process description of equipment purchasing. This leads to other weaknesses, such as lack of defined roles and responsibilities or lacking sourcing function as well as lacking of overall project view. When there are no clear roles and responsibilities assigned in the beginning of the project, the ownership of the project is not clear either.

Uncertain process and uncertain resources may also lead to problems with time allocating. According to the sources, there is currently no specific time allocated to the purchasing tasks even if they are important in securing the future functioning of the R&D laboratories. This leads to situation where the quality of the purchasing activity is not as good as it could be if full attention would be directed to the purchasing. Even when purchasing is done right, the purchaser is not sure that it is done correctly which affects by slowing the process and also creates misunderstandings. This is also related to lack of appropriate purchasing training.

Secondly, another important finding is that equipment purchasing specifications are not done properly. It is the purchaser's responsibility to buy equipment that fulfils the current as well as future test needs and if the purchaser does not know all of the details, the purchase can be unsuccessful: the purchased equipment may not be suitable for all intended testing or there are terms and conditions that are not considered in the negotiations. These terms and conditions maybe for example what is included in the purchase aside of the equipment. Since the specifications mainly are based on discussions and e-mail conversations, there is a big chance to forget something vital.

Other weaknesses are related to documentation. Document templates that are used within the process have references to other templates which have references to other templates which often are found to be obsoleted or non-existing. There are no further agreements of terms and conditions done between the vendor and purchaser which again leads to uncertainties about what is actually agreed, for example about training or installation of the equipment.

Informants also came up with some improvement opportunities at this point. They are described in more details in Section 5, Building Laboratory Equipment Purchasing Concept.

### 3.4 Key Challenges and Their Business Impact

This section discusses the key findings of the current equipment purchasing practice and their business impact. The key findings are listed in Table 9 as challenges and their possible effects are identified for each of them. As can be seen from Table 9, the effect of each challenge has an effect to the purchasing process. To maintain a holistic picture, the summary also includes the strengths (marked green) of the current practice as something that can be worth retaining. As seen in Table 9, the challenges are in coloured boxes. These colours are repeated throughout this study to indicate the topics.

Table 9, Summary of Data 1: current top challenges and their impact to the purchasing process.

Challenge	Impact
Established purchasing controls	<ul style="list-style-type: none"> <li>- Defined responsibilities and requirements in high level</li> <li>- Defines what Purchasing and Quality Management do</li> <li>- High level procedure that does not offer guidance in detail</li> </ul>
Decision trees	<ul style="list-style-type: none"> <li>- Help in decision making</li> <li>- Not always applicable to Helsinki R&amp;D</li> </ul>
Process is vague	<ul style="list-style-type: none"> <li>- Nobody has a whole picture of the process</li> <li>- Vendor selection criteria is not clear</li> </ul>
Lack of defined roles and responsibilities within the R&D equipment purchasing	<ul style="list-style-type: none"> <li>- Ownership is not clear</li> <li>- No time allocated only to purchasing activities</li> <li>- No assigned sourcing function leads to lack of negotiations</li> </ul>
Lack of thorough (equipment) purchasing specifications and uniform purchase order format; uncertainty of what did the purchase include	<ul style="list-style-type: none"> <li>- Installation may not be included</li> <li>- Validation activities may not be included</li> <li>- Maintenance services may not be available</li> <li>- Warranty period may not be defined</li> <li>- Accompanying documents may not be defined</li> <li>- etc.</li> </ul>

There are two positive features identified. Firstly, there are *established purchasing controls* which define responsibilities and requirements on a high level. They also define what Purchasing and Quality Management do and describe the requirements the case company has to satisfy for purchased or received products and services.

However, since the purchasing controls are on a very high level, they do not offer guidance for purchasing activities in detail. The purchasing controls explain the requirements for the procedures only, for example, which function is responsible to create, maintain and implement the procedures.

Secondly, there are *decision trees* available to help in decision making. These decision trees are specified in the internal company documents and are helping to decide for example whether the purchase is direct or indirect purchase, or if the purchase is Self Service Purchase (SSP) or not. These decision trees are very helpful when they work but unfortunately they usually refer to documents that apply only to the US based sourcing function and do not apply to the Helsinki based R&D.

Among the challenges, the first negative key challenge is *the vagueness of the process*. There is currently no process description for purchasing equipment. Due to this, nobody has a whole picture of the process. The second key challenge is the *lack of defined roles and responsibilities* within the R&D equipment purchasing. There is currently no assigned sourcing function so the R&D engineers are purchasing the equipment. This makes an effect on the ownership and time allocation. As a result, there is no clear owner of the purchasing process in general or for a certain purchasing project. The roles are divided based on who is available rather than who has the expertise. If there is no dedication or there is feeling that the purchasing is a side job, the time allocation for purchasing tasks is difficult. The third key challenge is *lacking of thorough equipment (purchasing) specifications* and uniform purchase order format. This challenge is also related to the resources, because lack of training and sourcing function lead to lack of negotiations with the vendor, based on the purchasing specifications. When the purchase is not specified thoroughly, there also is uncertainty of what the purchase included.

It seems that all of the challenges are related to the process of purchasing equipment or more specifically lack of known process. The interviewees were not always agreeing with each other about all of the details of the current way but basically they were in line with each other. One example of this is that there was no common understanding of who is the project leader. Other recognised issues were related to sharing knowledge and communicating, which would be part of the process description if there was one. The company documentation was somewhat utilised when purchasing equipment but most documents were not known to exist.

These challenges will be dealt with in the following sections, as there is a challenge of purchasing a range of equipment in the near future, as shown in the previous subsection. In the following section, best practice of purchasing is used as guiding idea in the search for solution models and tools in Section 4.

## 4 Best Practice of Professional Equipment Purchasing

This section overviews how process professional equipment purchasing is done in general as well as in technical context in order to find models and tools to help solving the current challenges.

### 4.1 Approaches to Purchasing

“Purchasing” as a term means operating between the buyer and the seller. The purchasing functions are not limited only to the transaction where the goods change ownership and they are paid but also there usually are other actions such as finding the best buy and up-keeping the inventories. (Pooler et al. 2004: 3,6-7.) The focal point of this thesis is purchasing testing equipment for R&D organisation of a medical device company. As the three major challenges in equipment purchasing in the case company’s R&D organisation relate to the shortage of process description, lack of clear roles and responsibilities, and lack of purchasing specifications, this section overviews how professional equipment purchasing is done in general and how roles and responsibilities can usually be allocated. This is done in order to find models and tools to help solving the current challenges.

Between different approaches of purchasing, there are some variations but in essence, they do not differ from each significantly. Pooler et al. (2004: 26) suggest that purchasing can be either centralised or decentralised. These terms as well as advantages and disadvantages of them are opened up in Table 10.

Table 10, Approaches of purchasing according to Pooler et al. (2004: 26).

Approaches of Purchasing	Description	Advantages	Disadvantages
Centralised Purchasing	Purchasing of the factory is in one department and the purchasers report to one head.	Uniform procedures and guidelines  Individuals can be assigned to the tasks for which they are best suited	Rigidity  Loss of key persons affects performance of organisation  Centralised purchasers may be too distant from material problems
	There are multiple factories but the purchasing for all of them is located in one of them.		
Decentralised Purchasing	Several independent purchasing groups report to individual managers	Quick response  Allows the divisional manager to retain authority  Flexibility	Scattering  Procedures and guidelines may be site specific  Everybody does everything; no effective utilisation of talents  Loss of voice
Centralised / decentralised purchasing	Mixture of centralised and decentralised purchasing	Location of purchasers and vendors can give strategic leverage	Communication between centralised people may be ineffective

According to Pooler et al. (2004: 26), *centralised purchasing* can mean two different things. Firstly, it means that purchasing of the factory is in one department and the purchasers report to one head. Usually this is the case in companies that have only one factory. Secondly, centralised purchasing means that purchasing of company's multiple factories is located in one of the factories. The advantages of centralised purchasing lie in uniform procedures and good change to utilise purchasers' individual strengths by assigning them to most suitable tasks. But there also are disadvantages: if one of the key persons is lost, it can be severe to the organisation. Centralised purchasing can be rigid and slow to change, and the purchasers can be too distant from the problems that occur with materials, especially when there are more than one factory. (Pooler et al. 2004: 26-27.)

On the other hand, *decentralised purchasing* may react quicker to the demand. There can be more flexibility as the authority is with the divisional manager. As a disadvantage, decentralised purchasing can suffer from scattering, when they have little contact with top management and may have little opportunity to be heard. The decision making can be elsewhere than the purchasing. (Pooler et al. 2004: 26-28.) Pooler et al. suggest that most companies start with centralized purchasing and convert to decentralised purchasing once they grow. They also claim that central/decentralised organisation is the most popular approach with cross-functional teams. (Pooler et al. 2004: 26-28.)

According to Stuart (1991), when purchasing equipment to R&D organisation, the R&D purchasers require relatively high level of relevant technical expertise. Lacking of technical background leads to low involvement in the early stages of purchasing process. He also claims that effective and meaningful purchasing can lead to effective R&D work as well by helping them to concentrate in research and development tasks.

Whether the purchasing is centralised or decentralised, or the purchasers are within purchasing or R&D organisation, the act of purchasing includes decision making. Making decisions can be hard whether it is a decision between two or three equipment vendors, or decision between two different equipment types. One approach to help with the task is a decision model. Decision model is a quantitative or analytical approach to problems and consists of three fundamental steps. The first step is to identify and structure the values and objectives of the decision. The second step is a logical framework that is structured from the elements of the decision is constructed. The third and last step is to refine and define the decision elements. (Clemen 1996: 6-7, 41.)

There are plenty of different kinds of tools and models that can be utilised in decision making. One example is a decision tree as shown in Figure 3. Elements of a decision tree are: decisions to be made, possible outcome of each decision, and consequence of each possibility (Clemen 1996: 67). There are also other types of decision tree models available and they basically pursue the same principals.

Other approaches, for example, for vendor selecting, can be outranking methods such as analytical hierarchy process (AHP) and a multiobjective linear programming (MOLP) model, in which three objectives are optimised and set of organisation re-

restrictions is defined. In MOLP, the three objectives can be for example purchasing cost, quality and delivery reliability. The organisation restrictions could be purchasing budget, delivery time and service support after the purchase. (Ting and Cho 2008: 117., de Boer et al. 1998.) These methods differ from decision tree model so, that they basically mean dropping off the poorer candidates until there is only one left instead of finding the winning candidate by comparing them in parallel. Figure 3 shows an example of a simple decision tree.

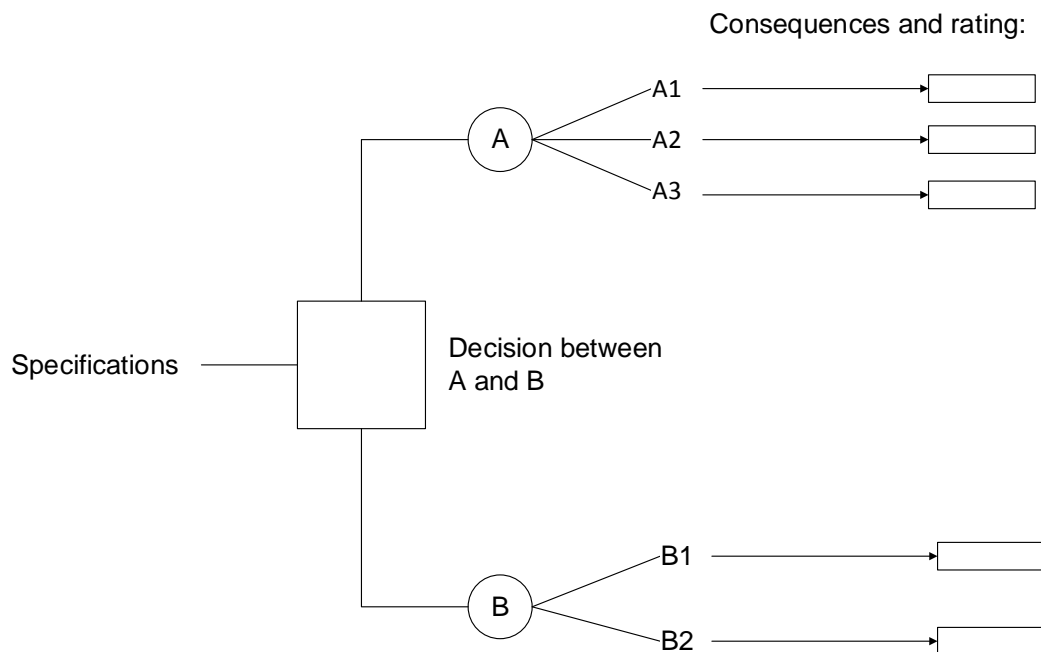


Figure 3, Sample of a simple decision tree to help evaluating the consequence of each option based on Clemen (1996: 67-81).

Figure 3 shows an example of using a decision tree for making a decision between vendor A and vendor B when evaluating which vendor and which equipment to buy. The decision tree is read from left to right. First, there are purchase specifications to which the decision of vendor and equipment is based on. Circled A and B represent vendors (chance events) and each branch (A1-A3; B1 and B2) represent separate equipment choices from that vendor. The lines after that represent the consequences of choosing that equipment (A1-A3, B1, B2). Finally, the boxes represent the rating of each choice. (Clemen 1996: 67-81.) The consequences can be anything that is related to the problem, for example qualitative such as performance criteria or quantitative such as costs. The rating is based on some kind of a scoring system that is decided comprehensively.

The vendor and equipment selection is usually made by purchasing based on their expertise. Paquette (2003) suggests that the word “purchasing” describes both department and function within organisation. Depending of the company, purchasing activities can include determining vendors, vendor qualification, conducting site visits, and background checks. Purchasing can also take price quotes and negotiates the price as well as makes other strategic recommendations based on the above activities. Further on, purchasing can conduct final contract negotiations, manages agreements, and oversees the approval process. (Paquette 2003: 5.) Pooler et al. also suggest that based on the organisation structure, purchasing duties ought to be assigned and delegation of responsibility take place in order to gain control over the purchasing activities (Pooler et al. 2004: 25).

Paquette (2003) suggests that negotiation skills are essential to the purchaser. When negotiating, the end result should be beneficial to both sides: the purchaser and the vendor so that they both feel that they got what they wanted. If both parties do not feel like winners in the end of the negotiation, the process has failed. Well conducted negotiations and knowing the needs of the other party may also result in a long-term partnership. (Paquette 2003: 141-145.)

#### 4.2 Professional Purchasing

Professional purchasing in general is function of buying and is part of procurement activities in companies. Typical purchasing process can be modelled as shown in Figure 4, The procurement process according to Pooler et al. (Pooler et al 2004: 3-4, 10.)

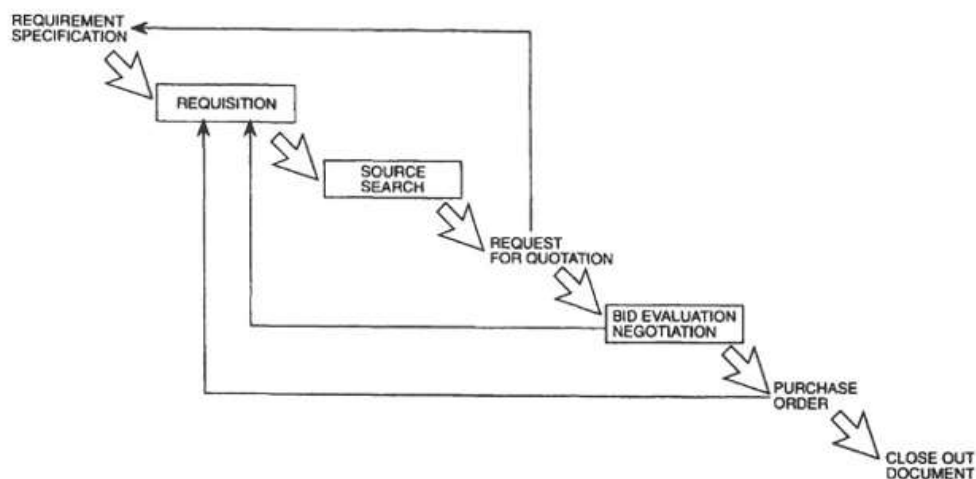


Figure 4, The procurement process according to Pooler et al. (2004: 10)

As can be seen in Figure 4 (Pooler et al. 2004:10), the purchaser coordinates the whole process and the purchasing process starts from requirement specification. The specifications are determined by the quality and engineering standards. Next step is the requisition or other type of definition of the need. The requisition will be the basis of the purchase order and it typically consists of internal information such as account to be charged and authorisation as well as description of what is needed, when it is needed and shipping information. Once the requisition is analysed, the purchaser identifies potential vendors and requests quotes based on the requisition. (Pooler et al. 2004: 63-65.) The requisition can also be based on purchase specification and equipment specification that are explained in section 4.3, Purchasing Technical Equipment.

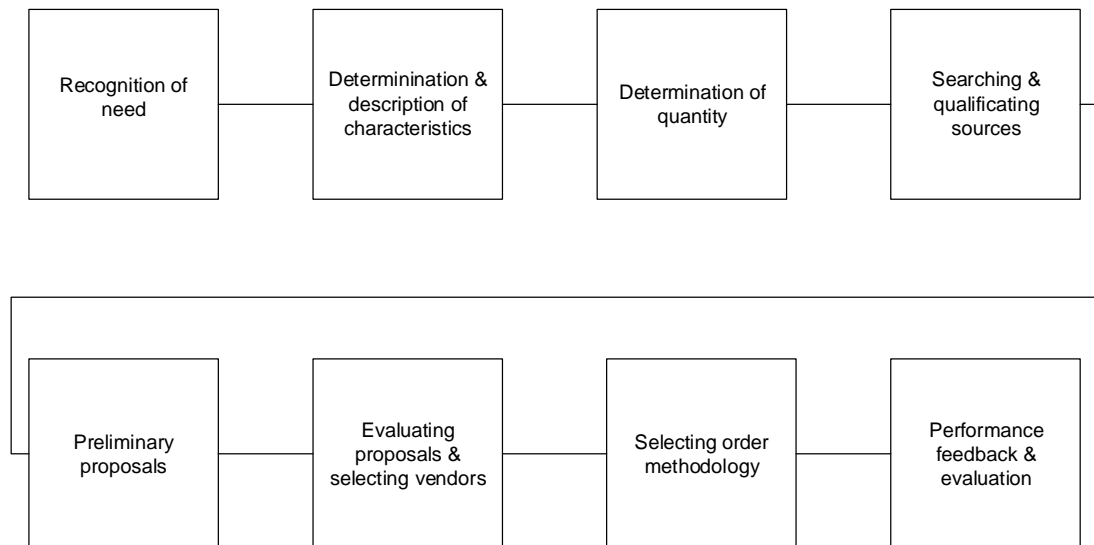
As de Boer et al. (2001) suggest, typical vendor selection consists of four phases: problem definition, formulation of criteria, pre-qualification of suitable candidate(s) and final selection of the vendor. Once the final selection is done, negotiations can start. They may include contract terms and price as well as other agreements:

*“While most buying negotiations involve prices, many things other than price are negotiable; for instance, terms and conditions of the PO, changes in packaging, reduction of overhead rates, settlements of disputes and damaged goods, and so forth. This is especially true when purchasing services or capital equipment and many other items where the price may be one of the least important performance factors. A powerful leverage effect is available to keep suppliers competitive before the buyer has committed to the complete terms of the purchase.”*

(Pooler et al. 2004: 248)

Once the negotiations are completed and both parties are satisfied, the purchase order is placed. The purchaser should be aware of who has ownership and who has authority to make agreements. (Pooler et al. 2004.)

Another model of purchasing is described by Stuart (1991): purchasing in R&D environment can be done in eight stages as illustrated in Figure 5, Stages of early Robinson-Faris model according to Stuart (1991: 30).



*Figure 5, Stages of early Robinson-Faris model according to Stuart (1991: 30).*

As shown in Figure 5, Robinson-Faris model described purchasing process in chronological sequence of stages. The process is the same in main parts as what Pooler suggests. The noteworthy difference is selecting order methodology and the last step, feedback and evaluation. This model is very simplistic but with additions it can be utilised in R&D purchasing. Additions, such as budget approval and enabling looping back in the process, make it more usable. (Stuart 1991: 31.)

The relevance of literature should be evaluated by questioning how recent it is and if it is likely to be replaced with more recent information (Saunders et al. 2007: 93). Keeping this in mind, it is observed that the purchasing as a concept has not changed much over the years. The Purchasing Handbook originally written by George W. Aljian is still partly up-to-date even if it is written in 1958 and there are five more editions made since that. However, this study utilised more recent publications which mostly told the same story between each other. Robinson-Faris model for purchasing in R&D environment was made already on 1967 and it still describes the main points of the process, but it can't be used as such because it is very simplistic. (Stuart 1991: 31).

It is also good to keep in mind that in medical business, the United States Food and Drug Administration (FDA) Quality System Regulation requires established and

maintained purchasing controls to received goods or services. This means that only vendors, contractors, and consultants that meet specifications should be used. (Daniel and Kimmelman 2008: 107-108.) It can be difficult to define if the new equipment to be purchased is amongst the FDA regulations especially if it is for R&D laboratory. Therefore, it is advised to use established purchasing guidelines and decision trees in vendor choosing stage.

#### 4.3 Purchasing Technical Equipment

Purchasing technical equipment requires clear and thorough specifications. The specifications are made to avoid errors and without thorough specifications, wrong type or size of equipment can be bought. ASTM international defines specifications in following way: “*an explicit set of requirements to be satisfied by a material, product, system, or service.*” (ASTM international 2015: vii).

*Purchase specification* defines the content of the purchase: purchasing and transportation costs, delivery details, service details, accompanying documentation and verification responsibilities, and so on (Ting and Cho 2008: 119). The purchase specification can be used as a basis for the purchase order. Procurement Services Group of Los Angeles Unified School District suggests that warranty requirements should be part of the purchase specification and it is beneficial to write down what is and is not included to the warranty period (The Los Angeles Unified School District, Procurement Services Group 2002: 13-14).

ASTM international defines purchasing specifications in following way:

*“Purchasing Specifications facilitate dealings between the purchaser and the supplier. Sufficient requirements should be included to ensure that all batches, lots, or deliveries from any seller that conform to the specification will be satisfactory to the purchaser. Unnecessary requirements are likely to increase costs and should be avoided.”*

(ASTM international 2015: B-1.)

*Equipment specification* defines the details of the equipment to be purchased. It is good to keep in mind that the equipment specification are not the same as design item specifications, although modified design specification can be used. Equipment

specification should include installation requirements amongst other details. (The Los Angeles Unified School District, Procurement Services Group 2002.) The specification also should include the key characteristics without going into too many details using technical literature as guidance. The objective of writing technical specification is to explain to the vendors what is required. (Stout 2004: 2-3.)

To demonstrate the main points found in literature, Table 11, Comparison of purchase and equipment specification sums up how the differences between purchase specification and equipment specification are considered in this study.

*Table 11, Comparison of purchase and equipment specification.*

Purchase Specification	Equipment Specification
Warranty details <sup>1,2,3</sup>	Placement; whether require specific environment <sup>2</sup>
Quantity <sup>1,4,5</sup>	Critical parameters <sup>1,3,5,6</sup>
Contact details <sup>1,5</sup>	Performance criteria <sup>1,2,3,5,6</sup> , targets and tolerances <sup>5,6</sup>
Purchasing and delivery costs, and details <sup>1,2,5,7</sup> ; and payment terms <sup>4</sup>	Drawings, photographs, or technical illustrations <sup>1,6</sup>
Transportation details <sup>1,2,7</sup>	Material requirements <sup>2,6</sup> ; physical, mechanical, electrical, chemical, etc. <sup>3,6</sup>
Installation details: who <sup>1, 2,3</sup>	Installation details: how <sup>2</sup>
Accompanying documentation <sup>1,2,4,7</sup>	Environmental considerations and requirements <sup>1,5</sup>
Verification details and responsibilities <sup>1,4,5,7</sup>	Safety considerations and requirements <sup>1,3</sup>
Service details <sup>1,2,3,5,7</sup>	
Signatures of approval if necessary <sup>1,4</sup>	
Training <sup>3</sup>	
Quality control requirements <sup>1</sup>	

<sup>1</sup> Pooler et al. 2004

<sup>2</sup> The Los Angeles Unified School District, Procurement Services Group 2002

<sup>3</sup> Stout 2004

<sup>4</sup> Paquette 2003

<sup>5</sup> Systems Management College 2001

<sup>6</sup> US Department of Defense 2008

<sup>7</sup> Ting and Cho 2008: 119.

As seen from Table 11 on the previous page, best practice and findings from literature suggest that the specifications and requirements must be analysed before proceeding to vendor selection. This analysis clarifies and defines functional and operational requirements as well as design constraints, and it has to be understandable, unambiguous, comprehensive, complete, and concise (Systems Management College 2001: 32). These constraints can be e.g. where the equipment to be purchased is going to be placed or other type of restrictions. Systems Management College (2001) sums up the functional requirements as follows:

*“Functional requirements define quantity (how many), quality (how good), coverage (how far), time lines (when and how long), and availability (how often). Design constraints define those factors that limit design flexibility, such as: environmental conditions or limits; defense against internal or external threats; and contract, customer or regulatory standards.”*

(Systems Management College 2001: 32.)

The operational requirements can be regarded as set of questions, for example, how the equipment is used, what are the critical parameters and what kind of performance is expected (Systems Management College 2001: 35). Once there are specifications for the desired equipment, there should be system to verify the purchase (Pooler et al. 2004: 73). Therefore the feedback and evaluation step described above is as important as the specifications themselves.

#### 4.4 Benchmarking Equipment Investment Process

There are companies that have developed thorough equipment purchasing processes. Benchmarking was done by visiting two of them, which are the leading companies in their own fields and who have established efficient equipment purchasing concepts. Benchmarking was chosen to be introduced at this part of the study, because it is used in creating conceptual framework, even though the researcher is fully aware that benchmarking is not part of the literature review.

The first benchmark is a company that is a global leader in the design, manufacture and supply of advanced electronic materials, components, and multi-functional modules. In this company, they have successfully established an equipment pur-

chasing concept that is developed by them. In this concept, the equipment purchasing follows strict Equipment Investment Process (EIP) discipline. In the EIP, there are three phases and each of them ends to Equipment Review Group meeting (ERG). The ERGs are gates that require formal approval before they can proceed to the next phase. The process is described in Appendix 1.

In the beginning of EIP, it is crucial to make thorough specifications. The established specification form and format is used as well as checklists to ensure that no important factors have been forgotten. These factors can be related to the placement of the equipment, for example compatibility to the environment, or they can be related to chemicals used with the equipment. They also consider training needs as well as installation details. Further on, they consider the documentation that is needed with the equipment, such as connection diagrams or type of electrical connections. According to the source, the strengths of the EIP are in orderliness, consistency, standard templates, standard check sheets and explicit process description. Additionally, since every function signs off the ERGs, all are equally responsible of the purchase. Weakness of this process is that the final Lessons Learned is not always done. Analysing the purchase action as well as the equipment purchased is important in order to improve. (Appendix 1: 3.)

Other benchmark is a leading research and technology company in the Nordic countries. They also have established purchasing process that is described in their sourcing procedure. In short, their process starts from the investment suggestion made by the research team and team leader. Once they have decided where to invest, the specifications are made together by investment team and the person in charge of the investment. There are competition formalities to take into account and hence the investment team is familiar with them, they are the actual buyers of the equipment, with collaboration of legal team. (Appendix 1: 4.)

The specifications are put into numbers, so that the final vendor selection is based on measurable data. After the vendor is selected, the specifications are adjusted and for example equipment support and training are added to the specifications. The equipment is inspected before receiving in order to avoid semi-finished product and the payments are staggered to ensure that everything that is in the contract gets done. According to the source, the strengths of their process are in checklists and clear process. According to the source, competent communication between the

interest groups is important. (Appendix 1: 4.) Communication was noted in other benchmarks as well (Appendix 1: 5).

Thus, based on the benchmarks, to form a comprehensive equipment purchasing process, the activities have to be organised, disciplined and qualified. It is equally important to assign clear responsibilities within the purchasing project. The purchase has to be defined by thorough specifications; moreover, based on the benchmarks, the purchasing actions are not finished once the equipment is received: the after activities are equally important to consider within the purchasing project.

#### 4.5 Conceptual Framework

The findings from best practice and benchmarking, and business and academic literature that are relevant for this study are summarised into the conceptual framework for equipment purchasing illustrated in Figure 6. The conceptual framework consists of three main elements: defining the requirements, selecting the vendor and purchasing the equipment. All of these are linked to each other and together, they form the purchasing process. The relevance of these three elements to the challenges of current state is shown in colours in Figure 6 on the next page.

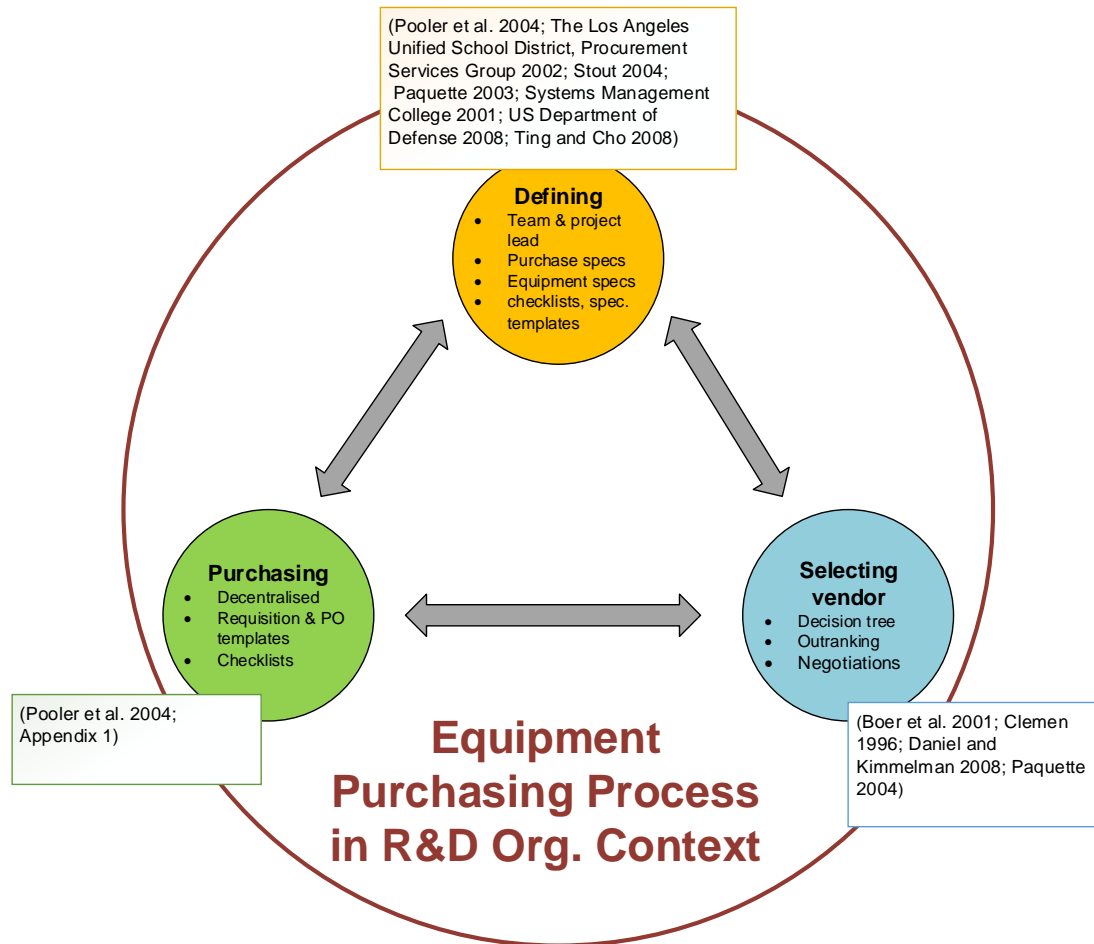


Figure 6, Conceptual framework for equipment purchasing.

As seen from Figure 6, *the defining phase* is the foundation of the purchasing process. In this stage, the project team and team leader are defined i.e. roles and responsibilities are divided. The equipment to be purchased is specified in that extend, that it can be effectively purchased. At this point, there is no need to go to very details, such as dimensions within millimetres or colour of the equipment unless it is relevant. The equipment specification can be refined later after the vendor is selected. The content of the purchase is also defined in main parts in the purchase specification. This also makes a basis for the purchase order. At the defining phase, it is good to consider whether there are training needs for using the new equipment. (E.g. Stout 2004; Appendix 1.)

Next phase, *selecting vendor*, consists of seeking suitable candidates, narrowing down the selection and then requesting quotes. The purchase and equipment specifications are used as basis in requesting the quote. The final candidate can be cho-

sen by using different methodology, which base on rating and ranking the candidates. Rating candidates can be based on several things: for example their location, possibility to offer services in the future and purchase price, although the costs should not be dominant factor when choosing the vendor. It is good to have the rating as measurable figures for transparency and ranking reasons. Ranking is done based on the ratings and for example the one that got biggest points is chosen. Negotiations with the chosen vendor are also done at this phase. (E.g. de Boer et al. 1998.)

When purchasing equipment, negotiations should include at least purchasing and delivery costs, and payment terms. The available services should also be discussed: installation, verification, future maintenance and calibration (when applicable). Transportation details and schedule as well as accompanying documents ought to be considered. Possible training need ought to be defined in the defining stage and if there are such needs, they should be discussed when negotiating the total costs and the equipment and accompaniments package. (E.g. Systems Management College 2001.)

Third element, *purchasing the equipment*, is decentralised which means that the R&D organisation acts as procurement function instead of the Global Procurement. Requisition template, or form, can be filled in if the actual purchaser is someone else than the purchase specification maker. Otherwise, separate purchase requisition may be unnecessary. It is good to have a PO template, or form, that regards the unchangeable inputs of the purchase. These inputs can be for example the above mentioned negotiable affairs. Checklists can be used as help when doing the purchase order. (Pooler et al 2004; Appendix 1.)

These three elements form the *Purchasing Process* and to get the maximum benefit of it, it should be written out as a process description with appropriate supplements such as templates, forms and checklists. The conceptual framework is applied next to develop the purchasing process for the case company.

## 5 Building a Concept for Equipment Purchasing

In this section, the interview transcripts are analysed and compared to the case company specific internal documentation and the conceptual framework. The first subsection is structured to reflect the current state analysis to the conceptual framework. The second subsection discusses the development needs of the Concept. Third section presents the final Equipment Purchasing Concept.

### 5.1 Steps of Building the Proposal

There were three key issues to be tackled from the current state analysis. Firstly, established purchasing controls and decision trees exist, but the process is vague. Secondly, the lacking of defined roles and responsibilities within the R&D equipment purchasing impact the time allocation and ownership. Third key issue, lack of thorough (equipment) purchasing specifications and uniform purchase order format, impacts the purchase by creating uncertainty of what the purchase included. These key issues are reflected in the conceptual framework in its three main elements: defining the purchase, selecting the vendor and purchasing the equipment. The dimensions are explained in more detail in Section 5.2, Proposal Draft.

Based on the challenges identified in current state analysis and the knowledge gained through conceptual framework, the purchasing concept proposal was built. Data 1 transcripts were analysed in details to form a firm understanding of the current strengths and weaknesses. Benchmarking equipment investment processes outside of case company was aligned with the literature in many places. Structured and analytical approach was emphasised in the literature as well as with the benchmarks.

The interviewees identified some improvement opportunities to the current ways of purchasing. Having a process description was mentioned more than once. Another thing mentioned was that centralising the purchases into one place would be nice. On the other hand, it might be tricky for R&D organisation to outsource purchasing activities to other departments. (Attachment 2: 3.) Data 1 showed how the purchasers acted differently from each other at the time this study was made. They also did

not follow the company guidelines to the letter. For example, purchasers were not aware of some important company documents due to lack of training.

The proposal draft was compressed to a workflow (Figure 7 in section 5.2). In the workflow, there are owners defined for each step. The proposal concentrates in Type 1 type equipment purchasing and Type 2 equipment (Self Service Purchase, SSP) or buying service are left out of the scope. Type 2 type purchases are not as heavy as Type 1 type purchases and buying services is left out of the scope because this study concentrates in equipment purchasing. The equipment classification is explained in details in Section 5.2.1.

## 5.2 Proposal Draft

The proposal draft is based on the reality check (current state analysis) and best practice found in literature and benchmarking. The proposal draft was discussed in workshop and one-to-one with some individuals. Majority of the concerned parties were involved to the evaluation of the proposal draft. Those that were not consulted were out of reach, for example on business trips. The participants were design engineers, equipment purchasers, management, Quality Engineering and Supplier Quality functions.

The three elements of the Conceptual framework are Defining, Selecting vendor and Purchasing which together with the strengths of current practice form the Equipment Purchasing Process for Helsinki based R&D organisation of the case company. The initial proposal is illustrated in Figure 7 as a workflow.

As seen from Figure 7, the process is simplified to be very chronological and it starts from the testing need and ends once the equipment installation is approved and lessons learned session is held. The process flow concentrates in Type 1 equipment purchasing, because Type 2 equipment and tools usually do not require specific conditions, installation or other considerations. Buying test services is left out of the scope as well, even though it follows basically the same work flow but yet there are some differences and putting them to the same workflow would complicate it.

Unlike the proposal draft, the final proposal has two actions for investment plan. This is because there might be a hunch of the price range of the equipment to be purchased when the purchasing project starts. In this case, it is best to do the CAR (if required) as soon as possible because it might not get approved as it is or the handling time can be long, and if the CAR is made late in the process, it might slow down the whole project.

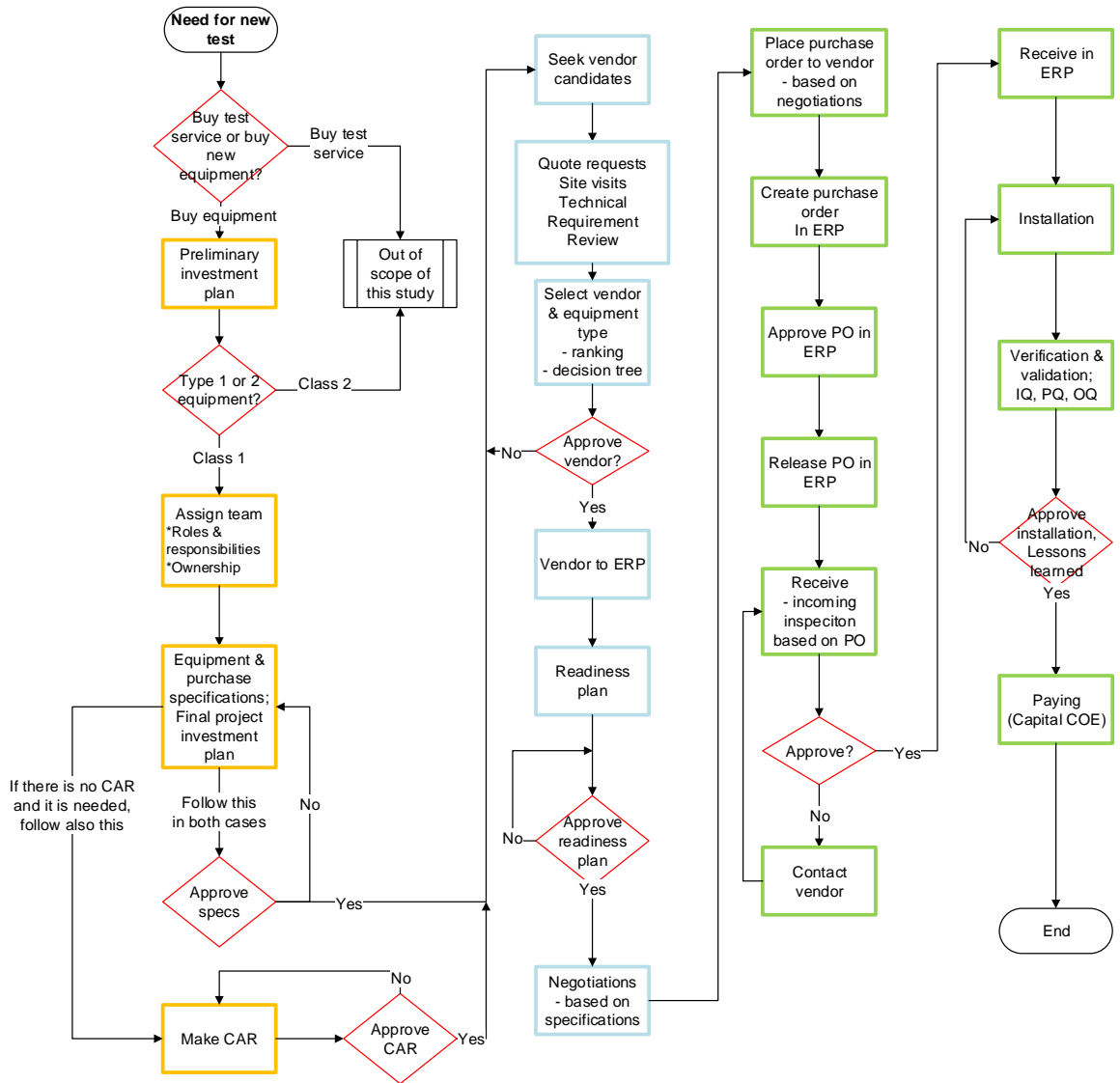


Figure 7, Initial Equipment Purchasing workflow for R&D Organisation in case context.

As seen in Figure 7, the initial proposal has more steps than the current process. There are colours added to reflect the logic of this study. These main colours (yellow, blue and green) can be reflected to the key challenges of the current process,

and they also can be found in the conceptual framework. The red 45° squares are decision points.

The owners of each action are identified and listed in the subsections below. Even though there are several different roles identified, for example Design Engineer, Purchaser and Engineering Team, these all can be the same person depending of the nature of the equipment to be purchased. The parts of the purchasing process workflow shown in Figure 7 are explained in details in the subsections below. There are four showstoppers, as presented in Figure 7: specification approving, CAR approving, incoming inspection approving and installation approving. This means that the showstoppers have to be tackled before proceeding in the workflow. The process can be followed up as shown in Appendix 4. There are owners for each step, status of the step and start and finish date to follow-up the process.

In the beginning, there is one selection point as there originally was: whether the test is done within case company's own premises or test services are bought. Otherwise the flow differs from the current practice as explained below. As seen from Figure 7, the proposal differs from the current situation in two fundamental ways. Firstly, there are roles identified for each step (Appendix 5). The roles can be performed by one person in most cases, although purchase order management in ERP requires at least two separate persons and even three if the purchase is over the personal limit of that person who is doing the purchase. For example, one person can be design engineer, project lead and purchaser but this person cannot be the engineering team by him/herself alone.

Secondly, there are approving points which require more than only one person's presence. First such approving point is when the specifications of the purchase and equipment are viewed. The team effort ensures that nothing has been forgotten, for example what kind of connections or electricity the equipment needs, or what are the desired performance parameters of the equipment. Second approving point is for the Capital COE and they approve the CAR. This is only if there is a need for CAR and there is no previous CAR that can be used within the project. If the CAR is not approved, the project cannot proceed. At this same time, the vendor is approved by the team that consists of engineers, sourcing representative/Supplier Quality and management.

Overall, the equipment purchasing process follows a clear route where each task has an owner. Next subsections open the workflow in subsets that consist of the three main dimensions formed in conceptual framework.

### 5.2.1 Defining the Purchase

This phase of the equipment purchasing concept is in Figure 8.

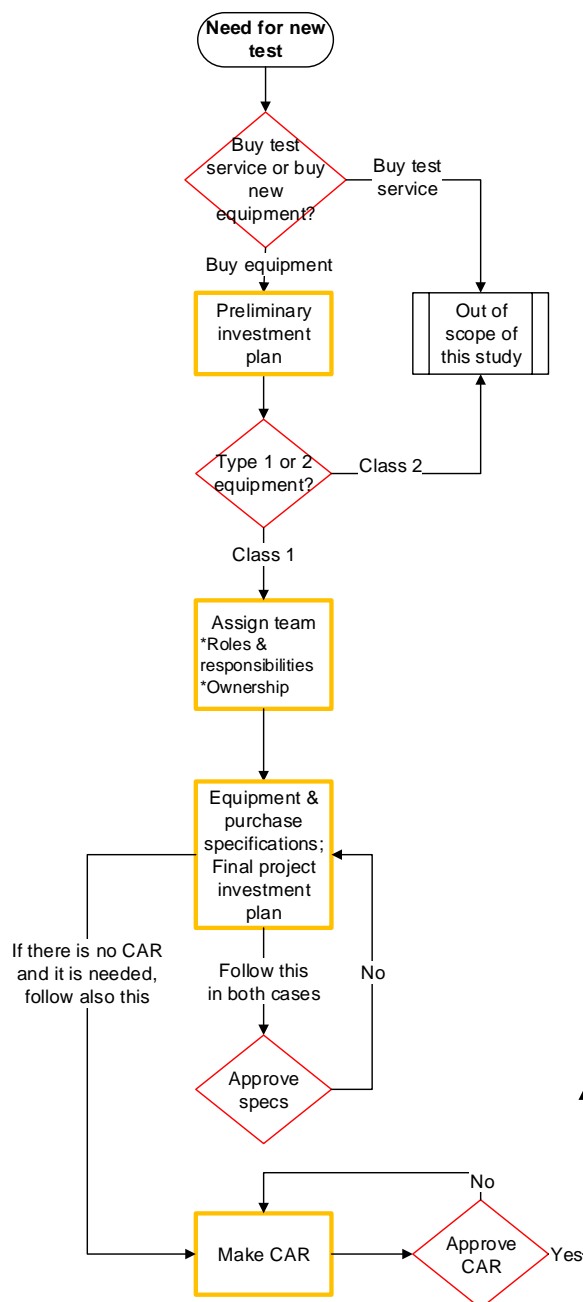


Figure 8, Purchase defining phase.

As seen in Figure 8, the purchase process starts when a need rises for a new type of test - usually from an R&D project - that cannot be performed with the current equipment. The new tests can be outsourced and testing services purchased, or the tests can be done in own premises with new equipment to be purchased. The decision is made by the project team and if there are uncertainties, the management makes the decision. This thesis focuses on equipment purchasing so purchasing testing services is out of scope. At this point, the preliminary investment plan can be made by the design engineer, i.e. the requestor, in order to evaluate the project costs. If the costs are well known, the CAR can be made in this point already.

The first actual step is to define the equipment classification. Decision trees are used to help with the classification and the decision trees are part of the company specific documentation and under revision control. If the equipment is Type 1, the process follows the proposed workflow. In this stage, it is good to involve sourcing or Supplier Quality representative, especially if it is not entirely clear what is the classification. The dimensions of the classification are illustrated in Figure 9.

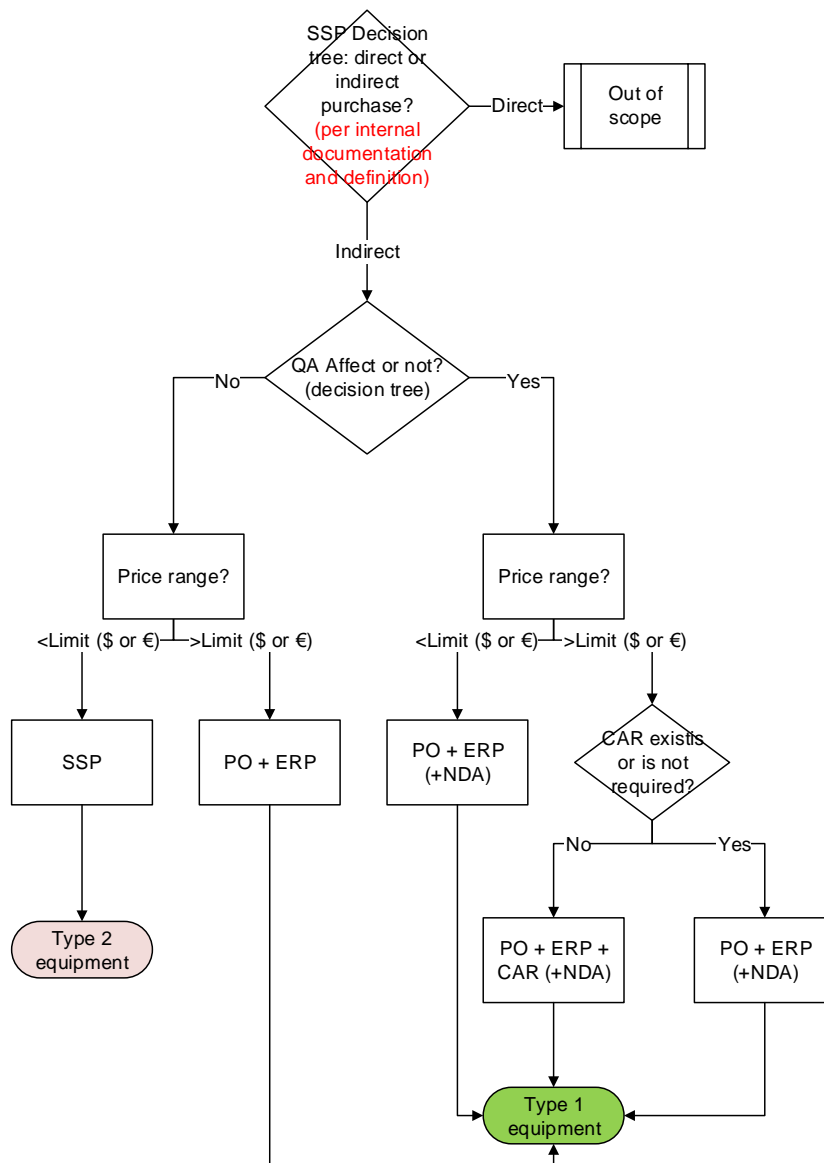


Figure 9, Rough decision tree for equipment classification in R&D point of view.

As seen from Figure 9, the equipment classification starts from defining whether the equipment is Quality Affect or not. This definition is done according to the company specific SSP (Self Service Purchase) Decision tree. If the equipment is not Quality Affect, the next definition is the price range where it might fall into. Small priced equipment, i.e. less than limit specified in the company (\$ or €) with no quality affect, typically are within SSP which means the vendor does not require setting up in ERP or the purchase does not require CAR (Capital Agreement Request) or PO (purchase order).

If the equipment is not Quality Affect but costs more than limit specified in the company (\$ or €) €, it requires purchase order and setting up in ERP for handling the PO. Same applies to small priced (less than limit specified in the company (\$ or €)) Quality Affect purchases. If the purchase costs more than limit specified in the company (\$ or €) and is Quality Affect, the investment plan has to be reviewed for whether there is CAR already existing. If there is one available that the purchase can be allocated to, there is no need to do another CAR for it. This kind of occasion can be, for example, when a multitude of laboratory equipment is purchased. There is one CAR for the whole project and all individual purchases are valued to that CAR. However, this case still requires a PO and vendor set-up in ERP. The last possibility is that there is no CAR and the value of the purchase is more than limit specified in the company (\$ or €), and it is Quality Affect. In this kind of a case, all of above are needed: CAR, PO and setting up in ERP. NDA, a contract between the case company and vendor that protects the confidential information of one or both parties, is needed to all Quality Affect purchases (Appendix 3: I).

Next, the purchasing project team is assigned. This team can be the same as the R&D project team, it mostly can be only one person or it can be a bunch of R&D engineers outside of the R&D project. This all depends on the scale of the purchasing project. At minimum, there has to be two engineers, one quality representative and one manager. The project owner is decided at this point and this person will have the overall responsibility over the process.

In the defining phase, the purchase is specified in detail. The Project owner is responsible to ensure that the specifications are made and approved. All important parameters that are required from the equipment are listed, for example, the electrical connection needed and the parameters related to the tests to be performed- In this thesis, this type of specification is called *equipment specification* to simplify the terminology. The purchase related parameters are also listed and this list is called *purchase specification* in this thesis. Such parameters are accompanying documents desired, training needs, installation and calibration service, and so on. Specification templates and checklists are used to ensure that no vital detail has been forgotten. The specifications are done by the team and owned by the assigned project leader. This means that the project leader is responsible of collecting all the relevant data and gathering the suitable members to review and approve the specifications. At this point, there should be at minimum two engineers reviewing and

approving the specifications in order to double-check the upcoming purchase. Table 12 demonstrates the roles in defining stage.

*Table 12, Roles and responsibilities in the defining phase.*

<b>Role</b>	<b>Responsibility</b>
Design Engineer (Requestor)	Initiates the need for a new test
	Participates in making specifications
	Approves specifications
	Preliminary investment plan
Purchase Project Owner	Ensures the specifications are made and approved
Engineering Team	Participate in making specifications
	Approve specifications
Purchaser	Participates in making specifications
	Reviews purchase requisition
Engineering Manager	Decides whether to buy test equipment or test service
	Assigns ownership
	Approves expenditure
Sourcing/Supplier Quality	May participate in deciding the equipment classification
Quality	Determines the quality affect level of the purchase

Following the equipment specifications, there might be a conclusion that the equipment has to be tailored because there is no off-the-shelf solution available. If it is so, the purchase specifications are even more crucial part of the purchase.

The defining phase in general means gathering technical, business, quality and regulatory controlled material, i.e. information that is necessary in supporting vendor selection, evaluation and qualification processes. The scope of planning activities is based on the complexity and risk of the procured equipment.

### 5.2.2 Selecting Vendor

Vendor selecting phase is based on the defining phase. In defining phase the foundation to the purchase is formed and to be able to find the most suitable vendor, the purchase criteria must be clearly stated as in specifications. The vendor selecting phase is described in Figure 10.

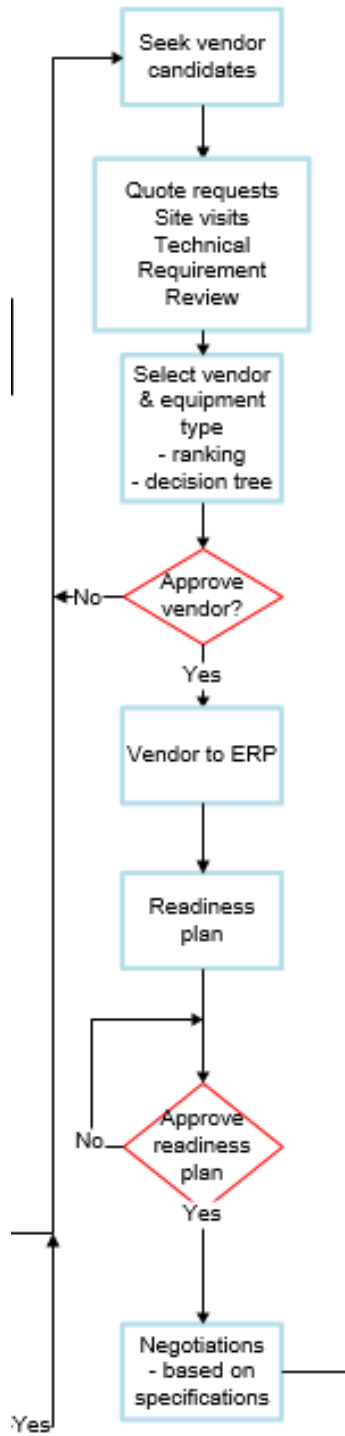


Figure 10, Vendor selecting phase.

The vendor selecting phase is done according to Figure 10. Basically at this phase, the purchaser is seeking, choosing and approving vendor. The identified roles are demonstrated in Table 13 below.

Once the equipment specification is ready, the purchaser starts seeking for the vendor candidates. This can happen based on, for example, previous knowledge, hints from associates and seeking from the internet. In the vendor selection phase, the candidates that are identified for further evaluation and potential use are listed and quotes are requested based on a combination of the purchase specification and equipment specification. To make valid decisions in equipment purchasing, decision models can be used in vendor selecting phase and when deciding between different equipment models. These decision models can be, for example, decision trees to determine the consequences of choosing a certain type of equipment. For vendor selecting, outranking models are utilised. Table 13 shows the roles and responsibilities in the vendor choosing stage.

*Table 13, Roles and responsibilities in the vendor choosing phase.*

<b>Role</b>	<b>Responsibility</b>
Purchaser	Seeks for vendor candidates
	Selects vendor based on team approval
	Selects equipment to be purchased
	Negotiates with the vendor
	Participates Technical Requirement Review with the Supplier
	Ensures that the vendor is approved and at appropriate level of purchase
	Verifies that the vendor meets the requirements
	Adds vendor to ERP
Purchase Project Owner	Makes CAR
	Participates Technical Requirement Review with the vendor
	Signs Technical Requirement Review with the vendor
	Makes readiness plan including risk management plan
	Approves vendor verbally
	Approves readiness plan
Engineering Team	Approve vendor verbally if needed
	Approve readiness plan
Engineering Manager	Approves vendor
	Approves readiness plan
Sourcing/ Supplier Quality	Approves vendor

Once the quotes are received, the most attractive candidates are chosen for further analysis, which is done by visiting them or them visiting the case company and with help of decision trees and outranking. In relation to this, when the price of the equipment to be purchased is known, the project owner makes CAR application if it is needed. There already might be a CAR existing if there is a big project going on, such as entirely new laboratory equipment base. The CAR making can happen ear-

lier than after quote requests if the price range is known, but at this point it should be done at the latest. At the same time, it should be checked whether any of the vendor candidates is already approved for the case company or should it be added to the approved suppliers list. This also includes adding the vendor to ERP if it is not there at this point. These tasks are for the purchaser to do.

Approving the vendor is done after established and executed vendor evaluation, and qualification actions based on the supplier risk level determination. This risk determination is done with help of company specific documents. The purchaser negotiates, if necessary, the details of the purchase. These details are based on the approved purchase and equipment specifications. The details may include documented supplier controls and responsibilities in contracts (i.e. purchase orders and Quality Agreements) as well as ensuring that validation and re-validation activities are properly performed. Additionally, a demonstration can be included in the contracts that the associated records have been reviewed and accepted.

The project owner drafts readiness plan for the equipment to arrive and this readiness plan includes risk management section. In risk management section, there are considered details such as identification of hazards and hazardous situations, estimation and evaluation of the risk associated with the use or installation of the equipment and so on. The readiness plan is approved before the installation happens by cross-functional team explained in Table 13.

### 5.2.3 Purchasing Equipment

The final phase, purchasing, is shown in Figure 11. This phase also includes the steps done in ERP.

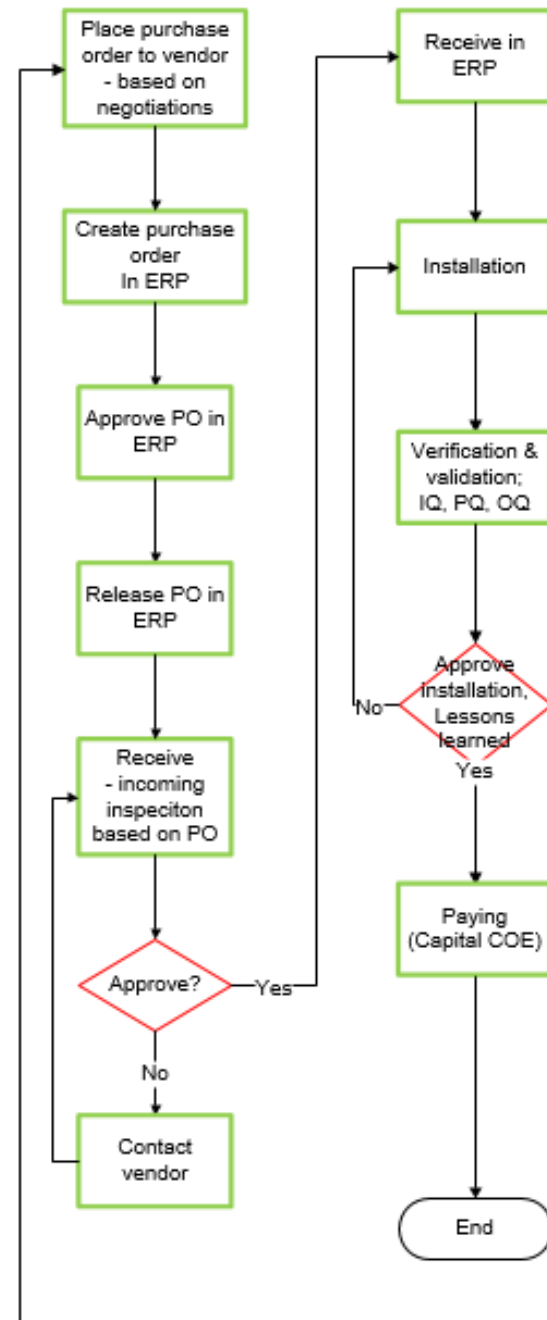


Figure 11, Purchasing phase of the proposal.

The actual purchasing is done by one of the R&D engineers instead of separate purchasing function in the company (decentralised purchasing). As can be seen in Figure 11, the purchasing engineer, purchaser, places the purchase order to the vendor based on the earlier negotiations. The purchase order is also placed in ERP by the purchaser and approved in ERP by another engineer, because the system does not allow the same person to do these two transactions in ERP. The purchase order is a legal document that describes the items that are ordered. The electrical

PO is not sent to the vendor automatically so the purchaser has to make sure the actual PO is placed to the vendor. The roles and responsibilities are listed in Table 14.

*Table 14. Roles and responsibilities in purchasing phase.*

<b>Role</b>	<b>Responsibility</b>
Purchaser	Places purchase order to vendor and communicates the requirements
	Creates PO in ERP
	Receives purchased equipment
	Receives purchase in ERP
	Incoming inspection to equipment vs. PO
	Participates in Lessons Learned
Purchase Project Owner	Releases PO in ERP
	Incoming inspection to equipment
	Ensures installation
	Ensures V&V activities
	Participates in Lessons Learned
Engineering Team	Incoming inspection to equipment
	Approve readiness plan
	Participates in Lessons Learned
Quality	Approves installation
	Participates in Lessons Learned

The listing of the roles and responsibilities, as shown in Table 14, reveals that in the purchasing phase, there are tasks not only for the purchaser but for the purchasing project owner (later: Owner) and engineering team also have important tasks to ensure successful purchase. The purchaser places the PO to the vendor as well as in ERP but the owner releases the PO in ERP. This happens since the system does not allow the PO placer and releaser to be the same person. In addition to placing PO and receiving the equipment, the purchaser also participates in incoming inspection which is now done against the PO and also to Lessons Learned meeting to improve the process. The Owner ensures that necessary actions are taken towards installation and V&V activities, and she/he also participates to the incoming inspection of the equipment as well as Lessons Learned.

Purchasing order template should be used to ensure that all R&D organisation purchases look the same and they take into account all relevant matters. The template should include places for the vendor details (name, address, phone), the purchaser details (name, address, phone), itemised list of the purchase with prices, date, reference to the quote, delivery details and so on. The template should be made in

collaboration with the sourcing and quality representatives. The checklist can also be used as a help when making the purchase order to make sure that nothing has been forgotten and also to use when receiving the purchase. Once the purchased equipment is received, it is inspected against the purchase order and if they do not match, the vendor is contacted for further actions.

After receiving the equipment and stating that it corresponds to the purchase order, the equipment is installed. Installation is done usually by the vendor and once it is completed successfully, the verification and validation activities can take place. These actions should be defined when negotiating the purchase and they usually include Installation Qualification (IQ) and Operational Qualification (OQ). The installation is approved also by cross-functional team including Quality Engineering.

The final step to the Equipment Purchasing Process is to have Lessons Learned which is a team meeting intended to find development areas in the process but also document the purchasing event retrospectively.

### 5.3 Analysis of the Feedback for the Proposal Draft

The background of this study and the proposal draft were introduced to the R&D team in a workshop. There was an open discussion about the current state and the proposal draft. In addition to the workshop, some one-to-one discussions were made. The feedback was documented on process map with corrections and handwritten field notes. The results can be found from Table 15. Since the participant group was small, the responses are not specified in order to maintain the anonymity of the informants.

Table 15, Summary of Data 2: Feedback for the proposal draft

Function	Reaction	Description
1. R&D Engineers 2. Quality Engineering 3. Supplier Quality 4. Engineering Management	Positive	"This is something we really need"
		"This is very "topical" and important topic."
		"Readiness plan is a really good step to check everything has been reviewed and set for the purchase (space, weight, training...) so decision is then made."
		"Very good overall!"
		"Good job!"
	Neutral	"Assigning roles in the team is important (e.g. we have 3 persons as purchasers) and explaining concisely who does what is even more important, because process/work instructions are abstract it is good to know how they match in our own team."
		"The flowchart requires some fine tuning."
	Constructive criticism	"Make sure that the flowchart is in line with SOPs and QPLs."
		"Flowchart to match with the global purchasing controls and SSP decision tree."
		"Please highlight that we are/were in the middle of integration and we have new persons on board."
"Service workflow could be added."		

Table 15 reveals that the responses were mainly positive about the proposal draft. The proposal draft was developed into the initial proposal together with the participants of Data stage 2. Their input for the workflow was essential, for example, when deciding the places of actions and also deciding whether some actions are needed or not.

#### 5.4 Development Needs and Ideas

Findings of Data 2 workshop and discussions revealed that some amendments ought to be made to the proposal draft, although there are only few development needs and ideas. Development needs identified in the discussion were related to matching internal company guidelines to the proposed workflow. Additionally, some participants wanted to extend the proposal to cover purchasing services as well. However, the final proposal did not consider that route because the focus of this

study is in purchasing equipment. The proposed roles did not change after the feedback was received. The participants were happy with the identified roles.

Summing up the results, the proposed workflow considered most parts that are needed in the purchasing concept. The amendments were mainly fine-tuning, for example moving some action boxes to other places in the workflow. ERP related actions were not in the draft version, but for the initial version they were added. Data 2 did not reveal any prioritisation or time plan either. Nor the first steps were discussed. Since the case company is going through a transition period, there will be a new set of the company specific documents available soon and they will have to be inspected, reviewed and added to the workflow.

## 5.5 Summary of the Proposal Draft

The proposal draft is based on evidence of the current state analysis, best practice and benchmarking. Developing the initial proposal from the draft version involved all concerned parties and the initial proposal identifies actions and owner to each action. The initial proposal differs from the current practice as summarised in Table 16.

*Table 16, Comparison of current state and the proposed equipment purchasing concept*

<b>Current Purchasing Process</b>	<b>Proposed Purchasing Concept</b>
No process description; no clear picture of the equipment purchasing	Process description as an easily readable workflow
No defined roles and responsibilities	Prescribed roles, responsibilities and ownership
No team meetings to see if all is as should be	Prescribed team meetings to give input and permission to proceed.
Vendor selecting justification unclear	Vendor selecting is done transparently
No formal inspections	Formal incoming inspection; formal approval for installation and validation of the equipment

As can be seen in Table 16, the proposed purchasing concept brings added value to the case company. Due to the proposed concept, workflow, the process description is available. There are also defined roles and responsibilities as well as owner-

ship not only to the purchasing project, but also to the steps of the process. The team meetings proposed for giving input works as the gates that the process has to pass before proceeding in the process. In addition, previously the vendor has been selected in various ways. The proposed concept offers more transparent ways for selecting vendor.

Next, the initial proposal is validated and refined to the final proposal.

## 6 Validation of the Proposed Concept

This section discusses how the proposed concept was utilised and what kind of feedback was given by the management and key stakeholders.

### 6.1 Implementing of the Proposed Concept, Experiences and Feedback

Implementing the proposed concept was done by presenting it to the engineering management, site quality leader and R&D engineers. This type of implementation was selected due to the short time of this study. Since there was no Type 1 equipment to be purchased and due to the tight schedule of the study, such a situation could not be waited. The initial proposal, that was refined from the proposal draft based on Data 2, was discussed with the managers. This formed Data stage 3.

The experiences are limited to theoretical implementation only and therefore there is no solid feedback about whether the proposed concept works or not. The feedback is summarised in Table 17 below. To maintain confidentiality of the participants, the feedback is grouped by its nature: positive comments, neutral comments or constructive criticism.

*Table 17, Summary of Data 3: Feedback for the initial proposal*

Function	Reaction	Description
Site Quality Manager Engineering Manager Principal R&D Engineer	Positive	"This is a good study."
		"This is something we need."
		"I can see this as a benchmark for future purchasing projects."
	Neutral	"Unfortunately at this moment we cannot test this in real life situation."
		"We could try this with some easy purchase and see how it goes... At least we would see if it doesn't work."
	Constructive criticism	"This study cannot be utilised in all equipment purchases, for example there are off-the-shelf equipment that do not require such heavy workflow."

As seen in Table 17, the team seemed to be quite happy with the initial proposal and there were only a few comments to improve it. Based on Data 3, the initial pro-

posal was revised and new workflow was drawn. This workflow is explained and the roles opened in the next section, Section 6.2, Summary of the Final Purchasing Concept.

## 6.2 Summary of the Final Purchasing Concept

The final Equipment Purchasing Concept for the R&D Organisation is a process description in a workflow format just like the initial proposal is (Figure 7). As there are no dramatic changes between the initial proposal and the final proposal, the steps and roles are described in details in the previous subsections and summarised in Appendix 5.

As can be seen in Appendix 5, there are more roles identified in the improved process compared to the current ways of purchasing. It may seem more bureaucratic as well. However, depending on the project, the roles can be divided to only few persons so that the Design Engineer, Project Owner and Purchaser are the same person. In addition, QE, manager and another engineer are required to ensure thorough groundwork for the purchase.

The findings from the current state analysis of this study revealed that there was a need to describe and visualise the equipment purchasing process in order to increase the understanding of the process. The best practice found in literature as well as benchmarking showed that building a good foundation to the purchase by defining it thoroughly. Therefore the idea of the final concept is that it works as a job aid to the purchaser. The concept consists of one sheet with the workflow on the other side and roles, responsibilities and owners on the other side replenished with the actual names of the responsible persons.

The researcher recommends that, firstly, the concept is tested as soon as there is a need for Type 1 equipment. Secondly, all related information, for example, related documents, is added to the workflow. Thirdly, the new process is trained to the engineers and for taking it into use, the checklists for the defining, selecting and purchasing stage are done accompanied with specification and purchase order templates to ensure compatibility with the company procedures and quality policy. Tracking system is set-up for equipment statuses: equipment ordered, received, waiting installation and installed.

## 7 Discussion and Conclusions

This section summarises this study and discusses the next, immediate steps that are recommended by the researcher.

### 7.1 Summary

The objective of this study is to establish, on a conceptual level, the way of systematic laboratory equipment purchasing in the R&D organisation; in other words, to establish the equipment purchasing concept for the R&D organisation context. The Helsinki based R&D organisation of the case company is in transition phase and building new R&D testing laboratories and therefore purchasing equipment for the new laboratories is decentralised from procurement functions to R&D engineers. The engineers have not been exercising a systematic or uniform way of equipment purchasing and therefore the objective is topical and very relevant for the case company.

Outcome of this study is a description and guidelines of the new equipment purchasing concept, specifying what factors ought to be considered and how the purchasing should be carried out, on a conceptual level. The description and guidelines are compressed into a workflow which also includes the owners for each step. The idea of the finalised concept is that it is visualized as one sheet with the workflow on one side and the roles, responsibilities and owners on the other side. This sheet is meant to be used as a job aid in the equipment purchasing. The outcome is met although it was not tested within this study due to tight schedule and lack of appropriate test purchase. The testing is done afterwards when appropriate situation occurs.

The business benefits from this study are clear. The current lack of process description is tackled in this study and the understanding of purchasing activities has increased within the R&D team. Previously, the new equipment was purchased by somewhat following the company guidelines, but the company documentation and procedures is developed on such a high level that they do not offer any detailed

enough guidance to the R&D purchasers. Additionally, there are also gaps in identifying roles and responsibilities, and defining the purchase. Therefore, the equipment purchasing concept proposed in this study defines the roles and responsibilities and also gives a detailed step-by-step guidance to perform the tasks effectively.

## 7.2 Outcome vs Objective

The objective of this study was to propose a systematic way of laboratory equipment purchasing in the R&D organisation as described in Section 1.4 . The outcome of this study was a detailed process description for equipment purchasing for the R&D context as declared in Section 6.2. When comparing the outcome to the objective, the result is that they are congruent.

## 7.3 Managerial Implications

This study tackles a vital challenge in our R&D organization, namely purchasing new equipment to the new laboratories. The current purchasing is done in various ways and may cause ineffectiveness, loss of time and also loss of resources.

This study has produced a proposal to tackle these issues. The proposal consists of process flowchart and description of roles and responsibilities in each step of the flowchart. As a result of this study, the R&D engineers have a tool to evaluate, decide and execute equipment purchases quickly and effectively, ensuring company procedures and quality policy.

Thus this study recommends the following actions to be taken by management:

- nominate a process owner
- decide on piloting the process
- decide on implementing the revised purchasing process after piloting
- dedicate appropriate resources
- encourage communication at all stages.

If these decisions are taken, the equipment purchasing is done more effectively in the future. On a practical level, the communication between the engineers is essen-

tial. The engineers should define the purchases carefully and also when receiving the equipment with solicitude. The owner of each purchasing project should demand participation from every stakeholder in the process steps that are defined in the workflow.

In addition to the above, the budget of the project must be acceptable to engineering and financial management. Since the CAR procedure is heavy, the purchasing projects should be bundled in one big investment plan, for example all future investments of one year to one CAR.

#### 7.4 Evaluation of the Thesis

The researcher made special efforts to conduct this Thesis in an orderly manner so that the outcome, a detailed process description for equipment purchasing, meets the requirements of the objective. The research design was clear and utilised, and it was constructed in a relevant order. Benchmarking was done before the current state analysis in order to get insight and ideas of what kind of questions should be asked from the interviewees of the current state analysis. The current state was then mapped extensively and good picture was formed. The literature review was conducted utilising various sources, although more time could have been spend on it. In this study, the literature review was carried out in a four months period and to dive into the most recent best practice, more time should have been consumed.

This study can be used as a benchmark to future equipment purchasing transactions in R&D organisations. This study does not apply to other purchasing actions as such, and if it is used for purchasing services, for example, it should be pre-viewed and adjusted accordingly before utilising.

#### 7.5 Validity and Reliability

Validity of the study is an estimation of how well the study measured what it is supposed to measure and whether the results are consistent with the goals and done with the suitable tools. The chosen method, interviewing, was not as effective as it could have been, because there were many key persons that did not want to participate. Therefore their input was documented based on their previous participation and statements, and some essential information may have got left out of the study.

The chosen questions were not 100% effective either and this shows, for example, when all of the interviewees did not answer all of the questions. However, all of the responses supported the business challenge.

Reliability of the study describes the consistency by asking whether it can be repeated. To ensure reliability of this study, hundreds of pages of the case company documentation were studied in order to get proper understanding of the company policy and eight people were involved in discussions from R&D, Quality and Customer Order Management to cover all key functions. Some of that documentation referred to were obsoleted documents and there also was an atmosphere of constant changes, so that some of the documents are already expired when this study is finished. All of these people were asked the same questions to get a proper picture of how they understand the current purchasing process. All of the participants did not answer all of the questions but regardless of that, the current state was mapped as comprehensively as it could within a small team and short period of time. The observations made during this study were documented in logs. However, many of the observations contain confidential, proprietary information to the case company and therefore they could not have been added to this study as such. To make them completely transparent, they should have been constructed in a way they could be added to this study as field notes.

## 7.6 Final Words

This study is important and topical to the case company. It helps the company in identifying the steps and tasks required in equipment purchasing to R&D laboratories. It also helps by identifying roles and responsibilities so consequently, the process is easy to absorb. Savings can be made through effective, established purchasing process due to simplicity of the process, as well as more effective task allocation with clear roles and responsibilities. Moreover, when there is no perplexity due to a well-established process, the time that is spent with the purchases is more effectively used.

This study has contributed to understanding and defining test equipment purchasing in the R&D organisation of the case company. In the future, the increased quality requirements effect the test equipment amongst other challenges. This is why it is important to have an established purchasing concept.

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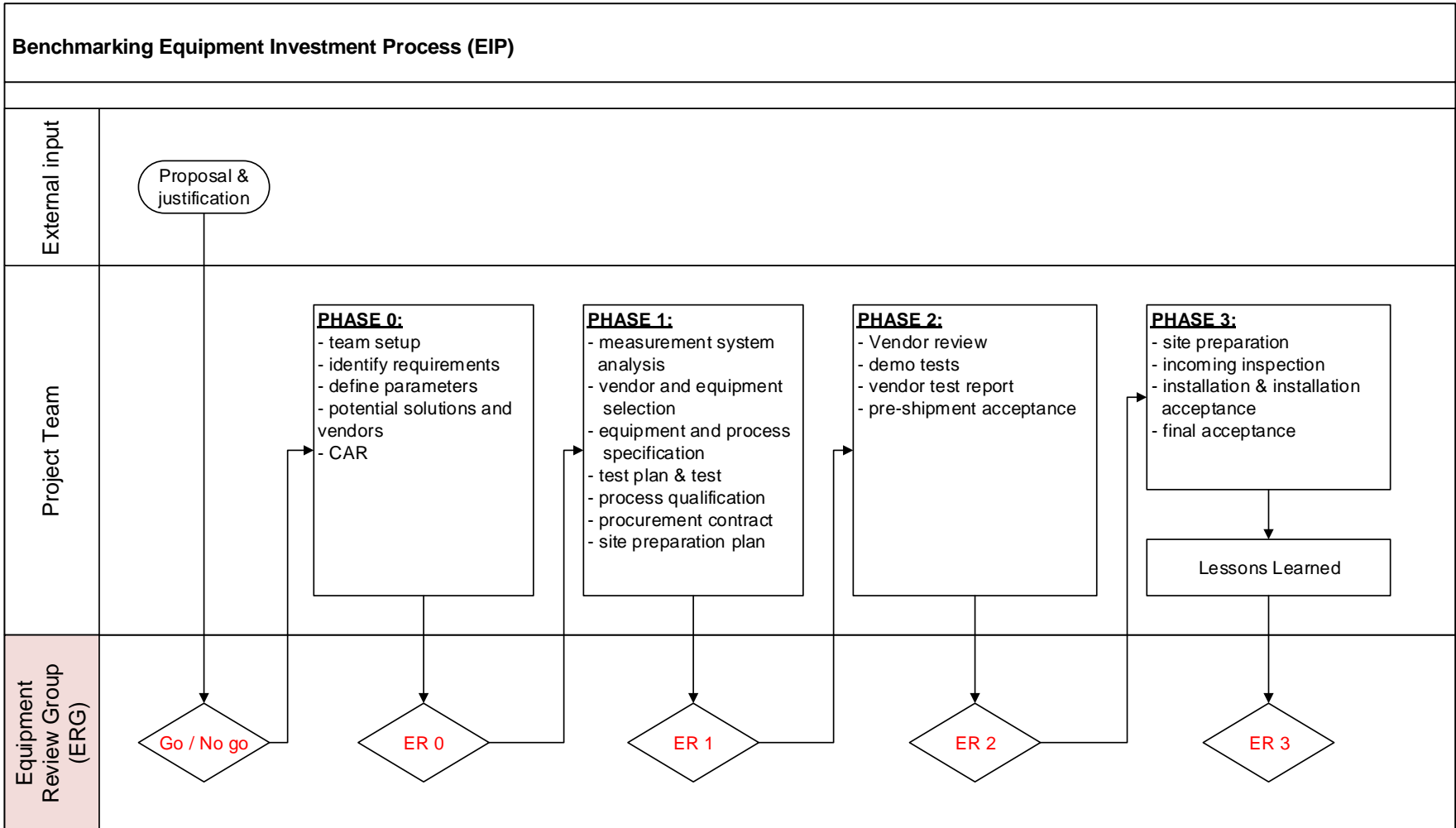
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### **Questions for Benchmarking**

1. Please, tell me about purchasing equipment?
2. What goes well in this (strengths)?
3. In your opinion, what could be done better?
4. How would you improve/develop?
5. Can you tell an example of a successful purchase?
6. Can you tell an example of an unsuccessful purchase?
7. Other that you would like to share?

<b>Date:</b>	February 2015
<b>Informant and position:</b>	Equipment Control Manager for 20 years; Equipment maintenance and investments, ERG manager
<b>Reason for the interview:</b>	Benchmarking
<b>Theme 1: Current ways of purchasing</b>	<ul style="list-style-type: none"> <li>- Investment process <b>starts when there is a clear demand</b> i.e. we see that the volumes are growing and hence comes the need for the new equipment. It may be a new product family or the capacity for growth of our current product family or portfolio. The future need for the equipment based on capacity increase in is easier, because we can buy something that is like what we already have. New product is more challenging and the equipment requirements need to be reviewed more carefully. For our products, there are not always equipment available in the markets, so they are custom made for us. The need for new equipment can become due to aging of the installed base.</li> <li>- it's a big team with <b>different roles</b>: project manager, buyer, specification makers; e.g. process development, equipment/service engineer, purchasing, legal. The project manager is responsible for progression of the project and takes it to ERG.</li> <li>- All <b>documentation</b> is in one index; there is a index tree that has all the project related documents (also revision control). It's a particular place where you can always find certain things.</li> <li>- We always use a <b>specification template</b>. E.g. IT issues are always considered the same way + clean room compatibility, ESD, etc. that always need to be considered. It's like a standard in our company. The things are always ready in the template and everyone can add process specific specifications. To help with the specifications, we have <b>checklists</b>: e.g. the new equipment uses new chemicals, so we check that this chemical is imported to Finland, is the cleanroom classification ok, are the safety datasheets ok, etc. that are additionally checked. Or the equipment: did we get the connection diagram, what electrical connection etc. Checklists help to foresee things so the purchasing and installing etc. go smoothly and there are no extra costs or waiting times. When we do specifications, we consider training as well; that is it budgeted in the investment or is it paid separately. You have to be strict: if you specify something, you have to stick to it. If you use the same vendor again and you have not abided by what you have agreed to, you do a disservice to yourself, because the vendor may thing that the next time they don't need to follow the contracts. The contracts are made by the buyer.</li> <li>- Equipment purchasing is part of Global Operations: The order book, capacity and capability management.</li> <li>- There are <b>gates</b> within the process (ERG) and each phase ends to these gates where there are <b>formal approvals</b>. In short, the process goes like this: <ul style="list-style-type: none"> <li>• There is a need for new equipment and proposal &amp; justification is made.</li> <li>• Phase 0: Decide the project manager and team. Make specifications. Find out what equipment we already have and/or seek for vendor. Compare different vendors. Make CAR =&gt; after this, ERG i.e. see the risks and decide whether to proceed or not.</li> <li>• Phase 1: detailed specifications, decide the vendor.</li> <li>• Phase 2: building the equipment, testing and approving before shipping.</li> <li>• Phase 3: installing, final testing and final acceptance, as well as lessons learned.</li> </ul> </li> <li>- The EIP is followed with smaller purchases as well, e.g. microscopes if there are extra parts with them.</li> </ul>
<b>Theme 2: Strengths</b>	<ul style="list-style-type: none"> <li>- Orderliness, consistency, standard templates, standard check sheets, explicit process description</li> <li>- Every function signs off the ERGs, so all are liable together.</li> </ul>
<b>Theme 3: Weaknesses</b>	<ul style="list-style-type: none"> <li>- Often the Lessons Learned are not done.</li> </ul>

<b>Date:</b>	February 2015
<b>Informant and position:</b>	Team Leader and Clean Room Manager for 16 years in a technical research centre
<b>Reason for the interview:</b>	Benchmarking
<b>Theme 1: Current ways of purchasing</b>	<ul style="list-style-type: none"> <li>- Investment suggestions are done by the research team with ~100 people in it. They and team leader make together a <b>suggestion of what investments</b> should be done in the following year, and the business unit manager decides how much money is given to each research team. Each research team can <b>prioritise</b> what investments are done and in which order. The person in charge of the investment contacts the investment team. They together decide the <b>specifications</b> for purchasing the equipment. Then the <b>bidding</b> of vendors is started.</li> <li>- Investment team is familiar with the <b>competition formalities</b> and they are the actual buyers together with the researcher. They also collaborate with legal team. There is a <b>sourcing procedure</b> which describes the <b>stages of the purchase process</b>.</li> <li>- <b>Specifications are put into numbers</b>, so that the final vendor selection is based on measurable data instead of "I feel" decision.</li> <li>- <b>Equipment support and training</b> are specified when selecting the vendor.</li> <li>- Manufacturing/factory inspection before receiving the equipment is essential. Do not accept half-made equipment to be received.</li> <li>- <b>Timing the payments</b>: do not pay all at once but make the contract so that the last payment is made when the equipment is installed.</li> </ul>
<b>Theme 2: Strengths</b>	- <b>Checklists</b> and <b>clear process</b> .
<b>Theme 3: Weaknesses</b>	<ul style="list-style-type: none"> <li>- There are no <b>long term</b> or <b>systemic plans</b>.</li> <li>- When starting the process, not knowing how much money can be used.</li> </ul>
<b>Theme 4: Improvement opportunities</b>	<ul style="list-style-type: none"> <li>- Long term plan: new equipment and the aging of old equipment.</li> <li>- Communication could be improved between the interest groups.</li> </ul>

<b>Date:</b>	February 2015
<b>Informant and position:</b>	Buyer of incoming goods for 7 years; works with various material management tasks
<b>Reason for the interview:</b>	Benchmarking
<b>Theme 1: Current ways of purchasing</b>	<ul style="list-style-type: none"> <li>- All purchasing is <b>planned in ERP system</b> based on forecasts and general sales.</li> <li>- We have company specific procedures and instructions for how to do this. The process <b>starts</b> from deciding <b>what kind of equipment</b> is needed and it flows from engineering to sourcing and from there to buyers.</li> <li>- Approved suppliers are chosen in <b>collaboration</b> of sourcing, supplier quality and engineering departments.</li> </ul>
<b>Theme 2: Strengths</b>	<ul style="list-style-type: none"> <li>- Clear <b>responsibilities</b>.</li> </ul>
<b>Theme 3: Weaknesses</b>	<ul style="list-style-type: none"> <li>- <b>Communication</b> between the different teams/roles is not always effective, e.g. sourcing team may have price as the first priority and buyers see that the location of the supplier is more important. If the supplier is e.g. in Asia, there can be delivery delays or other issues and if the supplier is closer, it could be more expensive but yet quicker service.</li> </ul>

1. Please, tell me about purchasing equipment?
  - How does this happen?
  - Are there roles? Who does what?
  - Who makes decisions?
  - What is the start and what is the finish point?
  
2. What goes well in this (strengths)?
  - What works?
  - Why do you think so?
  
3. In your opinion, what could be done better?
  - What does not work?
  - Why do you think so?
  
4. How would you improve/develop?
  - What more?
  - What less?
  - What not at all?
  - What should be?
  - What should not be?
  
5. Can you tell an example of a successful purchase?
  
6. Can you tell an example of an unsuccessful purchase?
  
7. Other that you would like to share?

<b>Date:</b>	March 2015
<b>Informant:</b>	Informant 1
<b>Type of data collection:</b>	Interview and data transcription
<b>Theme 1: Current ways of purchasing</b>	<p>The process starts from, that we know what we want: service or equipment. The need can become due to a project: when it goes further, we think "this kind of thing has to be done" and then we evaluate whether we buy it as a service from somewhere else or do we do it ourselves and from there we continue.</p> <p>Both [service and equipment] have a vendor. We start the project and evaluate the price. We make CAR: where the money is going, what is the impact if the proposal is not approved i.e. we evaluate and verify the need. We also evaluate if it impacts taxation in the future (= write offs, fixed assets). There are many approvers. The CAR is made by the project leader.</p> <p>There is one that has the whole responsibility, project manager, and this person is seeking for vendors and requests quotes and orders [the equipment]. But it can be also so that some people get parts of it i.e. some equipment and deal with the entire process for them and the whole responsibility of the entire project is with the project leader. He who orders the equipment also has responsibility over that, that the equipment is capable of doing what it is supposed to do. We also can rely on previous information so that if there is similar equipment, we check if there is later model available of it, or some other vendor. With collaboration anyway and based on the knowledge that what we want to do with the equipment (e.g. what kinds of tests), and the tester (i.e. verification engineer) should be able to say that what kind of equipment is needed and what are we going to do in the future possible and does it fulfil the precision specifications and so on.</p> <p>Then we look for the vendor and make decision that we want to buy from this one. We check if the vendor is approved in the purchasing system (SAP). If not, we add it there. Depending on what kind of service, there are different forms. If it is depending on Quality Affect, you need a form. For small (indirect) purchases there is another form. There is a decision tree that which process is the correct one. The vendor is approved by Engineering Manager (if indirect) and otherwise Sourcing, Finance, Engineering Manager and QE. The vendor has to provide presentations and demonstrations when required and also be able to support afterwards, e.g. annual maintenance.</p> <p>Then we make PO in SAP, but not now because we do not have access to SAP we make it manually with Excel. PO is approved by Engineering Manager or Director. Then the equipment and invoice arrive. In the invoice, there has to be the same sum than in PO. Equipment is received in SAP (maybe) and now when we do this manually, we let them [Capital COE] know that we have an invoice and it's gonna be paid.</p> <p>There are no actual contracts and training etc. has been agreed via e-mails so we do not have any official contracts.</p>
<b>Theme 2: Strengths</b>	<p>During this transition period, we have received lots of support from other functions.</p> <p>Flexibility and co-operation; when we've received the equipment, we have checked if this is absolutely what we wanted or do we need to change something; bold decisions.</p>
<b>Theme 3: Weaknesses</b>	<p>We haven't known very clearly what we are doing i.e. uncertainty; even if you do things correctly, you can't be sure that you've done it right. Makes it slow and there are misunderstandings and we can do things wrong.</p> <p>Takes time and it has been hard to allocate time to this, I mean we've been doing this along other tasks. We have to learn new because there is no equipment support.</p> <p>At this moment we need support from outside of our own team (SAP). There is a possibility to make two POs [in SAP] for one purchase because of the manual process.</p> <p>Document templates have references to other documents, it is confusing.</p>

<b>Date</b>	March 2015
<b>Informant</b>	Informant 2
<b>Type of data collection:</b>	Interview and data transcription
<b>Theme 1: Current ways of purchasing</b>	<p>As far as I am aware, we do not have any overall-process description but e.g. paying the invoice in SAP has been described in very details. Typically project leader is responsible for schedules, plans and expense tracking. The decision whether to buy equipment or service is ultimately with the Engineering Director but typically the projects can decide by themselves.</p> <p>The vendor has to be approved and we have not had a situation that some vendor could not be approved. We do not have a Purchasing Manager or centralised purchasing. Otherwise we trust that the equipment purchasers know what they are doing.</p> <p>PO is done in SAP; does not go to the vendor. No PO - no pay policy. In practice, PO is made in SAP when we already have the invoice because it is not necessary known how much it [services] costs until the invoice arrives. Although with equipment the costs should be known beforehand (received quote).</p> <p>Bigger investments are done with CAR. Single small purchases are rather done as expenses and each one of them are not done as CAR because of the heaviness of the process. CAR is made by someone that is free in the team at that moment of time. The person who makes CAR is not automatically the project leader. Basically, CAR is an application to the management to commit capital. Assumption is that these kinds of investments have long life. Investments against CAR are added to company assets and their value is re-evaluated annually within removal programme. This is to different the expenses and investments in the book keeping. Typically these are purchased services; contractors, calibrations etc. After the CAR is approved, the invoice comes in some point. You need to recognise the invoices that are related to that CAR and add the asset numbers to the invoices. This asset tracking number considers all of the equipment within that CAR, for example there is one CAR for lab equipment, another CAR for product moulds etc.</p> <p>The invoice is paid by Accounts Payable team. The invoice is sent there by a-mail with other details and they pick it from there. PO and Quote have to be attached. By this far, the vendor has to be setup in SAP. The PO is signed by the Engineering Manager and when we pay, we check at the same time that we received what we ordered. At this time, we also add information that what kind of expense this is: consult service, equipment purchase etc. We usually do not pay by instalments because we do not have custom made equipment but usually of-the-shelf equipment.</p>
<b>Theme 2: Strengths</b>	There is no high level follow-up, i.e. extra control. When everything goes as intended, we do not need any. The freedom in purchasing, i.e. there has not been any necessity to create additional controls e.g. for limiting the amount of vendors or centralising purchases; extra upkeeping follows and this eats effectivity.
<b>Theme 3: Weaknesses</b>	Everything is not entirely electronic but we have to scan signed documents.
<b>Theme 4: Improvement opportunities</b>	CAR is very heavy process so we could try to bundle the purchases for example like that, that all purchasing needs for lab equipment in 2016 are in one CAR.

<b>Date:</b>	February 2015
<b>Informant:</b>	Informant 3
<b>Type of data collection:</b>	Hallway discussion
<b>Theme 1: Current ways of purchasing</b>	<p>Well, we start by searching the net if there are good candidates for the equipment [<i>selling</i>] and then we ask for quotes. From there we choose one and place the purchase order. It is not very complicated.</p> <p>Paying the bills – I do not know about that. I guess the manager does that. We do not use SAP yet, so I guess they are done manually. I suppose they come in some point after the equipment is arrived.</p> <p>We have all sorts of Excel trackers to see what equipment we are to purchase. I guess we could mark there when they arrive.</p>
<b>Theme 2: Strengths</b>	I guess there are some but I do not know how to put it. Maybe it is better to ask someone else.
<b>Theme 3: Weaknesses</b>	I guess there are some but I do not know how to put it. Maybe it is better to ask someone else.
<b>Theme 4: Improvement opportunities</b>	We should have a process description. Something that shows what is done and when. It is sometimes a bit blurry what happens.

<b>Date:</b>	March 2015
<b>Informant:</b>	Informant 4
<b>Type of data collection:</b>	Hallway discussion
<b>Theme 1: Current ways of purchasing</b>	We have a list of equipment to be purchased and the responsibilities are divided to four people. Each one of them takes case of their own part.
<b>Theme 2: Strengths</b>	It has been quite free for us... I mean, we just buy and there is a bill in some point of time.
<b>Theme 3: Weaknesses</b>	<ul style="list-style-type: none"> <li>- the purchasing process is not clear</li> <li>- there is no purchasing organisation</li> <li>- there is no training for purchasing.</li> </ul> (sic!)
<b>Theme 4: Improvement opportunities</b>	Centralising the purchases into one place would be nice. In this way, there might be better deals. But as said, we do not have purchasing or sourcing organisation who would do this and there might be one time only –purchases so this could be tricky.

<b>Date:</b>	March 2015
<b>Informant:</b>	Informant 5
<b>Type of data collection:</b>	Hallway discussion
<b>Theme 1: Current ways of purchasing</b>	<p>In to my knowledge, there is no overall process description of the current ways of equipment purchasing.</p> <p>There are several forms to fill in and descriptions of what and how but there are more like how things are inserted into SAP or similar.</p>
<b>Theme 2: Strengths</b>	Well, the parts that I know, are well documented and into my understanding we can operate quite freely.
<b>Theme 3: Weaknesses</b>	We're missing clear picture of the entity of the process.
<b>Theme 4: Improvement opportunities</b>	There should be some kind of a process description for the whole process.

<b>Date:</b>	March 2015
<b>Informant:</b>	Informant 6
<b>Type of data collection:</b>	Workshop
<b>Theme 1: Current ways of purchasing</b>	[No comments on this theme.]
<b>Theme 2: Strengths</b>	We are quite free to make decisions.
<b>Theme 3: Weaknesses</b>	<ul style="list-style-type: none"> <li>- no clear ownership</li> <li>- we don't really know what was included to the purchase</li> </ul> <p>(sic!)</p>
<b>Theme 4: Improvement opportunities</b>	<p>There are so many things to consider: is the installation included? Validation activities? Are maintenance services available? Is the warranty period de-fined? What are the accompanying documents? Drawings, circuit diagrams? Manuals in which languages? Are we ready to receive the equipment? Is there a place assigned? Are the spare parts easily available? All these need to be considered when doing the purchase.</p> <p>Do we have OQ, IQ, PQ? Who does them? Have we considered these?</p>

**Details of the Company Specific Documentation**

<b>Group</b>	<b>Name of the Document</b>	<b>Pages</b>	<b>Description</b>
<b>A</b>	Quality Agreement Decision Tree	2	Decision trees
<b>A</b>	Self Service Purchasing Decision Tree	2	Decision trees
<b>B</b>	Contract Summary Sheet	3	Forms and instructions
<b>B</b>	Kanban Release	1	Forms and instructions
<b>B</b>	New Supplier Request Form	5	Forms and instructions
<b>B</b>	Purchase Order Requisition Form	1	Forms and instructions
<b>B</b>	Purchase Requisition	3	Forms and instructions
<b>B</b>	Self Service Supplier Request Form	5	Forms and instructions
<b>B</b>	Supplier Change Notification (SCN) Review Process	4	Forms and instructions
<b>B</b>	Supplier Diversity – Supplier Self Certification	3	Forms and instructions
<b>B</b>	Supplier Quality Performance Evaluation	2	Forms and instructions
<b>B</b>	Supplier Quality Self Audit Questionnaire	7	Forms and instructions
<b>B</b>	Supplier Scorecard Template	3	Forms and instructions
<b>B</b>	Supplier Self-Audit Questionnaire	4	Forms and instructions
<b>B</b>	Technical Review Form	2	Forms and instructions
<b>B</b>	Vendor Amendment Form	1	Forms and instructions
<b>C</b>	Contract Summary Sheet	3	Guideline Documents
<b>C</b>	Display Vendor	8	Guideline Documents
<b>C</b>	SAP Vendor Controls and Report	6	Guideline Documents
<b>C</b>	Supplier Scorecard Reporting Guidelines	7	Guideline Documents
<b>C</b>	Supplier Selection Criteria	1	Guideline Documents
<b>D</b>	Buyer Job Aid	37	Job aids
<b>D</b>	Debit Memo	1	Job aids
<b>D</b>	Molding Supplier Checklist	3	Job aids
<b>D</b>	New Supplier Request Form Instructions	8	Job aids
<b>D</b>	Shipping Memo	1	Job aids
<b>D</b>	Supplier Diversity - How To Find a Small or Diverse Supplier	2	Job aids
<b>D</b>	Technical Requirements Review	2	Job aids
<b>E</b>	Corporate Managed Scorecard Suppliers	2	Lists
<b>E</b>	Purchasing Controls Common Acronyms and Definitions	5	Lists
<b>E</b>	Purchasing Site Index	1	Lists
<b>E</b>	SET Master Index	3	Lists
<b>F</b>	Approved Supplier List	4	Procedures
<b>F</b>	How to create CAR	3	Procedures
<b>F</b>	Purchase Order Maintenance	4	Procedures

<b>Group</b>	<b>Name of the Document</b>	<b>Pages</b>	<b>Description</b>
<b>F</b>	Purchasing Support	6	Procedures
<b>F</b>	Supplier Change Notification (SCN) Review Record	7	Procedures
<b>F</b>	Supplier Maintenance and Changes	4	Procedures
<b>F</b>	Tooling Terms Template	1	Procedures
<b>G</b>	Guide Data Driven use of Supplier CITs	37	Process descriptions
<b>H</b>	Tooling Terms and Conditions Record	1	Records
<b>I</b>	Kanban	8	Standard work instructions
<b>I</b>	Kanban Terms	1	Standard work instructions
<b>I</b>	Manufacturer Evaluation	5	Standard work instructions
<b>I</b>	Purchasing	14	Standard work instructions
<b>I</b>	Purchasing Activities	24	Standard work instructions
<b>I</b>	Purchasing and Inspection Process	9	Standard work instructions
<b>I</b>	Purchasing Methods and Processes	10	Standard work instructions
<b>I</b>	Sourcing Plan	7	Standard work instructions
<b>I</b>	Supplier and Consultant Selection and Approval	17	Standard work instructions
<b>I</b>	Supplier Contracts	7	Standard work instructions
<b>I</b>	Supplier Evaluation and Maintenance	17	Standard work instructions
<b>I</b>	Supplier Evaluation and Maintenance	3	Standard work instructions
<b>I</b>	Supplier Management System	6	Standard work instructions
<b>I</b>	Supplier Quality Performance & Metrics	9	Standard work instructions
<b>J</b>	Purchasing Controls	6	Standard operating procedures
<b>J</b>	Capital Appropriation Request (CAR) Policy	5	Standard operating procedures

**Example of a Flowchart Report**

<b>Flowchart Report</b>						
<b>Master Name</b>	<b>Displayed Text</b>	<b>Status</b>	<b>Owner (Name)</b>	<b>Function</b>	<b>Start Date</b>	<b>End Date</b>
Start/End	Need for new test			Design Engineer		
Process	Assign team			Engineering Manager		
Decision	Buy test service or buy new equipment?			Engineering Director/Manager		
Decision	Class 1 or 2 equipment?			Design Engineer		
Process	Preliminary investment plan			Design Engineer		
Process	Make CAR			Project Lead		
Decision	Approve CAR			Engineering Director, Capital COE		
Process	Equipment & purchase specifications; Final project investment plan			Project Lead		
Decision	Approve specs			Project Lead		
Process	Seek vendor candidates			Purchasing		
Process	Quote requests, Site visits, Technical Requirement Review			Purchasing		
Process	Select vendor & equipment type			Purchasing		
Process	Readiness plan			Project Lead		
Process	Negotiations ( based on specifications)			Purchasing		
Decision	Approve readiness plan			Project Lead		
Decision	Approve vendor?			Purchasing		
Process	Vendor to SAP			Purchasing		
Process	Place purchase order to vendor (based on negotiations)			Purchasing		
Process	Create purchase order In SAP			Purchasing		
Process	Approve PO in SAP			Project Lead		

<b>Master Name</b>	<b>Displayed Text</b>	<b>Status</b>	<b>Owner (Name)</b>	<b>Function</b>	<b>Start Date</b>	<b>End Date</b>
Process	Release PO in SAP			Engineering Manager		
Process	Receive in SAP			Purchaser		
Process	Receive: incoming inspection based on PO			Purchasing		
Process	Installation			Project Lead		
Process	Verification & validation; IQ, PQ, OQ			Project Lead		
Decision	Approve installation, Lessons learned			Project Lead		
Process	Paying (Capital COE)			Capital COE		

## Roles and Responsibilities in Equipment Purchasing Concept for R&D

### Organisation Context

Role	Responsibility	Phase	Description	Rationale
Design Engineer (Requestor)	Initiates the need for a new test		Project meeting	Start
	Participates in making specifications		E-mail, workshop	Knows of the tests to be performed with the new equipment
	Approves specifications		Equipment purchasing project meeting	Knows of the tests to be performed with the new equipment
	Decides whether to buy test equipment or test service		Project meeting, if applicable	If the decision is not clear by the project team
	Preliminary investment plan		Free form, CAR	To evaluate the project costs
Engineering Manager	Assigns ownership		Project meeting, if applicable	If the decision is not clear by the project team
	Approves expenditure		Signature in CAR form	Required by company policy
	Approves vendor		Signature in vendor form	Required by company policy
	Approves readiness plan		Equipment purchasing Project meeting	The final approval that all aspects are taken into account
Engineering Team	Participate in making specifications		E-mail, workshop	To cover all angles
	Approve specifications		Equipment purchasing project meeting	To cover all angles
	Approve vendor verbally if needed		Equipment purchasing project meeting	To cover all angles
	Approve readiness plan		Equipment purchasing project meeting	To cover all angles
	Incoming inspection to equipment		At laboratories	To cover all angles
	Approve readiness plan		Equipment purchasing project meeting	To cover all angles
	Participates in Lessons Learned		Equipment purchasing project meeting	To improve the process
Purchase Project Owner	Ensures the specifications are made and approved		E-mail, workshop, equipment purchasing project meeting	Ownership to cover all angles
	Makes CAR		Form	(If required) by company policy
	Participates Technical Requirement Review with the vendor		Meeting, site visit	(If required) by company policy
	Signs Technical Requirement Review with the vendor		Meeting, site visit	(If required) by company policy

Role	Responsibility	Phase	Description	Rationale
Purchase Project Owner	Makes readiness plan including risk management plan		Deskwork	Ownership to cover all angles
	Approves vendor verbally		Equipment purchasing project meeting	To cover all angles
	Approves readiness plan		Equipment purchasing project meeting	The final approval that all aspects are taken into account
	Releases PO in SAP		SAP	For COE to be able to pay the invoice
	Incoming inspection to equipment		At laboratories	To cover all angles
	Ensures and documents the installation		With vendor	Ownership to cover all angles
	Ensures and documents the V&V activities		With vendor, if applicable	Ownership to cover all angles
	Participates in Lessons Learned		Equipment purchasing project meeting	To improve the process
Purchaser	Participates in making specifications		E-mail, workshop	To cover all angles
	Reviews purchase requisition if applicable		Deskwork	To cover all angles
	Seeks for vendor candidates		Internet, previous knowledge, other available knowledge	To get more than one option
	Selects vendor based on team approval		Decision trees, outranking	To get the best option
	Selects equipment to be purchased		Decision trees, outranking	To get the best option
	Negotiates with the vendor		E-mail, meeting	To get the best price and package
	Participates Technical Requirement Review with the Supplier		Meeting, site visit	(If required) by company policy
	Ensures that the vendor is approved and at appropriate level of purchase		Forms, ASL (Approved Suppliers List)	Company policy
	Verifies that the vendor meets the requirements		Forms	Company policy
	Adds vendor to SAP		Forms, SAP	Company policy
	Places purchase order to vendor and communicates the requirements		E-mail, SAP	Required by company policy
	Creates PO in SAP		SAP	Required by company policy
	Receives purchased equipment		Acknowledgment in the internal tracking list	To cover all angles

Role	Responsibility	Phase	Description	Rationale
Purchaser	Receives purchase in SAP		SAP	Required by company policy
	Incoming inspection to equipment vs. PO		At laboratories	To cover all angles
	Participates in Lessons Learned		Equipment purchasing project meeting	To improve the process
Quality	Determines the quality affect level of the purchase		Equipment purchasing project meeting	By company policy
	Approves installation		Equipment purchasing project meeting	To cover all angles
	Participates in Lessons Learned		Equipment purchasing project meeting	To improve the process
Sourcing/Supplier Quality	May participate in deciding the equipment classification		Equipment purchasing project meeting	To cover all angles
	Approves vendor		Equipment purchasing project meeting	To ensure the company policy is followed