Uncovering Hidden Needs in Ground Engineering: Case Study of LKAB Wassara

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Identifiering av dolda behov inom grundläggning: Fallstudie av LKAB Wassara

Igor Kordas

Godkänt	Examinator	Handledare
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Sammanfattning

Detta examensarbete utgick både från behovet av bättre förståelse för grundläggningsmarknaden av LKAB Wassara – ett innovativt företag som har utvecklat den nya tekniken av hydraulisk DTH-borrning; och från insikten att åstadkommande av kundnöjdhet genom uppfyllandet av dolda behov i byggbranschen är en lovande men samtidigt utmanande uppgift. Utmaningen som behandlas i detta examensarbete är tvåfaldig: dels leder de konventionella marknadsundersöknings metoder ofta till att de dolda kundbehoven inte erhålls, trots att dessa behov är mycket viktiga för produktinnovation; och dels är det en brist på fallstudier som utforskar de explicita eller dolda behoven i byggbranschen. Detta kan delvis förklaras av komplexa inbördes förhållande mellan produkter, tjänster och intressenter som är typiska för byggmarknaden. Dessa överväganden formade detta examensarbete som innehåller en fallstudie med analys av dolda behov inom byggsektorn; utforskande av explicita och dolda kundbehov i grundläggningsmarknaden i Sverige; och utveckling av rekommendationer för Wassaras nuvarande och framtida produkterbjudanden samt affärsutveckling, baserade på resultat från studien av grundläggningsmarknaden och behovsanalysen. För att möta dessa mål genomfördes en omfattande litteraturstudie om metoder för identifiering av dolda kundbehov och strategier för analys av kundnöjdhet. Litteraturstudien resulterade i en verktygslåda som möjliggjorde en marknadsstudie och analys av explicita och dolda kundbehov på den Svenska grundläggningsmarknaden. I sin tur lyckades marknadsundersökningen med att avslöja både de explicita och dolda behov som inte har uppfyllts av något av de företag som är verksamma på marknaden. De identifierade behoven har genom Kanos matris och värde-tolknings ekvationer översatts till rekommendationer för Wassaras framtida produkterbjudanden samt affärsutveckling. Vidare, har marknaden för byggutrustning visat sig vara främst ledd av tekniskt utveckling, vilket inte nödvändigtvis är en begränsning, men det finns behov av att både investera i nya teknikutvecklingsprojekt och att agera på kundernas behov. Studien fann särskilt många bevis på att service, support och kunskapskommunikation till kunderna och användarna är viktigt för att kunderna ska erhålla det kompletta värdet av produkten.

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2015-12-day	Anders Berglund	Jens Hagman
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Abstract

This thesis stemmed from the need for better understanding of the ground engineering market by LKAB Wassara - an innovative company that developed a novel technology of hydraulic DTH-drilling; and from the insight that achieving customer satisfaction through fulfilment of hidden needs in the construction industry is a promising yet challenging endeavour. The challenge addressed in this thesis is twofold: firstly, the conventional market studies often lead to the hidden customer needs being lost, while these needs are important for product innovation; and secondly, there is a lack of case studies exploring the explicit or hidden needs in the construction business that might be partially explained by complexity of interrelations of products, services and stakeholders inherited to the construction market. These considerations shaped the presented study to be aimed at performing a case study for hidden needs analysis in the construction sector; exploring explicit and hidden customer needs in the ground engineering market in Sweden; and developing recommendations for Wassara's current and future product offerings and business development based on results of the ground engineering market study and the needs analysis. To meet these aims an extensive literature review on methods for uncovering hidden customer needs and approaches for customer satisfaction analysis has been made, resulting in a tool-kit that enabled a market study and analysis of customer explicit and hidden needs for the ground engineering market in Sweden. In its turn, the market study succeeded to reveal both the explicit and hidden needs that have not been satisfied by any of the companies operating on the market. The uncovered needs have been translated into recommendations for Wassara's future product offerings and business development through the Kano's matrix and the value perception equations. Finally, the construction equipment market is found to be very technology led, which is not necessarily a limitation, but there is a need to both be able to invest into new technology projects and to act upon customer needs. In particular, the study found many evidences that service, support and knowledge communication to the customers and users is important in order for them to retain the full value of the product.

FOREWORD

This Master Thesis is the result of 20 weeks of work during summer and fall of 2015, researching the hidden depths of the ground engineering market. It culminates the five years of studies at the MSc program Design and Product Development at KTH in Stockholm, Sweden.

I would like to extend my sincerest thanks to all people who contributed to this Master Thesis:

My supervisor at Wassara, Peter Svangård and the market chief David Petterson who introduced me to the world of ground engineering and provided me with insightful advices;

All the staff at Wassara who made me feel welcome at all times: Anki Karlsson, Anna Chiara Brunetti, Anne-Sofie Bohman, Fredrik Egerström, Fredrik Gransell, Johan Jeansson, Kent Boström, Maria Bengtsson, Magnus Hörman, Markus Lundborg, Michael Beas, Mikael Forslund, Peter Johansson, Stefan Swartling, Tim Peco, Veronica Bäcker;

My supervisor at KTH, Jens Hagman who constantly helped me steering the master thesis to the final destination;

All the companies and people who took part in the research.

Finally I would like to extend a very special thanks to my Mom and Dad for all the great support, encouragement and motivation during my journey at KTH.

Igor Kordas

Stockholm, December 2015

NOMENCLATURE

Shown here are the Abbreviations that are used in this Master Thesis.

Abbreviations

DTH	Down-the-hole
NPD	New product development
PD	Product development
DMU	Decision making unit

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1 INTRODUCTION

This chapter presents background and purpose of the thesis work, following by the research questions, aims and objectives as well as delimitations of the study.

1.1 Background

Urbanization continues to increase throughout the world (Frenning and Ståhl, 2011) and according to Eurostat, Sweden is the country with the fastest urbanization rate in Europe, which leads to the need for more infrastructure and housing projects. Urbanization affects the sizes of cities and the population density. The higher density, in its turn, leads to building and renovation being done in places, where ground and environmental conditions can be troublesome, and where regulations impose additional requirements on construction work (Bredenberg, et al., 2014; Carrero, et al., 2013). These trends are reflected in the development strategy of the City of Stockholm, which is aimed at achieving the Vision 2030 (Stockholm City Council, 2007) through important land use policies, for instance, promoting compact higher density urban form and urban infill; stimulating brownfield regeneration; and reducing urban sprawl (Carrero, et al., 2013). These policies and construction trends require more effort from construction companies, especially on the foundation work.

According to Rundquist et al. (2013), the innovativeness of construction market may be hampered by its conservatism. Furthermore, it can be argued that the factors hampering innovation in construction identified by Blayse and Manley (2004), such as structure of production, industry relationships, procurement systems, regulations/standards, and organizational resources, are rooted in the conservativism of the industry. Though, some experts believe that it is not the conservatism, but rather uniqueness of each construction project that causes problems to innovation processes (Rundquist et al., 2013). Nevertheless, both papers (Rundquist et al., 2013; Blayse and Manley, 2004) have mentioned a gap in communication between stakeholders in construction projects, which implies a necessity for better understanding of needs and wants of different stakeholder groups.

As concluded by Ahola (2006), the delivery of customer satisfaction through fulfilment of hidden needs in construction industry is complicated, due to complex interrelations of products, services and stakeholders. Applying methodologies for discovery of hidden needs within the market study for casing advancing has a potential to give a deeper understanding of the customer and stakeholder needs, wants and requirements, not just towards a product as a tangible object, but also towards a product package including different services and support.

The traditional methods of identifying customer needs have been found lacking in accuracy; and they often bring about results that disappoint companies (Goffin and Mitchell, 2010; Narver et al., 2004; Carlgren, 2013). Moreover, the conventional market studies often lead to the hidden customer needs being lost, while these needs are important for product innovation (Goffin and Mitchell, 2010; Schilling, 2013). At the same time, innovation has been recognized as a fundamental driver for competitive advantage in business (Schilling, 2013; Pinchot and Pellman, 1999).

There is a lack of case studies that evaluated the explicit or hidden needs in the construction business towards ground engineering products or services. Some of few documented examples include a study on satisfaction of hidden needs in project delivery in the construction market by Ahola (2006). Further, there have been reported few case-studies on hidden needs analysis for industrial markets, with the most active in this field being Hannu Kärkkäinen and his colleagues (Kärkkäinen et al., 2001; Kärkkäinen et al., 2001a; Kärkkäinen and Elfvengren, 2002), who consistently explored this topic in the Finnish industrial market setting.

Finally, according to Raja et al. (2013), there is a lack of research on integrated product and services.

1.2 Purpose

This Master thesis has been held at LKAB Wassara – a company that develops drilling systems for a wide range of different applications. These applications are mainly in ground mining, engineering, exploration and dams. Wassara headquarters and production facility is situated in Flemingsberg, Stockholm. Wassara has also a testing facility in Malmberget and designated sales officials all over the world.

The feature that distinguishes Wassara drilling systems from the others is the use of water to activate the DTH-hammer, instead of the more conventionally used air. The Wassara drilling system excels other drilling methods and systems by many parameters and is, in some cases, the only system that is possible or permitted to use (Bruce et al., 2013; Wittig et al., 2015). Nevertheless, Wassara has not succeeded yet in taking a considerable share of the ground engineering market, and is generally used as a last resort.

From the company´s perspective, the purpose of this study is to get a better understanding of the ground engineering market, as it is rather new and very lucrative market for their DTH-hammers and other products. The results of the study are to be applied for development of an offer for a drilling system that is by different factors meets the need of the ground engineering market. Currently, Wassara has no clearly stated offer for this market; and it is solely in the hands of the customer to choose the system configuration. Ultimately, the long-term benefit for Wassara from this Master thesis would be a larger market share of the ground engineering market.

Thus, Wassara's aims include:

- Establishing Wassara on a new market, namely ground engineering;
- Increasing Wassara competitiveness on the market;
- Increasing market share;
- Increasing market revenue.

To reach these aims the following objectives were formulated by Wassara:

- To perform a market study;
- To analyse Wassara's past, current and future product offerings based on the findings of the market study and assessed customer needs;
- To develop a product offer that would meet customer and company requirements;
- To develop the complete Wassara offer meeting customer and company requirement.

Wassara's aims and objectives are connected to hidden needs analysis and customer satisfaction theory through the research questions, aims and objectives presented in the next chapter.

1.3 Research questions, aims and objectives

This thesis is designed to answer the following research **questions**:

1. What are the explicit and hidden customer needs in the ground engineering market in Sweden?
2. How the revealed customer needs in the ground engineering market could be translated into recommendations for improvement of Wassara's product offerings and strengthening its business development?

3. What can be learned from a single case study of hidden customer needs analysis in the construction sector?

The **aims** of this thesis are to perform a case study for hidden needs analysis in construction sector; to explore explicit and hidden customer needs in the ground engineering market in Sweden; and to develop recommendations for Wassara's current and future product offerings and business development based on results of the ground engineering market study and the needs analysis.

These aims are to be met through the following research **objectives**:

- To review approaches for customer satisfaction analysis and methods for uncovering hidden customer needs;
- To perform market study and analysis of customer explicit and hidden needs for the ground engineering market in Sweden;
- To analyze Wassara's current product offerings and to develop recommendations for Wassara's future product offerings and business development based on results of the market study and needs analysis.
- To reflect on approaches to hidden needs analysis in construction sector on the base of lessons learned within the performed case study.

1.4 Delimitations

The market study is to be conducted for the Swedish market segment. Wassara has a hypothesis that the outcomes could be applicable for the whole northern Europe, and partially for North America. This hypothesis will not be assessed within this thesis.

The research is to be conducted only for the casing advancement applications used in ground engineering with focus on studying the ring-set concentric casing advancing system.

Only identification methods for uncovering the explicit and hidden needs are to be applied in this study, no need assessment will be performed at this stage.

The methods chosen for finding the hidden customer needs are often used to generate radical innovation, which is not the aim of this study. The focus is rather to improve the existing product and offer.

2 METHOD

This chapter presents the research design of the study that outlines the research process and the methods for data collection and analysis. The mixed methodology is used in the thesis, combining both quantitative and qualitative methods. The ethical consideration of the study is addressed at the end of the chapter.

The problem addressed in the study, namely uncovering the explicit and hidden needs in ground engineering, requires combination of quantitative and qualitative approaches to data collection and analysis, which is often the case for complex socio-technical phenomenon according to O´Leary (2010). Market studies usually include both the primary and the secondary research (Churchill and Iacobucci, 2005). The primary market research is targeting new specific questions and involves surveys, interviews and observations. The primary research of this thesis is focused on revealing hidden customer needs, and therefore, the methods and techniques for identification of hidden needs derived by Goffin and Mitchell (2010), Narver et al. (2004) and others are central for the study. The secondary research of this thesis aims at analysis of market trends and offerings, and therefore, includes analysis of market reports and marketing materials.

The research design of this thesis is presented in the Figure 1.

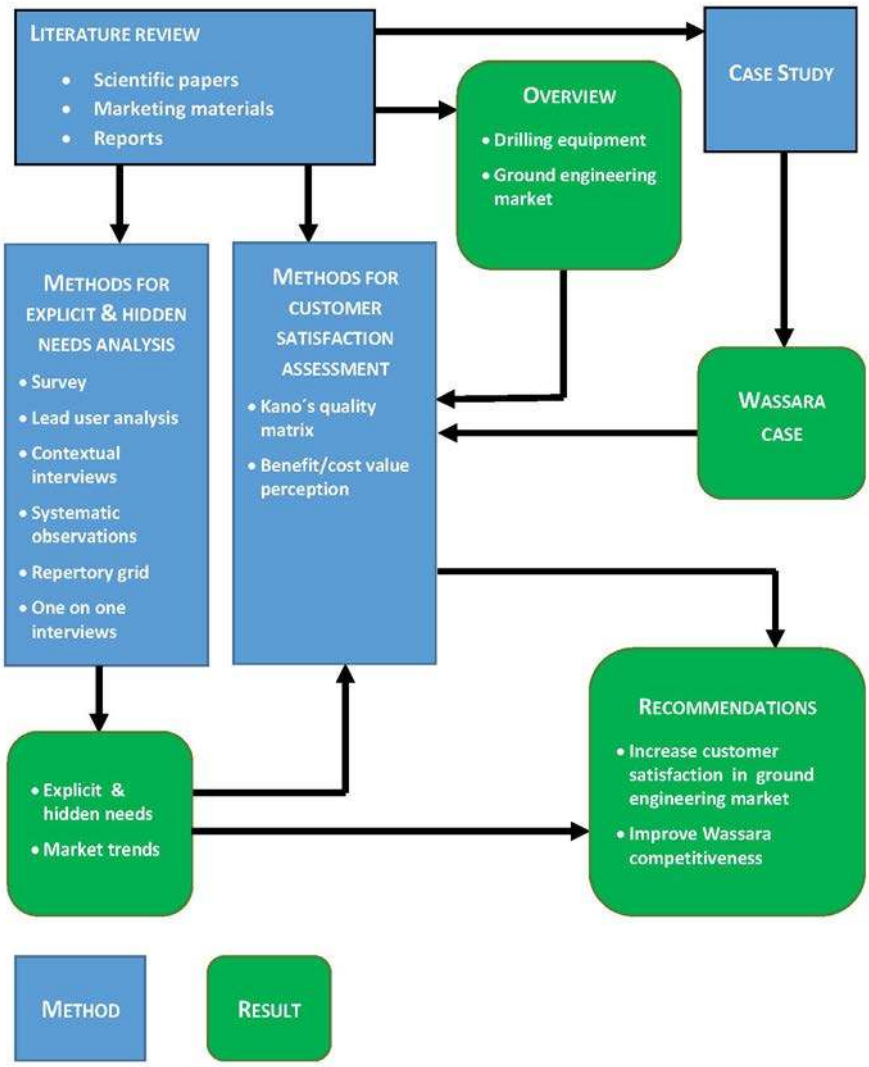

Figure 1: Research design

The methodological framework of this study includes literature review; case study of Wassara that embedded methods for explicit and hidden needs analysis; and methods for customer satisfaction assessment to translate the findings of the empirical study into recommendations for improvement of Wassara's product offerings and strengthening its business development.

2.1 Literature review

The extensive literature review has been done for two main purposes; firstly, to elaborate a tool-box for identification of explicit and hidden customer needs and for defining the methods to be used for customer satisfaction analysis within this study; and secondly, for studying offerings and trends of the ground engineering market with focus on casing advancement approaches.

For the first purpose the scientific papers and books on market research have been reviewed, particularly the ones focusing on:

- Market research models and methods;
- Methods for discovery of hidden customer needs and wants;
- Methods for application of market research on system configuration;
- Analysis of stakeholder influence in the ground engineering market and other heavy industries;
- Similar case studies in industrial markets.

For the second purpose, the archival documents, market reports and marketing materials have been studied.

2.2 Case study

This thesis incorporated a single-case study of Wassara. The case study is a methodology that is applied for in-depth studies of real-time complex social-technical phenomenon, especially in the cases when it is impossible to separate the phenomenon from its context and when the data should be collected from multiple sources and analysed through triangulation approach (Yin, 2009). The ground engineering market involves a large number of stakeholders and incorporates various formal and informal rules, regulations and values. Furthermore, the customer needs are clearly context-dependent. Therefore, the case study is an appropriate methodology for this research (O'Leary, 2010).

The case study designs vary from the single-case to multiple-case designs. The main limitation of the single-case studies is impossibility of statistical generalization of the research results from the single case. However, for the situations where the cases have unique features, the single-case studies are providing valuable insights (Yin, 2009); and instead of asking for generalizability as a credibility indicator of the scientific research, the transferability indicator is applied, namely whether the study leads to lessons learned that are important for other cases (O'Leary, 2013). Wassara can be regarded as a unique case as it is an inventor of the novel solution of water-activated DTH hammer that distinguishes it from all other producers in the market. And therefore, the single-case design has a potential to reveal useful information for many other companies in the market.

2.3 Data collection

The empirical study is made in collaboration with LKAB Wassara and internal/external stakeholders, including the market, production and R & D departments; retailers; customers; users; consultants and others.

The data collection is performed through conventional market research methods such as survey and one-on-one interviews; and the methods of hidden needs analysis identified through the literature review. These methods include Lead User; Empathic Design, comprising Contextual interviews, Systematic Observations, and Empathy building; Experimentation (co-development); and Repertory Grid. The detailed description of these methods is presented in the Chapter 4.4 of this thesis.

2.4 Data triangulation

The data collected by applying different quantitative and qualitative methods, have been converged in a triangulating manner and clustered into requirements, needs and hidden needs. Further, it was important to compare the data from different sources, as contradictory information often bares hidden needs (Goffin and Mitchell, 2010).

2.5 Ethical considerations

Application of firm ethical principles is central for researchers practicing methods from social sciences (O'Leary, 2010). In its turn, the ethical principles are rooted in moral obligations, including conscientiousness, equity and honesty according to O'Leary (2010).

The conscientiousness means that the well-being of respondents could not be jeopardised by the research. The equity refers to a requirement that all target groups are treated with equal respect, while the honesty is referred to the right of participants to get correct information about the study.

O'Leary (2010) suggested three general principles that are covered by ethical guidelines applied to different disciplines and institutions. These include informed consent, no harm to respondents, and confidentiality, which could be further strengthen to request of anonymity.

These principles are translated into the following rules of this study: all participants have a choice to decide about their participation in the study and the right to stop their participation at any time; the non-disclosure approach is to be applied, meaning protection of identities of respondents and informing them about the ways the results would be published at the beginning of the project; and finally, the empathic approach should be applied to ensure the well-being of the respondents.

3 DRILLING TECHNOLOGIES IN GROUND ENGINEERING

This chapter provides overview of drilling technologies and methods, including history of their development, operating procedure and application fields. Further, the water-driven drilling solution introduced by Wassara is described followed by discussion on advantages of the Wassara water-DTH system. Finally, the chapter covers overview of casing advancement methods as well as casing advancement applications for ground engineering.

3.1 Drilling technology

The main drilling methods used in ground engineering, including cable tool, rotary drilling, auger drilling, top-hammer and DTH-hammer, are presented in the Table 1. The table covers information on their history, how they operate, different applications and current use (Bruce, 1989; Bruce et al., 2013; Heiniö, 1999; Ruda and Bosscher, 2005; Walker, 2012).

Further, the differences between the rotary, top hammer and DTH-hammer drilling methods are explained in the Figure 2.

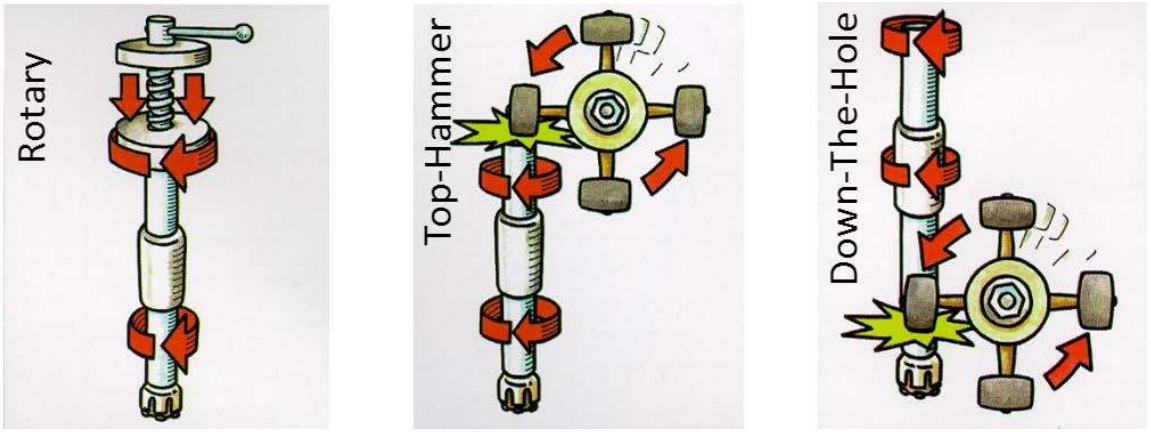

Figure 2. Simplified visualization of difference between Rotary, Top-Hammer and DTH-hammer drilling as proposed by Bruce et al (2013)

Among these methods, the DTH-hammer drilling is considered to be a more effective one for drilling in hard formation (Wittig et al., 2015; Walker, 2012; LKAB Wassara, 2015). The Wassara DTH-hammer is water activated rotary-percussive drilling method and it will be further explained in the next chapter.

Besides the abovementioned methods, there are a number of new drilling methods, such as sonic drilling, resonator percussive drilling and others. These drilling techniques are not fully developed yet and their application areas are not clear at time of writing this report.

Table 1: Overview of drilling methods

Drilling methods	History	Operation	Application	Current Use
Cable tool	The cable tool is the earliest drilling technique used and was applied already 4000 years B.C. in China. Deep wells (900m) often took generations to finish.	Drilling is done by lifting and dropping a heavy tool into a borehole. It breaks or crushes the rock or loosens soft material, which is extracted by a bailer.	Suitable for remote locations as it needs fewer supplies and is more cost-efficient. Has very low penetration rate. Mainly used in well-drilling.	New cable tools are more efficient, but they are still at the bottom of the penetration-rate charts, especially in hard rock. As a result this method is rarely used.
Rotary drilling	Rotary drilling is an ancient technique. There are indications that it was used already 3000 B.C. Current technology gained popularity in early 1900s.	The drill bit is rotated down into the borehole and cuts away or pushes aside material. Rotation is nowadays achieved with some type of motor.	Used for all types of ground engineering and well-drilling. It can penetrate most types of rock, but the drilling rates get too low and the bit wears out fast.	For casing advancing a dual rotary rig is used, basically implying that both the casing and the bit rotate separately. This method is often used in Sweden.
Auger drilling	Auger drilling started to be used in early 1900s, when engines become more available. The concept is nearly as old as the rotary drilling.	Auger drilling is similar to rotary drilling. The auger is drilled down and a hole is excavated as the material is drawn upwards.	For conditions such as loose overburden and sand. Augers get fast penetration rates, while being fairly cost efficient. Not fitting for conditions when the overburden contains boulder, gravel etc.	Used for site investigation, and boreholes for construction purposes. The main issue is that when a hole is excavated, it remains open only due to the ground properties.
Top-hammer	Top-Hammer started to be used in the late 1800s, but it became widely used during the 1950-1960s with emergence of the hydraulic top-hammer.	The top-hammer hits the drill string that percussively breaks down material into fragments. It also rotates in order to hit fresh material.	Used for all types of ground engineering. It has a limit in depth due to power losses and the need in significant size of the rig.	The method is often used in Sweden, especially when the DTH-hammer is not permitted, for example, when no air inflow into the formation is allowed.
DTH-hammer	The Down-the-hole hammer system was invented in 1950s, but started to be used more often during 1970s. Today there are both pneumatic and hydraulic DTH-hammers.	The method is similar to the top-hammer with the difference being that the hammer hits the drill bit directly, and therefore, no power is lost.	Used for all types of ground engineering in all types of material. Has theoretically no limit in depth after introducing of hydraulic DTH-hammers.	Has become one of the most used drilling methods worldwide. A barrier to its use might be high initial investment. Used generally for holes over 4 inch in diameter.

3.2 The Wassara Solution

The equipment components of Wassara rig-solution are presented in the Figure 3.

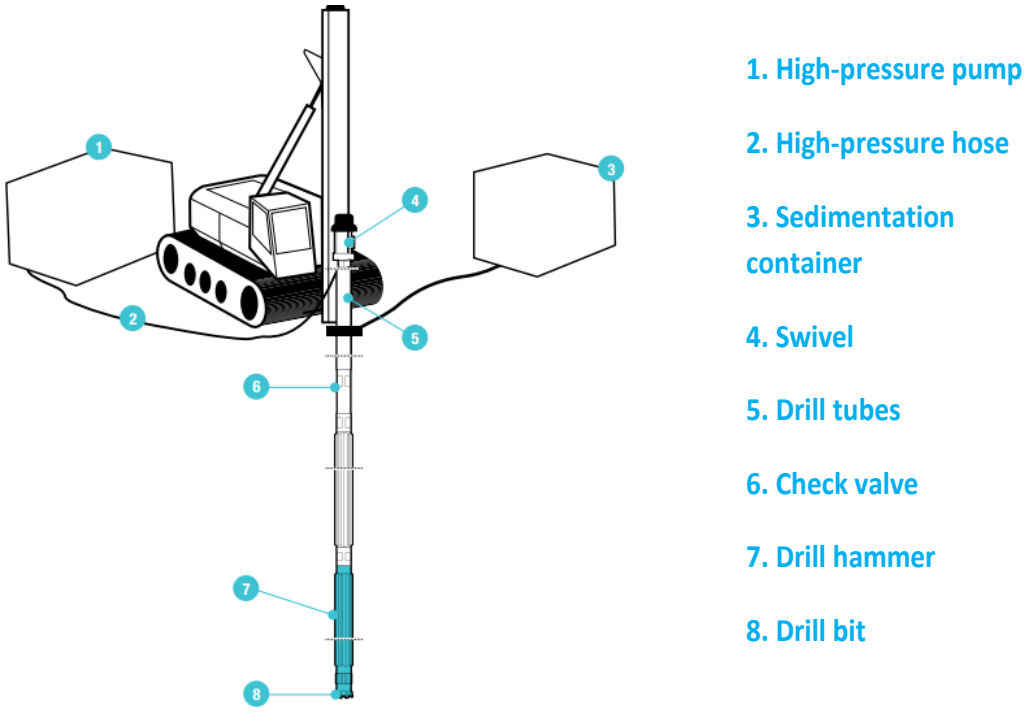

Figure 3. Overview of the complete drilling package and Wassara drilling system (in blue), from wassara.com (2015)

The DTH hammer is the central part of the Wassara system and is the only part fully manufactured by Wassara. Most of the other parts of a drill string are quite similar to pneumatic drilling systems, but have some adaptions to fit the specific medium, like for example, O-rings. Wassara holds the patents for these parts, but the production is outsourced. Wassara also rents out water-pumps optimized for water-DTH drilling systems.

Drilling with water-DTH hammer is achieved when the hammer hits the drill bit and, in its turn, the drill bit crushes material. The drilling process contains the following steps visualised in the Figure 4 (LKAB Wassara, 2015):

Step 1: The hammer valve is open and the piston moves back from its starting position.

Step 2: The piston gets in position, ready to strike.

Step 3: The valve closes and the high-pressure water forces the piston to strike.

Step 4: The piston strikes the bit. The valve opens to release the water through the bit. A new cycle starts.

Ultimately, when there is a change from high pressure to low pressure and vice versa a movement is made. The pressure changes appear when water passes a gate.

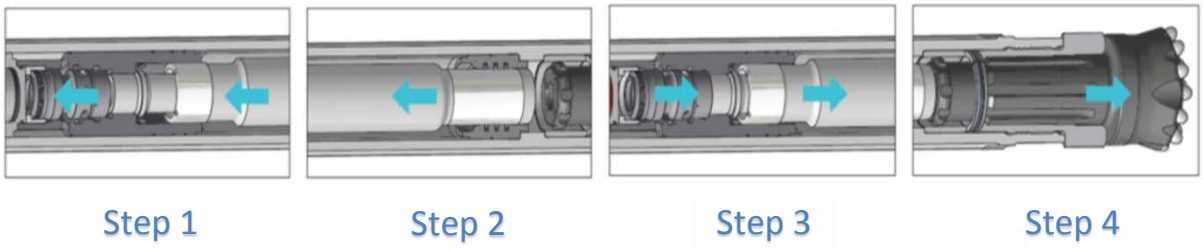

Figure 4. Drilling process with water-DTH hammer, from wassara.com (2015)

3.3 Wassara water-DTH system, its advantages and barriers for implementation

The unique feature that distinguishes Wassara´s drilling system from the other ones is the use of water to activate the DTH-hammer instead of the more conventionally used medium, namely air. This feature leads to many positive aspects that are linked to the properties of water and its interaction with down-the-hole and external environment. The essential for this technology properties and qualities include the following:

- Water is a fluid and thus incompressible.

Air is a gas, and therefore compressible, which implies that as the drilled hole gets deeper, the larger air flow is necessary to achieve the pressure required for an air-DTH hammer to function. The rule of thumb says that for every ten meters drilling below the water table, a loss of 1 bar is made (Halco, 2015; Wassara, 2015). That is a quiet substantial loss, taking into account that a high-pressure air compressor usually provides a pressure of 25-40 bar (Atlas Copco, 2015; Wassara, 2015). The water-pump may deliver a pressure of up to 180 bar. Taking into consideration that water is a fluid and thus incompressible, a water-DTH only needs the same continuous amount of water to function properly. This feature provides the possibility to drill deeper and straighter holes. The holes drilled with Wassara have an approximate deviation of 1-2% (Wittig et al., 2015; Walker, 2012), which is very low compared to deviations when using the pneumatic DTH-hammer. The lower deviation when using water-DTH hammer may also be due to the water hammer being guided much tighter due to less space requirements for water and cuttings to exit the hole. Air, on the other hand, expands significantly after passing through the hammer, and the cuttings from a pneumatic hammer are much larger than those of a hydraulic hammer, thus require more space to exit the hole (Wittig et al., 2015; Bruce et al., 2013; Wassara, 2015).

Further, when the air gets out from the drilling system through the drill-bit, it starts to expand, which is a major issue. When the air expands it can pressurize the ground area, lead to erosion, harm nearby structures and etc. Water, on the other hand, flows up to the surface and is gathered by a drain pump or simply flows out into the ground water, as it is not pressurized. As a result, hydraulic drilling systems are more suited for drilling in sensitive formations and sensitive areas than the pneumatic drilling systems (Bruce et al., 2013; Algmark and Eskilsson, 2014). A lot of current pneumatic drilling system development is concentrated around decreasing its effects on the ground conditions and nearby structures, for example, the Elemex casing advancement system developed by Atlas Copco (Walker, 2012; Atlas Copco, 2010).

- Ground water does not affect the drilling performance

When an air-powered drill reaches the groundwater table, two things would happen: firstly, water gets into the drilling system, which means that the air pressure falls and ultimately, if no actions are taken (f. ex. adding a booster) the drilling process will stop (Speer, 1996); and secondly, the water and shattered geological particles are pumped upwards and create an

unpleasant stream of slurry spraying all-over the site, which worsens the working conditions and contaminates the environment (Bruce et al., 2013). There is also a substantial issue with the amounts of water that are being pumped up when using an air-DTH hammer. This is due to the fact that the water needs to be removed from the site, which can be tricky as the amounts may get even larger, than with hydraulic systems and are scattered all over the site. The hydraulic systems, on the other hand, give the operator control over the water flow, which makes it easier to collect the water. Further, as long as a sedimentation tank is used, the matter of collecting the up flow of water blended with fragments is relatively easy (Wassara, 2015; Wittig et al., 2015).

- More environmentally friendly

Hydraulic drilling systems are more energy efficient, than pneumatic ones. This is largely due to the fuel consumption of a water pump, which is up to 4 times lower compared to an air compressor (Lindholm, 2011). The difference in energy efficiency might be even higher, as the abovementioned evaluation did not take into account the so called "boosters" needed for an air-powered drilling system when for different reasons the pressure is not high enough.

Moreover, the lubrication of parts inside an air-powered drilling system is done by adding oil. This is not environmentally safe and can lead, for example, to groundwater contamination. That is why in some cases drilling with this method is prohibited or the drillers are required to use the environmentally friendly oil, which is more expensive and has inferior lubrication properties leading to the system wearing out faster, than when using standard oil. Hydraulic systems have the lubrication procedure done by water, which is much safer (Bruce et al, 2013). Using a hydraulic system leads also to less airborne dust compared to a pneumatic system, as water binds most of the small particles created by drilling. Furthermore, there is no oil-mist in the air, as oil is not used for lubrication (Bruce et al., 2013).

Finally, both the underground and aboveground environments are less affected by vibrations and the sound of the drilling process. For instance, the tests done in "Malmberget" testing facility have shown that hydraulic systems have 20-40 dB lower sound-level, than the pneumatic ones (Wassara, 2015; LKAB Wassara, 2015). It should also be noted that air-compressors are very loud compared to water-pumps according to interviews with Wassara, drillers and observations within the performed site-visits.

While having the aforementioned advantages, implementation of the Wassara technology is limited because of the following barriers:

1) High initial investments

The water-DTH drilling method requires relatively high initial investments. These investments include water pumps, drill pipes and some case-specific parts or equipment. This is the similar situation to the times when the air-DTH has been introduced to the market; then it was considered that one of the main barriers for implementation of the air-DTH were the initial investments in air compressors, and service cost of the compressors and the DTH-hammers (Ruda and Bosscher, 2005; Walker, 2012). Having in mind that the air-DTH technique is considered to be mature and is used worldwide nowadays (Walker, 2012), it can be assumed that the investment barriers are not perceived as very high by customers.

2) High water consumption

The water consumption is a strong barrier for Wassara technology, as the drilling process requires large amounts of water. Furthermore, in many cases the large amounts of water need to be taken care of. These issues could be solved by using a water treatment and recirculation system, but there is no such adequately priced system available on the market at the moment (Wittig et al., 2015).

3) High water quality requirement

Wassara DTH-hammers require high water quality. This requirement concerns the acceptable size of grains and amount of particles in the water. Therefore, it is, for example, not obvious that taking water from a seemingly clean lake can ensure that the hammer will work properly or have adequate service life (Wassara, 2015; Wittig et al., 2015).

3.4 Casing advancement methods

The processes of drilling a hole and advancement of casing into the hole are always executed simultaneously in Sweden, according to interviews with Wassara and its retailer. The main advantages of simultaneous drilling and casing advancing are the prevention of collapsing walls and time-saving (Kardos, 2008; Hix, 1991). Most casing advancement users experienced that sometimes the casing cannot be advanced to the preferred depth (Hix, 1991). But, since the casing remains in the hole all the time, every part of the hole can be retained (Kardos, 2008).

From interviews with Wassara, the following description of how casing advancement is generally carried out is derived:

The most price effective way of driving down a casing is by using a casing crown bit and inside it a drill string with a DTH hammer and a rock drilling bit. This method is commonly known as the dual rotary method (Ruda and Bosscher, 2005). The casing is rotated down and the DTH hammer bit crushes the material in the middle of the casing. This method requires a dual-rotary rig that can both rotate the casing and the bit. It is important to mention that these rigs cost nearly double the price of an ordinary single-rotary rig according to Wassara´s retailer. Further, this casing advancing method is used as long as the casing crown can handle the material it comes across. With boulders in the way it stops working, and therefore, the eccentric or the concentric casing advancement systems need to be used.

3.4.1 Eccentric and concentric casing advancement systems

The eccentric casing advancement bit, as presented in the Figure 4 (a), utilizes a part that flips out, when the bit is lowered done through the casing, and drills a hole with a marginally larger diameter than the casing.

The eccentric casing advancement method is executed with the following steps (Bredenberg et al., 1998):

1. The eccentric pilot bit is lowered through the casing;
2. By rotating the pilot bit in one direction a wing flips out making the size of the pilot bit slightly larger than the casing;
3. The eccentric bit rotates and reams the whole while the casing simultaneously slides down;
4. When the desired depth is reached the wing is flipped back into the pilot bit and the drill can be extracted from the hole;
5. Often when rock has been reached the next step is to lower down a regular rock-drilling bit and continue further.

The eccentric bit´s main weakness is that in hard formations or in the case of too many boulders in the ground it may deflect too much, which leads to a crooked hole (Atlas Copco, 2009).

When the ground properties are too harsh for the aforementioned casing advancement methods, the best solution is to use a concentric ring-set system, shown on Figure 4 (b) and Figure 5. The ring-set system can drill through any formation and delivers the straightest holes (Wassara, 2015; Finnra, 2003; Atlas Copco, 2009). However, the cost of a ring-set system is significantly higher compared to the others, largely due to the need to leave the ring bit in the ground, if the casing is required to be left in the ground. Consequently, for a project where hundreds of steel-piles are drilled down, the need to leave hundreds of ring-bits incurs high costs. Using an eccentric system eliminates the need for a ring bit.

On the other hand, from a risk assessment point of view, interviewed drilling professionals consider the concentric ring-set to be the safest casing advancement system. The ring-set casing advancement method is explained the next chapter.

Recently, systems incorporating benefits from both eccentric and concentric systems, Figure 4 (c), have appeared on the market. These systems have parts that are placed concentrically around the middle of the drill-bit, and when the bit is lowered through the casing they flip out, by that creating a drilled diameter that is larger than the casing´s diameter. The main benefit with this system is avoiding the need to leave expensive ring-bits in the ground. These systems are considered to be more efficient in tough environments and deliver straighter holes than the eccentric systems, but they are considerably inferior to the ring-set systems according to interviewed ground engineering companies and Wassara´s retailer. In this study, this type of systems will be called the" concentric wing-system".

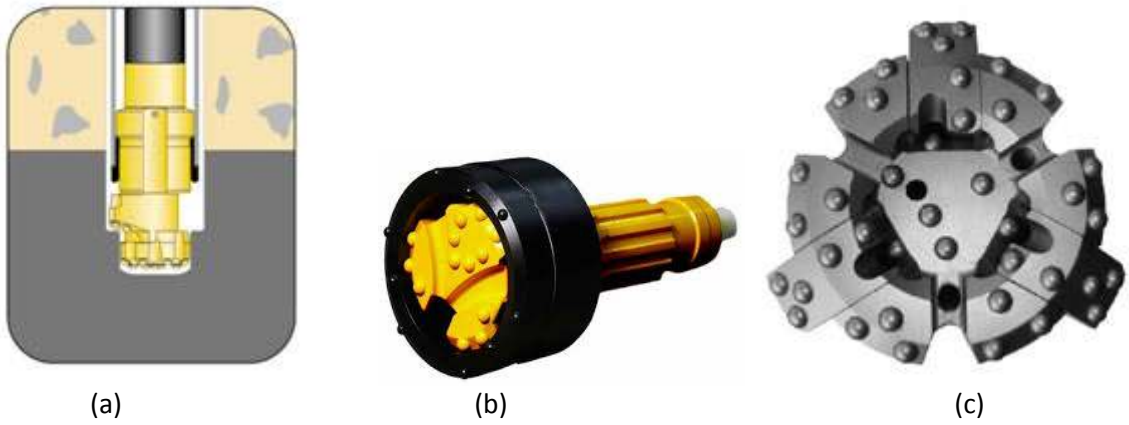

Figure 4. (a) Eccentric system (Bredenberg et al., 1998, p. 75), (b) ring-set concentric system (Atlas Copco, 2010) and (c) concentric wing-system (dthrotarydrilling.com)

3.4.2 The ring-set casing advancing system

Ring-set casing advancing with a DTH hammer is used for a variety of different purposes in ground engineering. The act of drilling down steel-pipes (casings), Figure 5 (c), which is called "piling" is used to build foundations, reinforcements, geothermal holes and etc. (Atlas Copco, 2009).

The ring-set system consists of the following parts, Figure 5 (a) (Atlas Copco, 2009, p.4):

- Pilot bit: the pilot bit is lowered into the casing and is fixed to the ring-bit with a snapping motion. It drills away the centre part of the hole and guides the drill string. The pilot bit is attached to the hammer with a standard shank.
- Ring bit: the ring bit is locked onto the pilot bit and drills the void for the casing to advance down the hole.

- Casing shoe: the casing shoe is welded to the ring-bit and the casing pipe, which is pulled forward by the impact of the DTH-hammer and the pilot bit.

Only ring bit and pilot bit rotate during drilling, casing and casing shoe do not rotate.

During the drilling process the casing might end and a new casing may need to be welded onto the previous one in order to reach a certain depth, Figure 5 (b). There is also a technique where the casings are threaded and are bolted together. The drill pipes also need to be prolonged during the drilling process, and generally more often than the casings. The drill pipes are, on the other hand, always threaded.

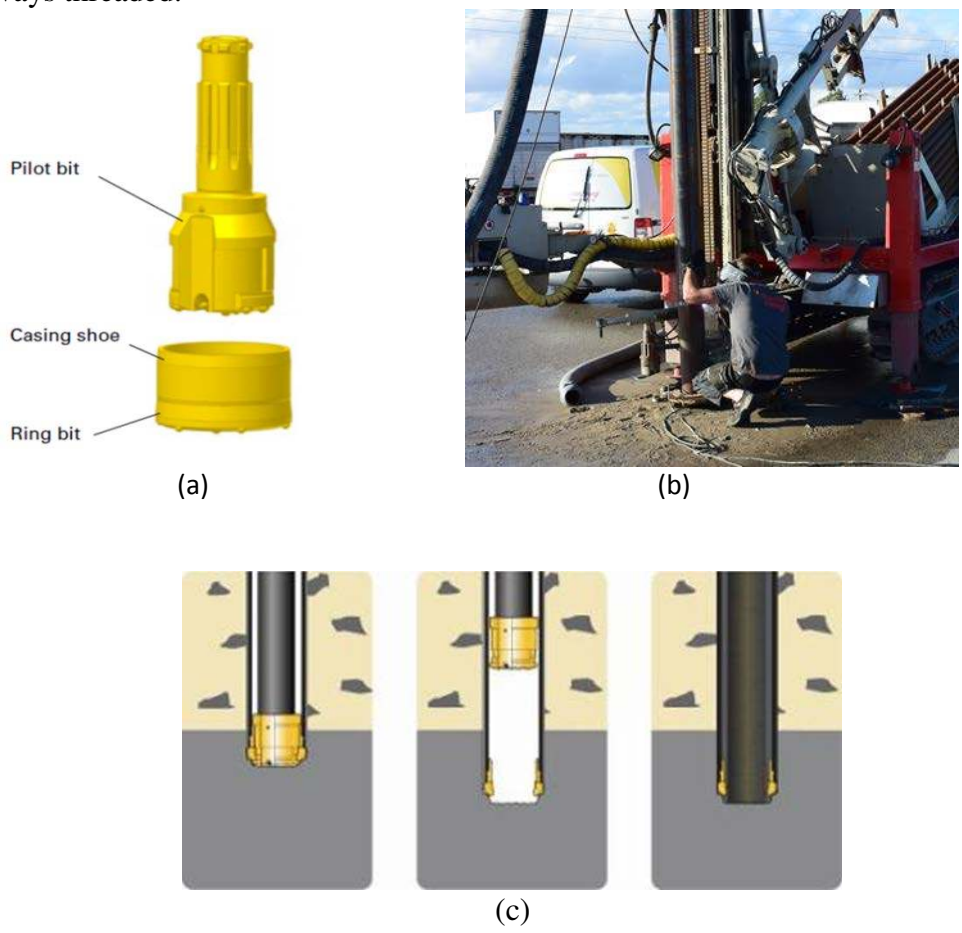

Figure 5. a) Typical concentric casing advancing system (Atlas Copco, 2009); b) welding of the casing pipe to the casing shoe (author´s picture); c) When the hard rock is hit the drilling ends and the casing with the ring bit and casing shoe is left while drill bit is extracted (Atlas Copco, 2009).

3.5 Casing advancement applications for ground engineering

The different ground engineering activities are executed with beaten concrete piles, beaten and drilled steel piles, wooden piles or other piles (Pålkommisionen, 2015). According to Wassara and the report by Pålkommisionen (2015), the concrete piles are the most usual method used for ground engineering (60%), next come the beaten steel piles (23%) and finally the drilled steel piles (13%). Drilled steel piles are generally used in the cases when the ground conditions are tough; the outside environment should not be affected by sound or vibrations; when there is a small working area at the site and etc. (Finnra, 2003). In the majority of cases, when possible, the other aforementioned methods are used, as they are more cost-efficient. The drilled steel-piles may be more expensive, but can often be the only possible solution due to the requirements of the urban environment or the many obstacles in the ground (Bredenberg et al., 1998).

The number of steel piles has grown steadily since reports by Pålkommisionen started to include steel piles in the statistics in 1980. As concluded by Kardos (2008), developments in metallurgy, related equipment and expertise increase drilling with steel-casing.

There are two types of piles drilled with the DTH-hammer method: steel piles and steel core piles. Both have a casing of steel and are cast with concrete. The difference is that the steel core piles are cast with a steel core and, because of this, they have higher compressive and tensile capacity than steel piles. The casing with the ring-set is left in the ground to enhance the strength of the casted concrete pole. This extra strength is not taken into account in construction calculations in the case of steel-core piles, while in the case of steel piles it is considered as the primary one. The reason is that, generally, the casing thickness is much smaller in steel-core piles than in steel piles (Finnra, 2003).

Some factors working against use of drilled steel piles are those, when rock is situated deeper than 30 meters, or if the rock´s surface has a very steep sloping surface, as well as when there is a high risk of corrosion in the ground, for example, in polluted industrial land.

Steel piles may be divided into three types according to how they transfer the loads (Finnra, 2003).

- Tip-bearing piles are used if it is possible to drill down to solid ground, mainly rock. The loads of the structure are then transferred directly to the solid ground through the pile.
- Friction piles are used in sandy grounds, where driving down a pile is not possible. The loads of the structure are then taken up by the friction between the soil and the pile´s lateral surface.
- Cohesion piles are used in clay-reach grounds, where driving down to the bedrock is not technically or economically justified. The cohesive forces between the clay and the pile´s lateral surface take up the loads from the structure.

Piling is further divided by size into micro piling and coarse piling, which are done with casing under 300mm and over 300mm respectively (Bredenberg et al., 1998). Micro piling is used more frequently than coarse piling in Sweden, according to interviews with ground engineering companies, Wassara´s retailer and statistics from Pålkommissionen (2015).

The size-range for steel-core piles is 115-270 mm in diameter for casing and 80-180 mm in diameter for steel-core (Styrud, 2015). It is possible to have larger sizes, but this method gets too expensive. Inquiries at Wassara and competitor analysis (Atlas Copco, 2009) show that overall, casing advancement may currently be carried out with a diameter of 60 to 1220 mm, while the thickness of the casing varies between 5-16 mm. Drilled steel-piles over 150 mm size have grown 10 percentage points 2014 compared with 2013, while those under 150mm have grown marginally (Pålkommisionen, 2015).

Steel-core piles had similar market share 2008-2013; but decreased by 3 percentage points in 2014 (Pålkommisionen, 2015).

The aforementioned sorts of piles are used in the following applications (Bredenberg et al., 1998):

- Foundation for housing, infrastructure and etc.

Foundation work is performed in order to reinforce the ground and, in turn, be able to transfer loads from a building or any other structure to the ground. The most usual way to construct foundation in Sweden is to drive some sort of pile all the way down to solid rock. This is due to the Swedish rock layer being located on a relatively shallow depth compared to other countries.

In foundation work for bridges, the drilled steel piles may be used as pillars, according to interviews with ground engineering companies. This means that the piles also serve as structural elements above the ground. This is advantageous, as no base or separate bridge support needs to be casted. It can thus lead to shorter construction time and it can simplify the execution of bridge support in and around watercourses. This method is originated from Finland, where more than 400 bridges have been built in this manner (Styrud, 2015).

- Underpinning

Underpinning is required in order to strengthen existing foundation of a building or any other structure. For example, underpinning is needed when the original foundation cannot hold the structure anymore, because of change of ground conditions. This is a quite frequent situation in central parts of Stockholm. Most old foundation work in Gamlastan and Södermalm is done with long and wide tree trunks according to interviews with ground engineering companies working in this area. These tree trunks work well until the groundwater level drops and the rotting process starts due to contact with oxygen. This leads to houses, roads and other structures starting to sink, why underpinning is needed.

- Drilled pile-retaining walls and RD-pile (Rautarukki Drilled) walls

Drilled pile retaining walls are assemblies that are put up in order to both lower and in some cases raise the ground water level, to create a building site and to use as a part of a structure. Often, putting up pile-retaining walls is the first step in creating a construction site, as the walls are used to control the ground masses. It is common that these walls are left in the ground to strengthen the formation and as a part of foundation.

- Well drilling

A casing is always drilled down to the rock and a bit into the rock when drilling either a water-well or a geothermal well. This is done in order to have a stabilized hole that is not affected by outer environment and to keep the groundwater apart from surface water. In Sweden the law states that casing needs to be drilled at least 6 meters down from the surface and at least 2 meters into solid rock, when drilling some sort of well (Energibrunnsnormen).

Furthermore, there is a large variety of different applications of casing advancing in ground engineering, such as anchoring, tunnel umbrella and others. These applications will not be explained any further, as they are often varieties on applications described above.

4 APPROACH TO HIDDEN NEEDS ANALYSIS

This chapter presents the state of the art in the hidden needs analysis. It starts with the description of the customer satisfaction notion and its effect on product development processes. Further, the concept of customer needs is discussed and the necessity for customer explicit and hidden needs analysis is explained. Finally, various frameworks and methods for hidden needs analysis are presented.

4.1 Customer satisfaction

Customer delight or satisfaction denotes "*a profoundly positive emotional state commonly resulting from having one's expectations exceeded to a surprising degree*" (Rust and Oliver, 2000, p. 86). Rust and Oliver (2000) concluded that over-exceeding the customers' expectations can be highly profitable for the business as more satisfied customers would lead to more loyal customers. In its turn, an increase in customer loyalty by a mere 5% can increase the profits for a company by 100%, because the satisfied buyer would purchase the product more often and in larger quantities (Matzler et al., 1996). Furthermore, it is shown that satisfied customers are generally less price-sensitive and more motivated to spend extra on successfully tested products (Matzler et al., 1996).

Many industries have implemented a variety of different quality management systems and standards (QCC, ISO 900, TQM etc.) with the aim to create customer satisfaction (Yang, 2005).

One of the most renowned methods for analysing customer satisfaction is the Kano´s model (Figure 6). This model allows analysing product features and structuring them in a way that gives an understanding of how they impact customer satisfaction (Matzler et al., 1996).

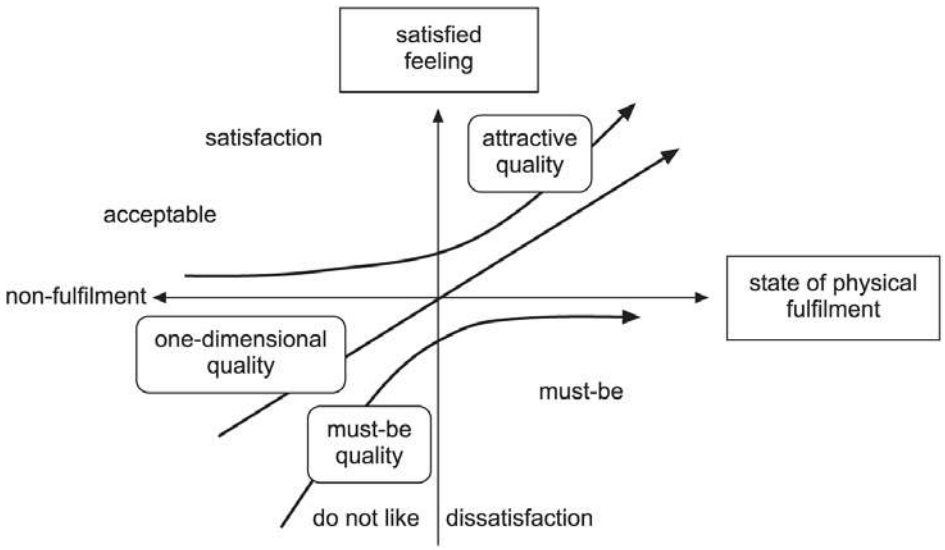

Figure 6. Kano's customer satisfaction model from Kano et al. (1996, p.64)

Kano's model describes product attributes in terms of basic attributes, performance attributes and excitement attributes (Goffin and Mitchell, 2010; Yang, 2005) as follows:

1. Basic attributes – must-be quality

Basic product attributes are perceived as fundamental requirements towards a product. If these attributes are not of a satisfactory level, the customer will be dissatisfied with the product

regardless of the satisfaction level of other attributes. On the other hand, if these attributes are fulfilled to a higher extent than demanded, they would not render in higher customer satisfaction.

2. Performance attributes – one-dimensional quality

Performance attributes are the ones, with which companies are most often competing on the market. They can either be functionalities that customers desire, or factors such as cost, service life etc. Fulfilment of performance attributes is linearly related to customer satisfaction, which means that each improvement leads directly to higher grade of satisfaction. These attributes bring about a considerable part of total customer satisfaction.

3. Excitement attributes – attractive quality

Excitement attributes provide high level of satisfaction if present, but no dissatisfaction if absent. These attributes are considered to be important for attracting potential customers and distinguishing the company from its competitors. Further, these attributes have the highest influence on total customer satisfaction from a product (Matzler et al., 1996)

As it can be seen in Figure 6, in order to reach the high level of satisfaction it is not enough to focus on the performance features of the product, as they constitute one-dimensional quality. The company has to put more efforts to bring about excitement features – the attractive quality. However, it must be taken into consideration that over time many excitement features become mainstream and turn to be viewed as basic or performance attributes. An example provided by Goffin and Mitchell (2010) is a remote control for a TV, which was ground-breaking when came into the market, but has nowadays become a basic feature.

Similarly to Kano et al. (1984), Clemmer (1990) presented a visualization of customer delight by concentric rings, Figure 7, in which the innermost ring is described as the central features that are essential for the functioning of the product and, therefore, must be provided. Next ring features "satisfiers" and the outermost one - "delighters". The "satisfiers" are add-ons to the central features of the product. High levels of fulfilment of satisfiers may provide more satisfaction, beyond the already provided satisfaction by basic features. The "delighters" are the product features that are unexpected by the customers and may lead to surprising satisfaction, as the customers are not used to this particular feature (Rust and Oliver, 2000).

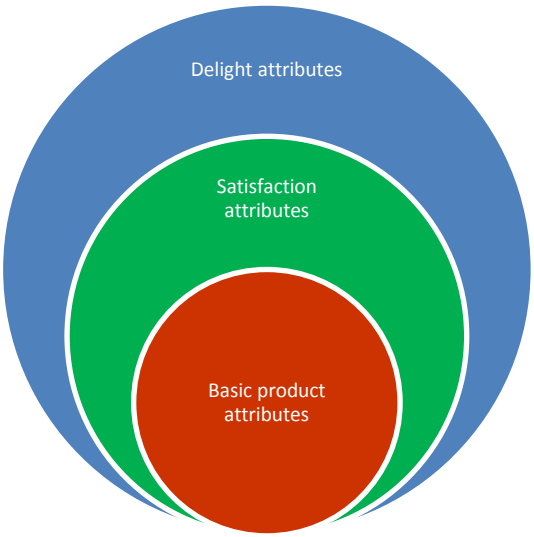

Figure 7. The three rings of perceived value, adapted from Clemmergroup´s (clemmergroup.com).

Slater and Narver (1999) further developed on "the three rings of perceived value" by introducing the notions of the "expected product", "augmented product" and "potential product". The expected product corresponds to what the customer considers the least acceptable benefits that the product must comprise following the explicit needs. The augmented product, on the other hand, encompasses benefits that satisfy hidden needs, thus delivering unexpected customer

satisfaction. Finally, the potential product includes all the attributes that satisfy both explicit and hidden needs (Slater and Narver, 1999). The augmented product brings differentiation to a company's offer, which is crucial in order for the company to avoid purely price-focused competition (Narver et al., 2004; Pinchot and Pellman, 1999). The balance between customer satisfaction and price implies that when a market consists of a number of companies providing expected products, the companies would compete with price in order to deliver superior value for the customer. Yang (2013) suggested a simplified definition of customer value perception from works of Park (1998) and Browning (2002). This definition envisions value as a trade-off between functions and costs, or benefits and costs. By delivering differentiating functions or benefits, it is possible to generate higher customer value, which would lead to a decreased need in price reduction.

Reaching higher degree of customer satisfaction could be achieved through understanding and anticipating what customers would need from the product in the future, while not expecting the satisfaction of those needs at present (Matzler and Hinterhuber, 1998). It is necessary to take into consideration that some quality attributes, though fulfilling individual customer expectations in a great extent, do not automatically lead to a higher level of customer satisfaction (Matzler and Hinterhuber, 1998; Pinchot and Pellman, 1999). To deliver the attractive quality as defined by Kano (2001), it is necessary to both regularly reveal current needs and predict future ones (Carlgren, 2013). This is not an easy task as the earlier unrevealed needs are rarely being recognized prior to being solved (Carlgren, 2013). Finally, it is important to make the created delight or satisfaction memorable by the customers in order for the company to be able to capitalize on the invested efforts (Rust and Oliver, 2000).

4.2 Customer needs in the industrial market

Industrial markets consider customer satisfaction as the primary goal of need analysis due to conviction that satisfied customers are ultimately an asset to the company (Griffin and Hauser, 1993).

There are many different definitions of a customer need. According to Griffin and Hauser (1993), a customer need is a "description of the benefit to be fulfilled by a product or service" made in the customer´s own words. Similarly to Griffin and Hauser (1993), Salovaara (2004) explains needs as goals a user wants to achieve while working with a specific product. According to Holt et al. (1984), customer needs are differences between the actual situation and the expected situation that are either identified or missed. Finally, customer needs are abstract constructs and perceived differently, as also needs differ amongst various customers and users.

The needs can be classified as the existing and the future needs, with existing needs including unrevealed needs. A distinction is often made between needs that are obvious for the user and that can be articulated; and needs that are non-obvious for the user or that cannot be articulated (Faste, 1987; Koners et.al., 2010; Narver et al., 2004). The first set of needs is defined as explicit, while the latter set of needs is defined as hidden (Goffin and Mitchell, 2010; Matzler et al., 1996) or latent (Kano, 2001; Narver et.al, 2004; Durgee, 2001). As described by Kano (2001), while customers may recognize some of the basic needs, they might easily forget to mention those, as they are often perceived as obvious or as fundamental. The terms "hidden" and "latent" are being used as synonyms, which have been also stated by Carlgren (2013). In this study the term "hidden needs" is used all through the text.

Customer needs are often satisfied through wants, specifications and attributes and are, thus, independent from any product's solution (Ulrich and Eppinger, 2000). As stated by Patniak and Becker (1999), needs persists longer time than specific solutions and, thus, they are more long-term than any customer want or requirement. Furthermore, focusing on needs may become a motivator for a company to keep innovating for better ways of meeting the needs. As concluded

by Holt (1987), while rapid technological changes produce new prospects, changes in a customer need calls for new solutions. Nevertheless, both patterns of development demand information on customer needs. As explained by Patniak and Becker (1999, p. 39): "…looking for needs rather than specific solutions keeps all possible solutions open for consideration and avoids prematurely limiting possibilities." This statement might be visualized through an equation: "needs +solutions = Innovations" Patniak (2005). Finally, Ahola (2006) formulated a quite obvious but nevertheless important conclusion that simple products or services would generally contain fewer hidden needs than multifaceted combinations of products and services.

Several studies confirmed the importance of the customer needs analysis by showing that the PD-projects based on well-defined customer needs have a higher success probability than those spurn from technological breakthroughs (Holt et al., 1984; Kärkkäinen et al., 2001; Szakonyi, 1988). According to Szakonyi (1988), extensive research results suggest that the most important factor influencing the success of NPD is the coordination between the "development of technology" and "market research on customers' needs". Kärkkäinen et al. (2001) pointed out the importance of companies´ ability to understand customer needs and to react fast to customers changing needs due to the toughening business environment. At the same time, Hanna et al. (1995) reported that majority of industrial product managers in their study ranked the lack of market analysis as the most important contributor to failed NPD-projects. This was by a significantly larger margin than consumer product managers who answered the same question. The study of Finnish industrial companies by Kärrkäinen et al. (2001) revealed that 58% of the responding companies considered recognition of new needs as very significant and 38% as rather significant. According to the same study, 85% of respondents experienced that the clarification of hidden and future customer needs was "rather beneficial" or "very beneficial" for their company. Further, Kärkkäinen et al. (2001) did not find any correlation between the success and company size, industry type and competitive strategy. Therefore, the study concluded that independently from a PD-project realities, it is of utter importance to understand customers' explicit needs and assessing hidden and future needs during the early stage of the PD-process, in order to be able to develop successful products and to eliminate the risk of the unrecognized needs being found late that would require an additional design loop to fulfil them (Kärrkäinen and Elfvengren, 2002). While it is concluded by the aforementioned studies that it is important for a company to get needs rather than wants, product specifications or attributes (Holt, 1987; Szakonyi, 1988; Kärrkäinen et al., 2001; Hanna et.al., 1995), there is no specific formula for how general or definite a customer need statement should look like, and no information source suggests any standards for needs description (Kärkkäinen et al., 2001; Ericson and Ståhlbröst, 2006).

Identification of customer needs is one of the main objectives of market research (Iaccobucci, 2009; Pinchot and Pelman, 1999). The traditional methods used are, for example, surveys, focus groups and interviews. These methods are well-equipped for evaluation of customer preferences for existing products (Paniak and Becker, 1999). But, according to numerous studies (Koners et al., 2010; Carlgren, 2013; Goffin and Mitchell, 2010; Narver et al, 2004), these traditional market research methods are not appropriate for providing a deeper understanding of customer needs and for uncovering hidden needs. The traditional methods result in companies getting information that is already accessible, because the interviewees, focus groups and participants of surveys articulate the needs that the customers are able to communicate (Goffin and Mitchell, 2010; Kärkkäinen et al., 2001; Holt et al., 1984). Besides, the traditional methods have also been found lacking in accuracy and their results often disappoint companies (Goffin and Mitchell, 2010, Von Hippel 1986). Furthermore, the traditional methods are often focusing on present markets or products and their findings are usually limited to explicit needs (Von Hippel, 1986). It is clear that collecting information about user requirements towards a specific product is simpler than towards new solutions, as the users actually have something to compare with (Ericson and Ståhlbröst, 2007). Analysis of the aforementioned limitations of the traditional market research

methods lead to the conclusion that the use of the explicit needs, which can be easily articulated by customers, is not sufficient for the successful PD-project; and therefore, the hidden needs should also be considered (Goffin and Mitchell, 2010; Kano 2001; Carlgren 2013). Stanko and Bonner (2012) further emphasized the need for closer cooperation between companies and customers using highly interactive processes for effective customer need assessment, and especially for discovery of future and hidden needs. The closer relationship may also motivate the customers to reveal information about future needs and requirements.

Even though the significance of a deeper understanding of customer needs is widely recognized, most companies stick to the traditional methods and do not emphasize enough the new market research techniques (Goffin and Mitchell, 2010; Kärkkäinen et al, 2001; Goffin et al, 2012). For example, the survey of 160 companies in US done by Cooper and Edgett (2008) revealed that only 12.9% of the companies used some of the ethnography techniques. According to the Keith Goffin's interview to European business review (2011), many companies are unwilling to put enough effort into understanding their customer; they are often outsourcing customer needs analysis, which leads to lack of internal competence in market research that is perceived as much needed by Keith Goffin. The previously mentioned inadequacies have led to the hidden customer needs being lost and these are often the needs that should be identified in order to generate product innovation (Goffin and Mitchell, 2010; Schilling, 2013). Those hidden needs could actually differentiate the company's product from the competitions' ones. Getting back to the theory on customer satisfaction, Hamel and Prahalad (1994) concluded that a company's goal is not to be solely led by customers' explicit needs, but also aim to surprise customers by anticipating and satisfying their hidden needs. By fulfilling previously unrecognized or hidden needs it is possible to effectively increase customer satisfaction as delighters are targeted and create competitive attributes described by Kano et al. (1986). In its turn, the satisfaction often leads to customer loyalty and increased market share (Narver and Slater, 2004).

To identify hidden needs in the industrial market, it is important not to limit the target group for the market research to the customers only (Carlgren, 2013). The industrial markets and product development of business-to-business organizations differ significantly from those of the consumer market. As described by Kotler and Keller (2012), the main differences are fewer buyers, larger buyers, closer supplier-customer relationship and decision making units (DMUs). In industrial markets the customer may be a large organization where different stakeholders may have different demands and needs towards the product. The view on the complexity of industrial markets and specifically the DMU is strengthened by Kärkkäinen et al., (2001a) who noted that in industrial markets there are long chains of stakeholders and customers, whose needs and opinions should be considered when making decisions on product development. Furthermore, customer needs can originate from stakeholders that might be perceived as too distant and from trends influencing them (Ahola, 2006; Kärkkäinen et al., 2001a). This is particularly relevant for the construction market that has a number of complex chains of customers, stakeholders and distant stakeholders (Ahola, 2006). Empirical results provided by Ahola (2006), revealed that customer´s DMUs have been found in many cases unable to deliver the precise explicit customer needs to suppliers. Therefore, it is often left to the supplier to search for both hidden and explicit needs.

Finally, it is worth to mention that listening carefully to the customer is not necessarily profitable. As has been concluded by Christensen and Bower (1996), many industry leading firms that lost their leadership position did not lose it because of a technological breakthrough, but rather because they listened too much to their key customers, which in its turn made them limited in the strategies they could pursue. The problem with focusing too much on customers´ needs is also discussed by Wagner and Hansen (2003), who suggested that companies may tend to only be led by current customers' needs and miss all other current and new market information. While customers may be expected to lead the suppliers towards sustaining innovations, the highly innovative companies may fail due to the lack of application of the

innovation on the predictable needs of their present customers (Christensen and Bower, 1996). Hamel and Prahalad (1994) stated that a company that is purely customer led is in danger as customers are typically lacking in anticipation considering NPD and new technologies. Further, research by Christensen and Bower (1996) suggested that another cause of the lost leadership position may stem from the firms inability or unwillingness to allocate enough resources to technologies in emerging markets. These technologies may later become dominant in mainstream markets and in that way lead to loss of leading position. Therefore, it is necessary to balance needs to be found between technology innovation and customer input.

4.3 Approaches combining needs and hidden needs analysis

Customer needs assessment does not solely comprise the search for recognized, unrecognized and future needs, but also the needs analysis in order to deliver them in a format that can be communicated and applied in a PD-project (Kärkkäinen et al., 2001a).

There are a few known frameworks for need analysis (Ericson and Ståhlbröst, 2006). One of the most frequently referred frameworks is the so-called "needfinding" process that was designed by Robert McKim and further described by Patniak and Becker (1999). The needfinding approach overcomes limitations of the traditional market research techniques that are not able to identify the actual needs, which customers cannot communicate (Patniak and Becker, 1999), by focusing on the search for hard-to-articulate needs (Faste, 1987; Patniak and Becker, 1999; Ericson and Ståhlbröst, 2006)

Needfinding implies the use of contextual interviews and observations as they allow uncovering noteworthy details on the customers´ doings in the specific settings of their working environment. Further, the need to rely on the customers' ability to notice, remember and articulate an experienced need is eliminated. It is though important to let the customer keep control over the activities and schedule in order not to disturb the natural workflow and routines for execution of the activities (Patniak and Becker, 1999).

The iterative approach to needfinding is found to be preferable as it allows R&D proceeding with their work, while the process of finding needs is on the way and because it is simply not possible to get the full range of unrecognized needs during one cycle of market research (Patniak and Becker, 1999).

The needfinding process consists of four steps described by Patniak and Becker (1999) and they are similar to the steps of the methodologies proposed by Goffin and Mitchell (2010) and by Ulrich and Eppinger (2000). These four steps include: 1) Frame and Prepare; 2) Watch and Record; 3) Ask and Record; and 4) Interpret and Frame. The steps are shortly described below.

1) Frame and Prepare

This first step is aimed at establishing the goals of the needfinding process; identification the targeted customer group and selection the places to visit. This can be seen as a research design stage, which also includes planning for customer visits. It is important to be well prepared, having a clear idea about the goals for visiting the customer as well as knowledge about the customer's branch and the site-specific knowledge. These preparations would prevent from wasting resources on gathering already known information, and moreover, put the market researcher in a position of a trustworthy and genuinely interested person in the eyes of the target group.

2) Watch and Record

The second step of the needfinding methodology is focused on observing customers in the contextual environment in order to snap up the problems that are not recognized by the customer. Such observations can help in identifying some usual problems that have been forgotten or

unintentionally ignored. This can also be done by an observer taking part in the activities together with the members of the target group. Here it is important not to influence the usual activities or customer behavior. If possible, the needfinder should use different recording media in order to gather all sorts of information, both verbal and non-verbal.

3) Ask and Record

During the third step, the observations should be complimented by interviews in order to understand the background facts and driving factors behind the observed situations. The interviews should be carried out in the business environment of the customers shortly after the observation session, so that ensure that the customer remembers different activities carried out during the observation session. This could be helped by going through the working process again or by having artefacts to illustrate the workflow to reach tacit knowledge of the customer. Data from the interview should be presented in the customer´s own words as they might hold a meaning that otherwise might be lost.

4) Interpret and Frame

At this final step of the needfinding, the aim is to analyse and compare the outcomes from observation and interview sessions to provide input into the NPD-process. As stated above, the needfinding process is an iterative methodology, therefore, during the fourth step the research question is to be reviewed and altered if needed. Thus, this step includes the following parts: formulation need statements; classification and prioritizing the needs; and reframing the research if needed (Patniak and Becker. 1999).

A similar five-step methodology for customer need identification is suggested by Ulrich and Eppinger (2000):

- Gather raw data from customers.
- Interpret the raw data in terms of customer needs.
- Organize the needs into a hierarchy of primary, secondary and (if necessary) tertiary needs.
- Establish the relative importance of the needs.
- Reflect in the results and the process.

In the next section of the chapter an overview of methods for hidden needs analysis is provided. The overview includes both the methods that have been used within this thesis work and the methods that are found to be relevant for the study, but not tested because of the time limitation.

4.4 Methods for hidden needs analysis

When doing a hidden need analysis it is important to realize that a single method might not give the “whole story”, thus a holistic approach is needed. Applying different methods increases chances to find a broader range of hidden needs. Furthermore, each project on hidden needs analysis demands a tailor-made methodology (Goffin and Mitchell, 2010; Goffin and Mitchell 2004).

Need assessment in industrial markets is quite often carried out through freeform discussions and informal talks with customers during everyday contacts (Holt et al., 1987), which corresponds to the methods for hidden needs analysis proposed by other authors (Koners et al., 2010; Ulrich and Eppinger, 2000; Carlgren, 2013) as all of them aimed at openness during conversations. Kärkkäinen et al. (2001) conducted a survey of Finnish industrial companies, which showed that cooperation with lead-customer or lead-users and free-form customer contacts were perceived as the most important sources in hidden need analysis. In its turn, the main path to recognize user needs is to study and evaluate past and present user behaviour, as such studies might among

other things show which changes have influenced the use of the product (Ståhlbröst and Kårebom, 2007).

The hidden needs analysis literature describes surveys as commonly ineffective method for identifying the specific characteristics that make customers choose one product over another (Goffin and Mitchell, 2010; Wagner and Hansen, 2003). The inefficiency is in particular due to respondents answering the questionnaires with too narrow idea on competing products or substitutes, while the knowledge about substitute products may assist in surfacing hidden customer needs (Wagner and Hansen, 2003). Other identified downsides of surveys and questionnaires include the following: (a) questionnaires are frequently poorly designed; (b) customers and users can rarely adequately express their needs and the usual direct questions do not help to solve this problem; (c) finally, the response rate is rarely adequate, especially in the construction industry, where it has been found to vary between 7-14% (Wagner and Hansen, 2003). Furthermore, mail and telephone surveys are found to be not suitable for collection of qualitative data such as customer needs due to difficulties in controlling the scope of responses.

Customers´ words are generally too wide-ranging and/or too detailed to be directly used as customer needs statements. Therefore, the collected words are usually organized using some formalized approaches, including concept mapping for building up tree-like hierarchical structure, affinity data analysis or cluster analysis (Carlgren, 2013).

Other commonly applied method of a market study involves focus group. The main limitation of the focus group method is that discussions take place outside the normal business environment, where there are lots of clues important for product designers could be revealed. Furthermore, members of the focus groups found to behave differently outside the natural product use environment (Goffin and Lemke, 2004). Other notable limitation is that all members of a focus group rarely get to provide their input as a focus group is often dominated by a couple individuals (Griffin and Hauser, 1993). Griffin and Hauser (1993) concluded that using one-on-one interviews may be slightly more efficient than a focus group, when it comes to counting numbers of needs found per an hour. Moreover, one-on-one interviews provide opportunity to go deeper than focus groups. Finally, Von Hippel (1986) stated that focus group technique should be used only during search for attributes of already existing products or services.

To get a deeper understanding of customer needs, more elaborated methods need to be used. For instance, many researchers based their studies on methods originated from social sciences, such as sociology, psychology, anthropology, etc. One of the most commonly used example, is ethnographic market research that is developed by anthropologists, who have developed the advanced techniques of looking at a product through the “customer’s glasses”. The ethnographic methods are considered to fit very well to the cases with smaller numbers of customers - about 30, which is applicable on industrial markets that have substantially fewer customers than consumer markets (Goffin et al., 2012; Kotler, 1998). While ethnographic methods seem intuitive and easy to understand, Capper (2006) suggested that the success of their implementation depends on the competences of the expert who applies them. Koners et al. (2010) confirmed the aforementioned conclusion and suggested that users of ethnographic methodologies should acquire skills in observation and analysis through practical training. Generalizing this statement, Thomas and McDonaugh (2013) advocated that product developers should get skills to understand and empathize with their customers. There is a whole set of methods for hidden needs analysis provided by different sources, which results in a problem described by Goffin and Lemke (2004). They concluded that the main challenges of hidden needs analysis are not resulted from necessity to learn one or another research technique, but from the task to effectively create the portfolio of techniques chosen from the set of available methods. For each case a tailor-made solution is required, taking into account that each chosen approach may often generate a large volume of data that should be scrutinized (Goffin and Mitchell, 2010).

The following section describes different design-thinking and co-creation methods that are considered to be appropriate for hidden needs identification and analysis and that are used for more pro-active market studies (Narver et al., 2004). The methods include: Lead User; Empathic design, comprising Contextual interviews, Systematic Observations, and Empathy building; Experimentation (co-development); One-on-one interviews; and Repertory grid.

4.4.1 Lead User

Lead User method was first developed by Von Hippel (1986). "Lead users" are the users that have specific needs that precede the rest of the market and, at the same time, they have requirements that are harder to satisfy. The needs that the Lead Users are currently experiencing can in time become the conventional needs of the majority of customers; thus, a continuous application of the lead user methodology could provide valuable insights to the company (Von Hippel, 1986). Lead users are aware of conditions that are still yet to come for majority of other users; and they often attempt to fulfil their emerging needs themselves. Therefore, they are able to provide ideas for new product concepts and other relevant information, unlike the users that are not proactive concerning the current situation (Von Hippel, 1986). Though the lead users are able to identify the hidden needs earlier than other customers (Wagner and Hansen, 2003; Von Hippel, 1986), overemphasizing the search of the extreme lead user needs is risky as the needs may prove to be unwanted by the rest of the market (Von Hippel, 1986).

The Lead user method consists of following stages derived from Goffin and Mitchell (2010) and Von Hippel (1986):

The first stage is a screening process, which is to be done through the existing user group in order to identify the users with extreme needs. Screening may also be done through identification of important market or technological trends and following analysis to understand, which companies are the leaders of this trend by either knowledge or strength of need.

Another way of identifying lead users is by searching for the users that do a lot of development themselves. According to Von Hippel (1986), a typical characteristic of a lead user is a readiness to invest resources in own innovations.

Finally, it should be mentioned that in industrial markets the identification of lead users is usually an easier task than in consumer markets, as there are fewer customers and the companies are often knowledgeable on the characteristics of each customer group (Von Hippel, 1986; Kotler and Keller, 2012).

Next stage is to identify the application fields, where users face similar and even more extreme challenges. As also noted by Von Hippel (1986), the search for lead users should not be conducted exclusively in own customer base, but should also include competitors´ customers and users outside the concerned industry.

The following stage is aimed at forming a lead user group comprised of the lead users from current market and from similar markets.

After forming the lead user group, the information extraction process can be started using methods of the empathic design, such as contextual interviews and observations, as well as one-on-one interviews.

Finally, the collected data is to be analysed and applied to the rest of the market to evaluate the possible demand and reaction of the majority of the market on the findings of the lead user analysis.

4.4.2 Empathic design

Emphatic design is based on the need to deeply understand a user or a customer. By applying the realities of the product user, the market researcher gains empathy, which enables designing the product according to it. The methods used in empathic design have their roots in ethnographic and anthropological market research (Goffin and Mitchell, 2010). Tomas and McDonaugh (2013) concluded that product and service development efforts need to include the development of empathy with users in order to deliver products that fit both individuals and the larger group. Moreover, according to Ericson and Ståhlbröst (2006), it is essential to develop and understanding of the user´s problem situation to be able to generate their requirements.

The case studies done by Goffin et al. (2012) show that the ethnographical and anthropological methods for hidden needs analysis can be successfully applied to both consumer and industrial markets no matter the size of the industry or complexity of the product/service.

The empathic design includes the following methods that will be described further: Contextual Interviews, Systematic Observation and Empathy Building.

Contextual interviews

A contextual interview is a way of using the working environment in order to motivate the user to provide more actual answers, reach their tacit knowledge and also observe the body language (Goffin and Mitchell, 2010; Stickdorn and Schneider, 2012). Being in the own working environment makes the interviewee more relaxed and more motivated to describe working activities and situations. The interview questions should aim to collect background information and stimulate users to describe their activities even deeper. Further, the idea of the method is to let the interviewee lead the conversation, which makes structured interviews not applicable here. It is important for interviewer to be able to instinctively add questions following observations. Goffin et al. (2012) proposed questions that could guide contextual interviews.

To summarize, the main components of this method are:

- Interviews conducted in the user´s actual workplace;
- User and interviewer collaborate to understand user´s work;
- Interviewer shares the interpretations and insight with the user;
- Semi—structured interview with focus on making user do the talking.

Systematic Observations

Observations of a user of a product in real life gives an understanding of how the product has actually being used, while eliminating the need of relying on user´s reported perception. Observations the customers' work in the environment, for which a new product is projected, may expose important details and needs; and may reveal customer problems and solutions (Ulrich and Epppinger, 2000). Narver et al. (2004) also noted that customer hidden needs may in many cases be identified merely by methodical observations of customer behaviour. The conventional techniques of needs analysis has the spoken word as the centrepiece, which leads to the researcher getting an incomplete picture due to the non-verbal communication being lost (Zaltman and Coulter, 1995). This stresses the importance of including observations in the hidden needs analysis.

The observation method is quite time-consuming, hard to analyse and needs extensive preparations. In order to gain efficiency during the observations, a so called coding scheme is considered to be useful (Goffin and Mitchell, 2010). The scheme can be divided into data

categories; events to look for; observations; timings; and notes. A data category can be, for example, product usage; while an event to look for could be misuse or confusion. Then it is important to register when the observation was done, and to describe misuse or confusion. According to Goffin et al. (2012), the idea with the systematic observations is not only to focus on the customer using the product, but to observe the overall circumstances and the environment.

An example of a company that succeeded in NPD by use of systematic observations is Bosch, which has gained much deeper insights into product requirements through close observation of operators working in factories, than from interviews with production managers (Goffin and Lemke, 2004).

Empathy building

The empathy building method is focused on making designers empathize with the users of the product (Goffin and Mitchell, 2010). This approach differs with the previously mentioned methods in the empathic design, as those are focused more on gathering data and their analysis. There is no established methodology for this way of working, but rather cases from the industry. The main idea of this methodology is to get somehow the designers to "walk in the customers' shoes", by simulating activities made by customers in relation to the product. This allows developing a deeper connection with the customers and their problems.

4.4.3 Experimentation (co-development)

Co-creation and experimentation is considered to be a useful tool for needs analysis (Schilling, 2013, p. 240; Säfsten et al. 2010, p. 34). Goffin and Mitchell (2010) proposed the communication of needs and other information through experimentation done by building prototypes, both virtual and physical.

Thomke and Von Hippel (2002) suggested the method they called "Customers as innovators". There, customers are being provided with tools, so that they can design and develop the application-specific aspects of a new product on their own, thus incorporating their true needs. This method leads to a reduction of trial and error iterations required when the product development organization take on the whole PD-project. Durgee (2001) suggests a similar method of including customers in the PD process, called the "Product placement". This method is executed by providing the customers or lead users with prototypes of new product concepts to be used. The feedback is then gathered and integrated into upcoming PD-cycles.

With the emergence of rapid prototyping techniques the experimentation method has become very useful (Ullman, 2010 p. 118), as developing a prototype together with the user/customer provides a great opportunity to get direct customer inputs.

An example of industrial companies that have successfully included co-creation in combination with workshops is Hilti, a producer of mounting equipment (Herstatt and Von Hippel, 1992). The main advantage of co-creation was perceived as requiring less resources and being more efficient, than the traditional market research methods.

4.4.4 One-on-one interviews

The one-on-one interviews method is useful because of the fact that making a customer interested in an interview is a rather simple task when talking about the products that are crucial for the customers' job (Ulrich and Eppinger, 2000).

Typical project consists of 10-30 customers being interviewed one-on-one for approximately one hour each (Griffin and Hauser, 1993). Comparing one-on-one interviews to focus groups, it

appears that two one hour one-on-one interviews are similarly -effective in finding customer needs as a one two-hour focus group. But as the sample size rises, the one-on-one interviews are becoming more effective. Further, Griffin and Hauser (1993) noted that discussions with 10-30 customers would usually identify 200-400 customer needs, including basic needs, articulated needs and exciting needs – hidden needs.

Matzler et al. (1996, p. 9) suggested the following questions to assist during the interview process:

- Which association does the customer make when using product x?
- Which problems/defects/complaints does the customer associate with the use of the product?
- Which criteria does the customer take into consideration when buying product x?
- Which new feature or services would better meet the expectation of the customer? What would the customer change in product x?

Ulrich and Eppinger (2000) proposed similar, but simplified questions:

- What do you like and dislike about the existing products?
- What issues do you consider when purchasing the product?
- What improvements would you make to the product?

According to Ulrich and Eppinger (2000), it is recommended "to go with the flow" during the interview, which implies letting the customer to provide interesting information and not to worry about following the interview guide. Another practical advice emphasized by Clausing (1994), is to keep the communication in customer´s actual language. Similar approach is promoted by Thomas and McDonaugh (2013), which they call "shared language".

Ståhlbröst and Kåreborn (2007) used scenarios as stimuli during interviews. Scenarios could be used as a mean to start an interview session by presenting a scenario to interviewee; or the interviewee could be encouraged to get started by recalling a scenario. Starting with a question that encourages the customer to tell a story about using the product concerned is also advised by Ulrich and Eppinger (2000).

4.5 Repertory grid

Repertory grid is a market research method borrowed from psychology (Goffin and Mitchell, 2010). The aim of this method is to enable the interviewees to articulate their views on products and services, and to compare them using tacit knowledge. In order to facilitate comparison of products or services and employ the tacit knowledge, the indirect questions are to be asked.

The method consists of repertory cycles of questions that lead to a matrix of quantified data. At the beginning, the interviewee is requested to name six services, products or their providers. Then the six examples are written on post-card sized pieces of paper, which are assigned with a random number from one to six. The interviewee is presented with a triad of cards and asked to explain how using two of the products are similar and different from the third. The acquired response is usually a product or service attribute. The interviewee is then asked to rate the three products against a scale of one to five with five being good and one being bad. A new cycle is started with a new triad of products. All products/services should be rated against all attributes, and this process delivers a repertory grid. All new triads must have new attributes, repetition of attributes is not allowed. The guide for the repertory grid analysis sessions as well as the template used during these sessions is presented in Appendix A.

The ratings of the products uncover the interviewees´ perception of the products' attributes and show the differences in their importance. The hidden needs tend to be indicated by low ratings for all elements. The method can also be used to develop a cognitive map of the interviewee's perception of products or services (Koners et al., 2010).

5 EMPIRICAL RESULTS

This chapter presents empirical results of the study, structured by applied methods. It describes context, process and outcomes of each method. Further, triangulation of these empirical results led to identification of the explicit and hidden needs that are described in the Chapter 6.

5.1 Survey results

The goal of the survey was to collect quantitative information on the ground engineering market and to compare the results with information collected by other methods.

The target group of the survey included various companies that perform drilling, including contractors, sub-contractors, and well-drillers. The representatives of those companies have been selected through internet search and Wassara's customer list.

The on-line survey with open-ended and multiple-choice questions has been carried out during 10-21 September 2015. Out of 175 sand-outs, 63 respondents provided answers to the survey, which corresponds to 35% answer rate. This is at least two times higher than the usual response rate in the construction market, which varies between 7 and 14% according to Wagner and Hansen (2003). Further, 67% of the respondents answered all questions, and the rest answered a part of the questions. However, all respondents provided a meaningful input, as the non-compulsory questions were not logically dependent on the rest of the questions.

In order to analyse and present the survey results, the open questions have been clustered into groups (see Appendix B) and several informative quotes have been selected and retained to provide nuanced opinions of the respondents. This approach is recommended in the service design literature (Stickdorn and Schneider, 2012). The clustering procedure supported analysis of the following questions: What do the customers require from a drilling system? What does efficiency mean for the respondents? Who is included in the decision making units (DMUs)? The main findings of the survey are described below, while the survey guide is presented in the Appendix C.

5.1.1 Structure of respondents

The survey's respondents included 24% contractors, 73% sub-contractors; one respondent was a consultant and one acted either as contractor or sub-contractor depending on the project. This was an expected result considering how many contractors and sub-contractors were contacted. Furthermore, many contractors such as Aarsleff were not responsible for drilled foundations themselves, but rather contracted drillers on a project-to-project basis.

All 63 respondents worked in two different areas: 86% worked in ground engineering and 14% - in energy well boring.

The majority of the respondents (62%) were site-managers, foremen or production-managers (similar to site-managers) with some smaller varieties in their titles. The following study showed that this group have similar duties, while the difference in titles depends rather on their company's preferences. Another large group of respondents were CEOs or company owners (22%), which often represented smaller drilling companies. The top managerial/owner positions of this group did not exclude them from having extensive competences in drilling. In many cases, these respondents were drillers who started their own companies, owners inherited family companies, or simply staff who worked their way up.

5.1.2 Drilling methods

The majority of the respondents, namely 84%, used DTH-hammers, while the rest used top-hammer, rotary-drill and OD-pipe (drilling with casing). The respondents, who used DTH hammers more than 50% of the time, used it on average 90% of the time.

5.1.3 Casing advancement systems: concentric, eccentric or other

The survey showed that 80% of respondents used concentric systems, while 30% of respondents used eccentric systems. There are respondents who used both concentric and eccentric casing advancing systems.

The Everdigm Durawing system was mentioned as one of the "other" systems that were used. This is probably due to the system having the appearance of an eccentric system, as it has wings that stick out in front of the casing. However, the wings are concentric, thus the system could be classified somewhere in between the concentric and eccentric systems. This system is called concentric by Everdigm and was, therefore, counted into the overall statistics as a concentric system. This example of misinterpretation by the respondent may imply that producers or retailers are not always good at communicating properties of their products to customers.

Other mentioned casing advancement systems were "driving with casing" and the "steel fist" by Robit. The "steel fist" is also a concentric wing-system and it is designed specifically for larger holes.

5.1.4 Producers of drilling systems

The most commonly used DTH-Hammers, according to survey respondents, were found to be produced by: Atlas Copco - 80% of respondents, Wassara – 54%, and Mincon – 50%. Other producers, namely Halco, Bulroc, Top Drill, Rockmore and Robit, have been mentioned several times each.

Most commonly used casing advancements systems, according to survey respondents, were found to be: Atlas Copco – 68% of respondents and Wassara systems produced by Atlas Copco – 27% of respondents; Robit – 55%, and Mitsubishi – 46%.

The aforementioned concentric wing-systems, Everdigm and Robit, were mentioned twice. Though, the Everdigm system was said to be not suitable for tough environments.

The survey results imply that the competition is tougher in the casing advancement market, than in the DTH-hammer market. Further, most customers appear to use a couple of different DTH-hammers and casing advancing systems.

5.1.5 Factors that influence the choice of drilling system's producers

To identify the relative value of importance amongst various factors that might influence the choice of the drilling system's producer, the constant sum question was used in the survey. The respondents were asked to allocate 100 points to different factors that have been derived from literature review and interviews with Wassara and its retailer. On average, the reliability factor

has been assigned with the highest points by respondents - 30 out of 100 points. This follows with such factors as price and availability with on average 20 and 19.5 out of 100 points respectively (see Table 2). Among all respondent groups, the contractors showed slightly different preferences, assigning 40 points for reliability, followed by 27 and 24 points for availability and price respectively.

The respondents suggested one additional factor, namely the required depth of drilling in rock.

Table 10. An overview of points distribution between the factors influencing the choice of drilling systems' producers

Factors	**P/100**
Price	20.16
Availability	19.42
Reliability	30.19
Energy consumption	4.52
Environmental impact	5.94
Package solution	5.32
Drilling process control	10.61
Efficient service	10.87
Brand	2.71
Prescribed method and requirements	9.58
Conditions	11.48

5.1.6 What do the customers require from a drilling system?

In order to analyse customers' requirements from a drilling system, the answers on the open questions of this survey have been clustered and quantified. The similar method has been used for the notion of efficiency and identification of DMUs described in the following sections.

Most respondents named reliability or dependability as the key requirement to a drilling system. Durability or quality was the other highly rated requirement. These requirements in turn have a direct effect on the efficiency requirement that was also often named.

The availability and the efficient service/support requirements have also been mentioned, though not as often as the aforementioned ones. Availability and efficient service were said to be important both at the project start and during the project. Both of them have an effect on the efficiency requirement.

Price was named as a requirement by several respondents, but it was never mentioned as a single requirement. Price was often brought up as a "right price" or a "relevant price", which implies that the customers are not looking for the cheapest solution, but rather for a balance between value and price.

5.1.7 What does efficiency mean for the respondents?

The survey uncovered that one of the main criteria of efficiency is disruption-free drilling that depends on both internal factors, such as well-functioning equipment, and external factors, which influence operation of the equipment, such as working environment, geology and etc. The

respondents strived to have as much continuity in the drilling process as possible; the continuity in its turn may be viewed as maximizing the effective drilling time.

The clustering method, allowed extracting concrete performance indicators to measure efficiency as follows:

- Cost efficiency: kr/drilled meter;
- Productivity: number of drilled meters/day; or number of holes and drilled meters produced per day;
- Time plan and other plans are reached.

Furthermore, the respondents shared the following good practices leading to efficiency:

- Adequate preparatory work;
- "Good" staff and the team working well together. This is exemplified by the quote: "The Driller is from the same planet".

Finally, it is noticed that "efficiency measures are set for every specific project".

5.1.8 Drilling project costs

As for the costs of a drilling project, the respondents almost unanimously answered that the highest cost was the cost of materials. According to the respondents, the materials most often include casings, ring sets, drill bits, drill pipes, drill shoes and other parts that are wearied down or left down, for example, steel core piles. Other frequently mentioned costs were the fuel cost and the staff cost, as shown on the Figure 8.

In some cases the downtime was mentioned as a substantial cost; in its turn the downtime is highly related to the staff and fuel costs. The downtime cost is very important to take into consideration as it accounts for the risks related to the project. For example, choosing a cheaper method or system may lead to higher risk of downtime, which drives up all other costs drastically. The literature on the construction market also mentions the downtime as a potentially high cost of a project (Gransberg et al, 2006; Clough et al, 2015).

Finally, as was noted by a couple of respondents, the size of the costs largely depends on the project and specifically its dimensions, type of drilling, equipment availability, and ground conditions.

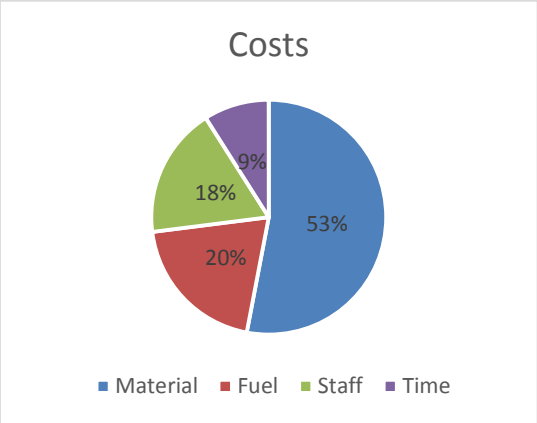

Figure 8: Most important drilling project's costs according to respondents

5.1.9 Required services

The majority of the respondents stated a need for fast service support or a need to be able to service the equipment themselves, 77% and 65% respectively. The need for expert's help was another frequent answer - 42%, Figure 9.

The majority (60%<) of those who wanted fast service and those who wanted to service equipment in-house required the flexibility to choose from fast service and in-house service depending on the project or situation.

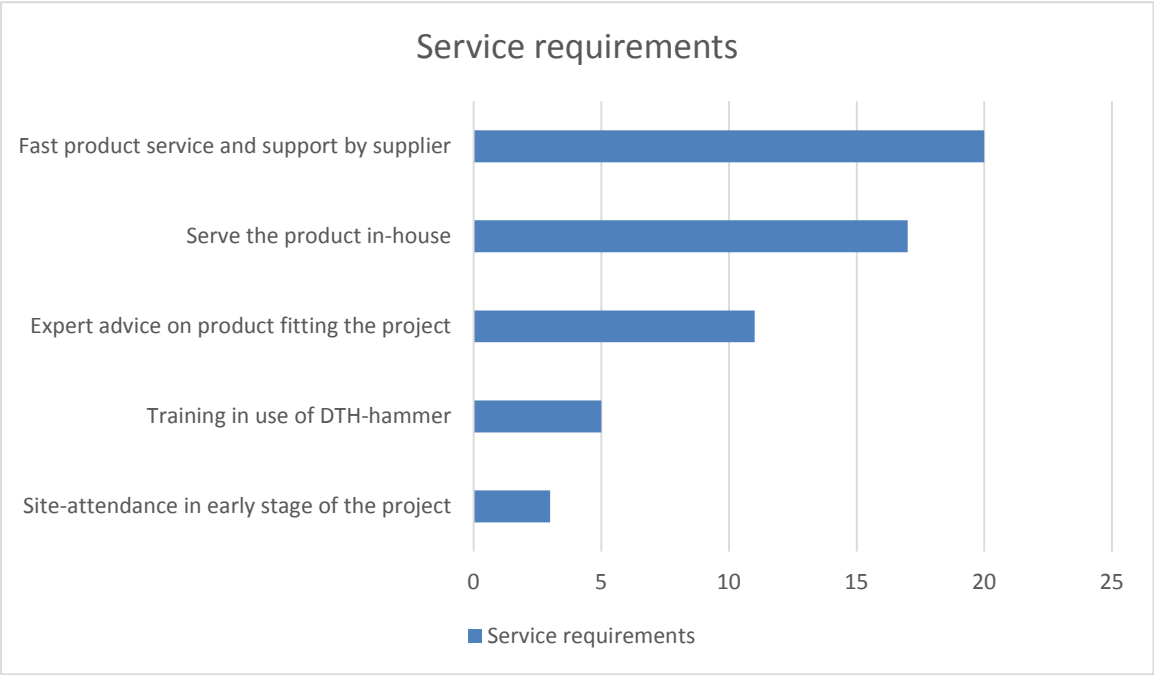

Figure 9. The distribution of answers on service requirements

5.1.10 Risk analysis

According to the survey, 78% of participants stated that risk analysis is performed when choosing a drilling system. On a 1-10 scale of importance of minimizing the risks, the arithmetic average is 8.46, which means that minimizing risk is perceived as important.

5.1.11 Decision making units (DMUs)

The survey showed that in most companies a DMU consists of 2-3 people. The majority pf DMUs contain a site-manager (32%), a foreman (32%), a head of the company (36%) and a driller (58%). The most usual configuration is having a driller and some sort of managers, such as a site-manager and/or a foreman, Figure 10. This indicates that the user´s opinion is important for the choice of a provider. Further, a project leader/project chief is included in 22% of DMUs.

The DMU, where a driller and the head of the company make decisions, is common in smaller companies with the head of company having extensive practical drilling experiences.

Finally, the survey results did not find differences between the DMUs of contractors or sub-contractors.

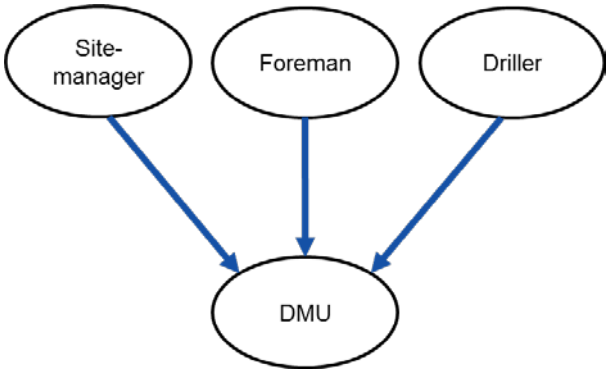

Figure 10. Visualization of a typical DMU

5.2 Results of Lead User analysis

The lead user was identified through an inquiry at Wassara about the companies that were first to investigate a possibility to use Wassara for ground engineering and companies that were loyal users of Wassara. Two companies were found to be potential lead users with the help of Lead User identification approaches derived by Goffin and Mitchell (2010) and Von Hippel (1986); and one of them has been chosen for the analysis because of the possibility to meet its staff during testing of a new concept for casing advancement. In this way, the lead user was met during a trip to the south of Sweden in August 2015. The lead user analysis was conducted during two working days.

During the Lead user analysis the empathic design methods were used, including observations documented through filming and photographing; contextual interviews with the context being the drilling process; and one-on-one interviews. The author has been fortunate to meet a very experienced and talkative rig operator, thus, simply listening and writing down his thoughts and comments on his actions gave a lot of useful information.

During the meeting it became obvious that the visited company, and specifically the contact person, was indeed a lead user, as the company has been the first to experience certain needs and also solved those needs itself on regularly basis by own innovation efforts. Some solutions even became patented products afterwards. In line with the theory on Lead Users (section 4.4.1), the company knew what it wanted and if solutions or products were not available on the market, the company created them itself. Furthermore, the contact person was knowledgeable in the areas outside the specific drilling field, such as water pumps and water purification systems.

The insights that have been uncovered through the lead user analysis are described below.

During the two days of testing of a new concept for casing advancement, the observations and contextual interviews allowed revealing an important issue of downtime and its consequences. The equipment wear down (rig, entire drill string, water pump) and misplaced or unavailable spare-parts leaded to only a few drilled meters being made by the end of the two day testing period. Each time a problem was fixed, another issue appeared. According to the lead user, this domino chain is an unfortunately frequent case and often leads to very high costs.

The word “continuity” was mentioned frequently by the lead user, meaning the need for assurance that the rig would work properly and drill accurately every time. The lead user t reflected on the perception of efficiency stating that from the company’s co-owner perspective, the efficiency means how many meters of holes a system can deliver, while from the driller´s perspective, efficiency means how easy it is to work with the system. To continue on that thought, the lead user mentioned that purchases of parts of a drilling system are usually done by the foreman or site-manager, but the driller has most to say about which parts should be bought.

According to the lead user, continuity is highly affected by the ability of retailer or supplier to quickly solve eventual problems. Availability of products, spare-parts, service and support during the whole project is therefore something companies need to focus on. Availability is crucial to avoid downtime. Furthermore, the lead user mentioned that it is hard to explain to a customer why a drilling project may be delayed with a month due to lack of equipment.

Beside the requirement of availability, the lead user expressed a need of both being able to solve the equipment malfunctions on its own and being able to call the service provider and get the service fast. Following this notion, Wassara has to provide tool-kits for service of its hammer, as the water DTH-hammer has more parts than an air-DTH hammer and, thus, needs special equipment to get served.

The lead user concluded that many companies find it difficult to provide adequate service and an efficient service concept is required. Component durability and access to spare-parts are very important factors, and the spare parts have to be delivered the next day after the order, according to the lead user.

The lead user had a great number of ideas and he was quite upset by the fact that a producer has not responded on his suggestions for improvement. Also when asked directly if he believed that the companies on the market used co-creation for product development, he responded that the level of co-creation was not sufficient. He also added that the companies test their products in a wrong way as they test-drill in the same places, which delivers misleading test results.

The one-one-one interview with the lead user uncovered that the involvement of the users into the product development process is an important requirement. If possible, the customer should be able to have direct contact with the supplier. Otherwise, the communication gets inefficient due to many steps leading to the customer´s ideas got lost. According to the lead user, the contact a customer gets with sails managers and the supplier's interest in the customer´s work are very important during a purchasing process. The sails managers have to understand how a drilling system works and, moreover, how a drilling process is executed.

Finally, the lead user elaborated on barriers towards greater penetration of Wassara equipment in the market. These barriers were:

- Water handling and purification systems are required as the work with the DTH-hammer requires high amount of water to be used. There is no suitable water handling system on the market at the moment.
- Customers have hard time finding suitable water pumps.
- Price of Wassara equipment is considerably higher than the price of conventional DTH-hammers.

5.3 Results of systematic observations

Systematic observations were conducted four times at three different sites in September and October 2015. The visited sites performed different types of ground engineering, including underpinning for a house in central Stockholm; foundation work for a parking garage; and foundation work for a bridge. The last site was the one visited two times with two working days being spent there. It is also the site, where the systematic observation was executed most close to theory, which prescribes that the observation has to be done throughout longer periods of time.

During the systematic observations, the previously unrecognized issues with using water DTH-hammer were revealed and the pros and cons of using the Wassara system were formulated as following:

- The water-hose was in the way when a casing-element was added to reach a certain depth or at the starting point of the drilling of a new hole. Thus, the drillers had to move away the hose in order for the casing to get through to the hole. The problem is that a water hose is heavier and vibrates much more than an air-hose, why it can damage the rig if it is fitted onto it.
- Drillers were running back and forth to switch on and off the water pump a couple of times during drilling of each hole, which seemed to be time-consuming by the observer, but not perceived as such by the drillers. This issue was observed on two sites, which was peculiar as remote controls are available to support operation of water pumps. The sites were generally manned by two drillers with one of them being a machine operator and the other one doing the "dirty" work. It was, therefore, in the second one's duties to switch the water-pump on and off. From chatting with drillers, it became clear that frequently, thought this is often not allowed and works only when both drillers are competent enough, the drilling operation is done by a single person and for that situation the use of remote control is crucial.
- The water was spraying the drillers due to wearied drill string parts, which is a common equipment issue, but it seems not to be disturbing the workflow or being perceived as unpleasant by the drillers. When questioning the observed personnel about this problem, they explained that the water spray causes much less inconveniences than the substance spraying when using the pneumatic system. They also claimed that it is relatively easy to avoid the spray if necessary, as opposed to when using air-DTH with airflows that are unpredictable. During a short chat with a drill operator at the site situated beside KTH-hallen who did not know about Wassara´s technology, it became apparent that dirty air-flows are perceived as a problem, but the issue was in many cases just ignored. This finding is in line with the needs literature, which stated that many problems experienced during a long time are either circumvented or simply neglected.
- The initiative of a producer to send its representatives to the site is perceived as very positive by all parties, including the drilling equipment operators, site-managers and foremen. The staff perceived the representatives as experts in drilling equipment and processes, and therefore they gladly exchanged information. Furthermore, their body language revealed that they appreciated heir supplier showing up on the site, and foremost, that the supplier demonstrated genuine interest in their line of work. Once the author observed the drilling process on his own, and even at that time the drillers were very pleased with having a direct bridge to support.

5.4 Results of contextual interviews

The contextual interviews were performed during five site visits. Here the difference is made between contextual interviews done with drillers and the ones with site managers. The interviews with site managers were performed at their onsite offices or at a regular company office, and are thus contextual in terms of being performed in the interviewee's environment. However, the interviews conducted not at the site fall on other requirements to contextual interviews provided in the section 4.4.3, for instance, embedding the interview into the interviewee's working process. Therefore, they are considered as one-on-one interviews.

The contextual interviews resulted in extensive information about the working environment, perceptions of different drilling methods and perceptions of producers, their products and the services related to the products. The major findings include:

- Each driller works in his own way, and therefore, it is not possible to develop a comprehensive manual for how the drilling process should look like. The

management in some cases has policies and training sessions in order to standardize the way drillers work, but at the end of the day it is the driller's ability to drill a hole that matters the most. As explained by a foreman while overlooking the drilling process: "The experienced guys go with the gut-feeling; equipment may wear down faster, but they get the job done".

- Even when drilling very close to each other, there is no guaranty that the drilling process will proceed similarly in two holes. The reasons for that are the differences in geology, pressure provided by water-pump or compressor, the rig operator and etc.
- Drillers require drilling systems that would work in different environments and can handle inhomogeneous grounds. Also, drillers need training before working with new systems in order to have a high performance rate and to increase the service life of the drilling equipment.
- The advantages with water-DTH drilling stated by Wassara, were verified by users during interactions, with every user emphasizing different advantages. As mentioned by one of the drillers concerning the site "It´s really nice and tidy, all you need is a pair of boots".
- A ring-set system needs to be easy to disassemble in all types of formations in cases of hammer-stoppage, the driller has to get the pilot-bit up for some reason, or the driller has to go further with a smaller diameter drill-bit.

During contextual interviews it became obvious that it is important that all equipment, both DTH-hammer and the casing advancing system work efficiently from day one and their optimal use is easy to grasp. This is due to many drillers being short-sighted; if something does not work it is branded directly as "crap", which leads to having a preference for a specific manufacturer.

5.5 Results of one-on-one Interviews

A total of nine interviews with eight market-leading companies were conducted during the fall period after the survey was finalized. Moreover, one interview was conducted with the retailer who is a very important stakeholder, being the retailer for the whole Swedish market. The timing of interviews with companies was chosen in order to analyse the assessable and articulable survey information before the interviews. This enabled deeper discussions using open questions. All interviews were conducted at the interviewees' workplace to make them more comfortable and willing to participate. The interview guide is provided in the Appendix D.

In order to kick-start the interview, a storytelling question about the usual way of conducting a drilling project was used, which in many cases led to several other questions being answered simultaneously. The most important findings from one-on-one interviews include the following:

- The trends are going towards larger hole-dimensions, meaning both deeper and wider holes are being drilled. This, in turn, leads to customers using casing systems and DTH-hammers with larger diameters.
- There is no virgin ground left to build on in Stockholm, why the construction companies need to tackle the issues with inhomogeneous environments.
- The construction market is highly competitive and notoriously lacking in foresight, which leads to construction companies often having a work overload, while being unsure on when and where the next project will be. Further, an important notion is that in construction business the economy is project-based and, thus, not yearly-based. All these factors put a lot of pressure on the supplying companies in terms of material availability, quality fluctuations, and providing service and efficient communication with construction companies.

- Service and support at the start and during a ground engineering project is extremely important, which could not be directly derived from the conducted survey. The superior levels of service and support are worth a higher price, as they directly affect the efficiency of the drilling process and lead to minimizing risks of downtime. Unlike the survey results, the interviewed staff emphasized that contextual training in use of different drilling systems is desirable, especially for the case of water-DTH drilling systems.
- The issues with use of water DTH-hammers were frequently mentioned by the interviewees, but interestingly, the majority of them have already been solved by Wassara or by the customers themselves. For example, one of the interviewee stated "In winter time you simply can´t drill with Wassara, the whole system will freeze and break", while another interviewee argued "I don´t really see a problem, yes there are some precautions you need take, like having constantly running water and blowing out all the water when finished, but that's not a big deal". This information implies that the customer-driven solutions to problems are relatively common in this market.
- Recently, the innovations that have changed the market the most were considered to be the ring-set casing advancing system and the Wassara water DTH-hammer. Overall, the interviewees had a hard time answering the question concerning innovations, which is explained by the fact that fairly few new innovative products have reached the market.

5.6 Results of Repertory Grid method

Two repertory grids were performed with customers that are using or have used Wassara drilling systems as one of the drilling methods. The theory on repertory grid analysis advises to have six examples of products, services or providers as described in the Section 4.5, but this was deemed to be tough for the respondents due to their companies aiming to standardize their equipment line. The choice was, therefore, made to ask the respondent to name 4-6 producers. Four elements is the least number that provides a possibility to use different triads and create a repertory matrix.

Repertory grid 1

During the first try of the repertory grid method (see Figure 11), the author experienced one of its strengths as the respondent did not only focus on providing the respective attributes, but was also motivated to share other information and discuss topics around the attributes.

Attributes	Card 1 Atlas Copco	Card 2 Robit	Card 3 Wassara	Card 4 Mincon	Card 5 Sandvik	Poles
Knowledge and service	*5*	*5*	*2*	5	5	Insufficient assistance
Price-efficient	*4*	3	1	*4*	*3*	Expensive
Performance	5	*4*	*3*	4	*5*	Short service life

Figure 11. The first Repertory grid

Following attributes were established and described by the respondent:

- Knowledge and service, i.e. how helpful the company is during, before and after the project;
- Price efficiency i.e. cost of equipment;
- Performance, i.e. the service life of a pilot bit.

The results of this repertory grid suggest that Wassara needs to work on the knowledge and service attribute and the price efficiency attribute. As previously mentioned, Wassara has currently no casing advancement system available for the market. The low scoring on the performance is rather due to the respondent experiencing that pilot-bits' service life is shorter when using Wassara´s water DTH-hammer. There was no apparent technical reason for this problem according to the respondent. The author's opinion on this matter was that the respondent had not gotten enough training and support at the start of the project, why the drilling process was carried out wrongly. This opinion was supported by Wassara staff who noted that generally the longer drillers' experience of working with Wassara, the longer the service life of components.

Repertory grid 2

The second repertory grid (see Figure 12) was much more straightforward than the first one, as the respondent had less time and maybe been a bit too far from the use of the product. The indirect result of this repertory grid is a notion that in order to generate a well filled repertory matrix, it is important to schedule at least a one-hour meeting with focus only on creating a repertory grid.

Attributes	**Card 1** Atlas Copco	**Card 2** Mitsubishi	**Card 3** Robit	**Card 4** Wassara	**Poles**
Sales and service	***4***	***3***	***3***	**3/2**	Not helpful
Focus on market	**5**	***4***	***3***	***2***	Insufficient market knowledge
Development activities	***3***	***4***	**4**	***3***	Insufficient new development

Figure 12: The second Repertory grid

The following attributes were established and described by the respondent:

- Sales and service, i.e. how helpful the company is during, before and after the project;
- Focus on market, i.e. market knowledge and understanding;
- Development activities, i.e. new developments and listening to customers on new developments

The main notion extracted from the repertory grid number two is that the respondent is not totally satisfied with the amount of new development done in the industry, which was also mentioned by several interviewees in one-on-one interviews.

While comparing the two repertory grids, it became apparent that the first mentioned attribute was almost identical in the two cases. This might imply that communication and support from the supplier is very important for the customers. Next types of attributes differ between the two companies: while the first respondent focused on efficiency, the second focused on market and

the product development. This can be explained by the fact that the first repertory grid was conducted together with a site-manager, while the second was conducted with a market and technology chief. These differences confirm the importance of interviewing various stakeholders.

5.7 Co-creation

The method of co-creation is often applied to drilling equipment, according to Wassara and interviewed companies, as well as due to observation results during two site visits. For example, at one site a large contractor company was provided with a new hammer-concept to be used during the project. This hammer was provided free of charge with the only condition being a feedback to Wassara and a possibility to use the project as a reference. This reminds a need-assessment method described by Durgee (2001), though the testing activity has not been intended for the need assessment. This might be explained by the fact, that similarly to this particular case, companies focus more on testing their equipment, than actually collecting customer needs with help of tests. Thus, the feedback consisted mainly of customers' perception on how the concept worked, rather what their needs were.

Generally, the producers of the drilling equipment are not so good at testing their new concepts and unexpectedly often put new products on the market without properly testing them first, according to interviews and Wassara staff. For example, Wassara has a rule of thumb that if a DTH-hammer has gone 1000 meters without issues, it is considered to be ready for market launch. This implies that every Wassara product should be tested in its real working environment before it is launched. Similarly, Atlas Copco has managed to get a deal with a well-drilling company in Stockholm that tests their new concepts. Finally an insightful notion by the lead user on this matter is the following: "You can´t call it testing, when you are simply drilling a couple of holes in a 5X5 meter area; you will never get the right result". Thus, trying out the product before putting it out on the market seems to be a good step towards satisfying customers.

6 ANALYSIS AND RECOMMENDATIONS

This chapter presents identified explicit and hidden needs, and provides analysis of customer satisfaction based on the empirical results described in the Chapter 5. Further, the chapter covers recommendations on Wassaras´ current and future offers, business development and prospective partnerships that are rooted in the performed analysis.

6.1 Identified needs

The performed study allowed identifying both explicit and hidden needs through survey, lead user analysis, systematic observations, one-on-one Interviews, repertory grid and co-creation.

6.1.1 Explicit needs

The following explicit needs have been revealed within this study:

1) Good quality equipment that is durable and has a long service life.

   Quality needs to correspond to what has been promised, which is often not the case, according to the respondents of the study.

2) Ability to drill in different environments with little variation in reliability.

3) Systems that can handle tough drillings and deeper drilling in rock, as there is increasing number of projects that have these requirements.

4) Availability of equipment and spare-parts at the start and during the project.

5) Available and efficient service and support of equipment during the whole project.

6) Fewer special systems and standardization.

   The respondents argued that the producers should follow the same standards such as Euro Code, and asked for quality documentation.

8) Possibility to be included more into the development of drilling equipment.

6.1.2 Hidden needs

In order to justify whether hidden needs have been discovered within the study, the following characteristics of hidden needs proposed by Goffin and Mitchell (2010) where used:

- The need is hard to articulate;
- Not a need apparent from surveys or phone-interviews;
- The need spurns from contradictions between customers' sayings and doings;
- Customers show great satisfaction when this hidden need is acted upon.

The following uncovered needs correspond to aforementioned criteria:

1) Ability to get an indication whether the solid rock has been reached.

According to interviewees, many drillers nowadays have not as long professional experience and broad knowledge compared to the past. This often leads to drilling deeper than needed, as there is no definitive way too asses if the rock has been reached. Seasoned drillers go with the gut-feeling, but even they get it wrong sometimes. The cases when drillers were 100% sure that they have reached rock, while this was proven to be wrong, were mentioned during the study.

Consequently, there seems to be a need to have more information on the down the hole environment.

2) Adaptive service, i.e. customers being able to service the product themselves and getting fast service if needed.

This need has been hard to articulate for most respondents, except the lead user. Furthermore, there were apparent contradictions between survey and interview responses. The majority of interviewees wanted only one type of service, that being serving in-house as much as possible, while the survey showed a slight preference for efficient external service and, at the same time, the majority of the survey participants wanted both types of services. A quote from one of the respondents communicates this discrepancy quite well: "We have all the tools needed, so we aim to serve at home, but we never got the time for that stuff." During deeper discussions about this issue, interviewees became enthusiastic when the adaptive service concept was proposed by the author as an answer to their claims about difficulties with service.

3) Quality communication and support

This hidden need has been revealed within several site visits. The customers showed great appreciation and satisfaction when Wassara staff visited the site. This appreciation could be explained as a response to the empathic behaviour of the suppler, for instance, the supplier showing interest in the current project or inquiring on the effectiveness of drilling process and if any assistance was necessary. Moreover, a customer feels more secure as the suppliers' presence at site increases confidence that assistance would be available if necessary.

This need was hard to articulate and it did not become apparent through the survey, rather the opposite has been indicated. The site visits seem to be just a step towards satisfying the aforementioned need, as customers expressed great dissatisfaction when the communication was not effective. For example, having to chase the relevant people to get assistance was perceived as very negative by the respondents. According to them, the customer communication is something most companies have trouble with and, thus, this need is seldom satisfied.

4) Commitment to success of the project through project design

As concluded by Ahola (2006), creating customer satisfaction in industrial projects through meeting hidden needs is a very complicated task, due to the projects being complex mixes of products and services. This notion can be applied to the products delivered by Wassara. Customers rarely perceive the purchase of a DTH-hammer and the casing advancement system as a simple deal. Purchasing these items is already a complex undertaking, as they need to fit a specific environment. Furthermore, customers require service and support that differs during various stages of a project, as well as efficient communication with the responsible company be that a retailer, or a supplier (many customers stated a want for communication specifically with the supplier). Therefore, delivering DTH-hammer and the casing advancement system is similar to delivering a project. Taking part in the project at its early stage means that the supplier understands the specific realities of the project (i.e. geology, plans and etc.), and thus able to provide the most fitting equipment solution, supplying solution and service solution. In its turn, this brings confidence to the customer and leads to establishing long-time relationship between a supplier and a customer. Several ways of satisfying this need were proposed by the respondents of the study, but these suggestions were articulated as wants, and not as comprehensive measures. Formulation of this need has been built upon the efficiency factors elaborated by the respondents. But, more importantly, it is based on the articulated customer opinion that a supplier's commitment should not end after the drilling equipment has been sold.

The majority of identified hidden needs might be satisfied by adequate communication and services. However, it seems that the companies operating on the market have been solely focusing on product development, rather than communication and service aspects of the offered package, as the majority of respondents did not find any company excelling in this matter.

Finally, the field study brought about an important observation related to the service design theory, which states that "evidencing" the service by adding tangible artefacts prolongs the positive experience of a service (Stickdorn and Schneider, 2012). The similar, but reversed relation appears in the ground engineering environment, where the product seems to be "evidenced" by services. This conclusion has been derived from the fact that interviewees tended to remember getting unexpectedly high levels of service, support and interaction with the supplier even long time after the purchased equipment has been used. Furthermore, it was rather the unexpected high level of service that satisfied the customer, than slightly higher product performance, which corresponds to the Kano´s matrix analysis presented in the following section of this chapter. This could be explained by the drilling process being a complex interrelation between different equipment, the driller and the environment, which makes it hard to point out one element as the reason for greater drilling performance.

6.2 Customer satisfaction analysis

The analysis starts with evaluation of Wassara´s offer with the help of Kano´s matrix described in Section 4.1, following with the functions/costs and benefit/costs value perception derived by Yang as presented in the same section.

6.2.1 Kano´s matrix

Kano´s matrix (Kano et.al., 1986) incorporates Must-be Quality, One-dimensional Quality and Attractive Quality.

Must-be Quality: in a DTH-hammer´s case, this quality attribute is related to the ability of drilling a hole, which is the essential value that a DTH-hammer provides. Wassara system is marketed as and considered by customers as the one that is working in practically all environments, which implies higher probability of delivering a hole. This quality is to be pointed out during the selling process by Wassara sales managers and retailers. According Kano´s matrix, success in delivering a hole would not lead to higher customer satisfaction as a drilled hole is actually what the product promises. On the other hand, failure in delivering a hole, even if it is due to user's incompetence or another factor outside of Wassara's control, will lead to dissatisfaction. This dissatisfaction would, in turn, erase all other qualities provided by Wassara system.

This analysis of must-be quality implies that Wassara has to provide sufficient information and know-how to the customers and users in order to maximize the probability of the DTH-hammer delivering a drilled hole. Also, it is important to understand the relation between the DTH-hammer and the rest of the drilling package components in order to minimize the chance of malfunction due to interaction and compatibility issues.

One-dimensional Quality: This quality corresponds to the attributes that have been articulated and the ones in which companies are competing. The empirical study has uncovered the following factors, in which companies are competing: price, drilling speed, energy-efficiency and service life. These factors are weighted differently by the customers and may also vary from project to project. This conclusion has also been confirmed by the answers to the survey question, which asked the respondents to assign 100 points to various factors affecting their choice of drilling system. Wassara is, for example, at the front end of energy efficiency, but at the same time, it is at the back-end by the price factor. As the product price is considered more important by customers, than energy-efficiency, Wassara cannot make full use of its competitiveness on quality attributes. Further, in Wassara´s case the articulated attributes include the cleaner and safer working environment and higher pressure. The mentioned attributes are either not perceived as important by customers or may be not fully understood, which shows the

importance of efforts in forming customer needs as argued by Christensen and Bower (1996). To summarize, Wassara has many unique and strong one-dimensional quality attributes, but due to the high price and insufficient appreciation of those one-dimensional attributes by customers, Wassara is not able to take full advantage of satisfaction from those attributes.

Attractive Quality: This quality relates to the attributes that provide satisfaction when achieved fully, but do not cause dissatisfaction when not fulfilled. Since these types of quality attributes lead to unexpected customer delight, they are often unspoken. As descried in the Chapter 4, the attractive quality often corresponds to satisfying hidden needs. Following this notion, the Wassara's offer should incorporate attributes satisfying the aforementioned hidden needs. For example, Wassara could provide an unexpectedly satisfying service and communication package to delight its customers. Further, Wassara could develop a solution that provides the user with more accurate information on the down-the-hole environment surrounding the drill bit. This could potentially differentiate Wassara´s DTH-hammers from other competitors' ones even more, branding them as "the smart hammer".

As for now, Wassara has no apparent attractive quality attributes, which is essential to boost up Wassara´s competitiveness. By analysing the costs and value incurred by satisfying the abovementioned hidden needs, two of them seem to be the most cost-efficient and possible to satisfy in a short-term, namely the (3) Quality communication and support and (4) Commitment to success of the project through project design. This is due to the fact that satisfaction of those needs merely require competences that have already been partly obtained by Wassara, and demanding a couple of extra staff-members for the Swedish market.

6.2.2 Value/Price analysis

According to Narver et al. (2004), companies should aim to compete with higher value, rather than with price, as in the last case the only way to compete is by constantly lowering the price. During interaction with customers within this study, the term "the right price" was frequently mentioned. Customers explained that they are ready to pay a stated price as long as the price relates adequately to the qualities of the delivered products and included services. While applying the functions/costs and benefit/costs equations provided by Yang (2013) to evaluate customers' perception of Wassara´s offer, it is possible to argue that Wassara is losing to its competitors in spite of more advanced technology. While Wassara provides more benefits than the competitors, many of Wassara´s benefits are not perceived as strong enough, because some beneficial product attributes do not necessary lead to higher customer satisfaction (Matzler and Hinterhuber, 1998). As it is mentioned above, this might be due to customers not remembering or understanding the actual benefit. Thus, capitalizing on the benefits generated by satisfaction of revealed hidden needs, combined with lowering the price, could lead to higher product value from customers' point of view. Hence, if satisfying the hidden needs, the price cut does not have to be as drastic as without doing so. Finally, the Kano matrix and price/value analysis in combination with the empirical study shows that Wassara have a good chance to compete with value rather than price if addressing the revealed hidden needs, and would in that case be unique on the market, as the other companies seem to be competing with price.

6.3 Recommendations

Based on the analysis of customer satisfaction in combination with empirical results of the study a number of recommendations could be drawn concerning Wassara's business development; its current and future offers; types of construction sites, where Wassara's technology is superior to its competitors' offers; and prospective partnerships.

6.3.1 Recommendations on business development

To increase the customer value perception, the following measures should be implemented:

- To develop new ways of cutting the price of the products without lowering quality, performance or any other important factors;
- To design efficient supply chain based on in-house distribution in order to cut costs, increase customer proximity and equipment availability;
- To design an efficient production flow in order to be more price competitive and have high availability of equipment and spare-parts;
- To design and implement efficient internal and external communication processes;
- To develop an efficient service package for higher customer satisfaction (see Appendix E);
- Market research should become a continues process that is conducted in-house (see Appendix F);
- To improve co-operation with companies supplying parts of a drill rig and other equipment needed for Wassara drilling.

6.3.2 Recommendations on Wassaras´ current and future offers

Results of the market analysis, provided in the Chapter 5, combined with identified explicit and hidden needs, led to the following recommendations on Wassaras´ current and future offers:

- To develop a package including a hammer designed for the ground engineering market, specifically the casing advancement application, and a ground engineering ring-set system that would work in different environments, including ”dirty” environment and deeper rock-drilling operations;
- To develop a system that may give an indication whether the rock has been reached;
- To include check valve in the hammer package;
- To offer Wassara drill pipes to large projects only. Only few large companies on the market offer drill pipes. Furthermore, there are more cost efficient alternatives to Wassara´s drill pipes on the market;
- W-Rex casing advancement system should not be revived;
- To deliver more cost-efficient spare parts and service kits, with better availability;
- To develop a tool-box and a manual for hammer service;
- Wassara´s future DTH-hammer size range should include a 10- and a 12-inch hammer.

6.3.3 Recommendation on construction sites, where Wassara’s technology is superior to competitors’ offers

Observations and contextual interviews during site visits as well as one-on-one interviews allowed revealing the following types of construction sites, where Wassara’s hydraulic system proved to be superior to the pneumatic drilling systems:

- Confined spaces, which are characterized by:

    - Bad working environment when using Air-DTH;
    - Unsafe working environment;
    - Cleaning of space is time-consuming.

- Near highways and other communication lines, where it is important to have no effect on the outer and inner environment.

6.3.4 Recommendations on prospective partnerships

In order for Wassara to maintain competitive advantage, it is necessary to establish and develop collaboration with business-relevant stakeholders. The performed market analysis, lead user analysis and one-on-one interviews allowed identifying the following types of partners that would be beneficial for Wassara:

- An innovative rig-production company that does not have DTH-hammers or casing advancing systems in the product portfolio. This is particularly important for development of a system for confined spaces.
- A water-pump production or rental company. This collaboration could support Wassara in becoming more customer friendly, to deliver better availability and to gain in-house knowledge about water-pumps.
- Companies that can reuse cuttings. This partnership has a potential to deliver an attractive and unexpected quality for customers. Wassara cuttings are environmentally friendly compared to air-DTH hammer cuttings that have oil traces. Wassara´s cuttings are also considered to be of a more adequate size and shape, than the ones generated from drilling with pneumatic systems.

The list of recommendations is not complete as some of the developed recommendations contained valuable company information that cannot be disseminated outside the company.

7 DISCUSSION AND CONCLUSIONS

This chapter includes discussion of the results as well as the conclusions drawn from the study. Further, the limitations of the applied approach are described and the future research topics are highlighted.

7.1 Discussion

This thesis stemmed from the need for better understanding of the ground engineering market by LKAB Wassara - an innovative company that developed a novel technology of hydraulic DTH-drilling; and from the insight that the achieving customer satisfaction through fulfilment of hidden needs in construction industry is promising (Goffin and Mitchell, 2010; Ahola, 2006) yet challenging (Ahola, 2006) endeavour.

To meet the needs of Wassara and to bring about new insights and experiences on customer needs analysis in a part of the construction market, specifically ground engineering, this study was designed comprising the following research questions:

1. What are the explicit and hidden customer needs in the ground engineering market in Sweden?
2. How the revealed customer needs in the ground engineering market could be translated into recommendations for improvement of Wassara's product offerings and strengthening its business development?
3. What can be learned from a single case study of hidden customer needs analysis in the construction sector?

The **first question** has been answered by an extensive study of explicit and hidden needs in ground engineering in Sweden, using both conventional market study methods and a tool-kit of hidden needs analysis developed through a broad literature review.

Among the uncovered needs, there are four that could be considered as the hidden needs, following a checklist derived by Goffin and Mitchell (2010). They were hard to articulate and were not apparent from the survey. Furthermore, three of them were connected to contradictions between customers' sayings and doings. Finally, it was observed that the customers were much satisfied when one of these hidden needs was acted upon, and when another one was proposed to be met by a concrete measure. However, the concept of hidden needs is not straightforward, as there is no way to be completely sure whether the discovered need is indeed a hidden one. As for the four aforementioned needs identified in this study, Wassara staff from all departments confirmed that even when relevant to the hidden needs observations have been done while communicating with customers, neither of them have been thought of as a need.

The experience from conducting the research showed that in order to identify the hidden needs, it is vital to meet the customers in person and letting them lead the communication. Such an approach enables revealing the whole picture, rather than only specific information, for instance, on product properties. Further, the greater empathy with the users and other personnel developed within this project allowed uncovering the previously unrecognized or neglected needs, as for example, the need concerning the ability to get an indication whether the solid rock has been reached.

To answer the **second question**, the methods for customer satisfaction assessment have been studied, including Kano's matrix (Kano et al., 1984) and, functions/costs and benefit/costs equations derived by Yang (2013).

These methods allowed translating the identified explicit and hidden needs into recommendations for improvement of Wassara's product offerings and strengthening its business

development. This was done through analysis of different quality attributes connected to each particular need and developing recommendations on how these qualities could be capitalized upon.

Kano´s matrix proved to be a powerful tool for comparison of Wassara´s current offer with the competitors' ones, and to explore how the customer satisfaction varied between them. This approach enabled analysis of factors, product attributes and product package attributes. One of the results of applying Kano´s matrix is an insight that no company on the market had strong attractive quality attributes, and furthermore, that Wassara has many beneficial attributes that were unrecognized or not fully appreciated by customers (e.g. lower sound levels and cleaner construction sites).

After identification and evaluation of quality attributes by Kano's matrix, the received results were further assessed through the abstract value perception equations (Yang, 2013). Consequently, the obtained function- and benefit-price relation was used for the qualitative evaluation of the price/performance ratio for potential Wassara's offers, which in its turn allowed formulating recommendations for Wassara future offers and highlighting the ones that seems to bring the fastest return on investments. However, it should be mentioned that the results of the classic Kano´s matrix are not quantifiable, and should be interpreted by experts, which implies subjectivity.

The **third question** concerns applicability of the achieved results to the construction sector. This thesis comprised a single-case study within the ground engineering segment of construction sector, which makes it impossible to generalize the results from the case to the whole market. However, as the case-study was done for a unique product, it is possible to claim that some lessons learned within the study are of high relevance for the market (Yin, 2009). The hidden needs analysis methods were applied to the specific parts of a drilling package, which are the casing advancement system and the DTH-hammer. These parts belong to a larger structure used during a drilling process. No apparent barriers have been recognized for adaptation of the lead user analysis, observations and contextual interviews to be used for identification of hidden needs connected to other parts of the structure, such as the water-pump, rig and the casing feeding crane. Furthermore, as the water-pump was interrelated with the DTH-hammer, a lot of information was acquired from interviewees on this part, even though it was not a focus of the study. Except for the DTH-hammer and the casing advancing system, the other abovementioned parts of the structure or varieties on them, are used in the whole construction industry. Furthermore, taking into consideration that all equipment is considered an important part of a construction project, and it comes with needs for service and support, it seems important to uncover hidden needs in order to deliver customer satisfaction through integration of the products and services in the construction sector.

Another finding of this study is that there is a need for proximity between ground engineering companies and the equipment developers in order to gather both the explicit and hidden needs. This appears to be of general importance for the whole construction industry according to Blayse and Manley (2004), who found the interaction between customers and equipment manufacturers to be the major driving force of innovation in the construction industry. While customers have been recognized to have a major impact on innovation in construction industry, companies still need to find ways to efficiently collect and integrate customer inputs in order to capitalise on them. Finally, this study demonstrated the importance of the Lead User approach for identification of hidden needs. This is in line with the conclusions by Blayse and Manley (2004), who argue the more demanding and experienced customers may fuel innovation in projects they take part in.

7.2 Conclusions

This study has provided an extensive literature review on methods for uncovering hidden customer needs and approaches for customer satisfaction analysis. The resulting tool-kit enabled a market study and analysis of customer explicit and hidden needs for the ground engineering market in Sweden.

Both the explicit and hidden needs have been revealed during the study; with the hidden needs not being previously recognized by Wassara, and not being satisfied by any of the companies operating on the market. The uncovered needs have been translated to recommendations for Wassara's future product offerings and business development through the Kano's matrix and the value perception equations (Kano et al., 1984; Yang, 2013).

One of the most significant conclusions of the study is the revealed lack of focus on the service aspect of product packages in ground engineering market. It appeared that companies operating on the market focused only on providing a product to the customers. The interviewed customers claimed that companies were almost never communicating with customers enough. Furthermore, when communication or service was perceived as inadequate from a customer's point of view, it was rather the producer than the retailer who got the blame. The study has ample evidences that service, support and knowledge communication to the customers and users is important in order for them to retain the full value of the product. This conclusion is also confirmed by Raja et al. (2013).

Finally, the construction equipment market seems to be very technology led, which is not necessarily a limitation, but as Christensen and Bower (1996) point out, there is a need to both be able to invest into new technology projects and to act upon customer needs.

7.3 Limitation of the study

Despite empirical evidence that the application of hidden need analysis methods lead to deeper understanding of both explicit and hidden needs of the ground engineering market, there is a lack of studies that evaluate how conventional market research techniques perform in relation to hidden need analysis methods in industrial markets and specifically in construction business.

This study has been done for an application that is a part of a larger product structure, thus, it is impossible to conclude whether the approach would work for the rest of the market

7.4 Future Work

There is a need for more case studies in the industrial markets, and specifically in construction business, in order to build up the field of hidden needs analysis and be able to find out which methods suit best for specific context and situations.

It seems important though challenging task to develop a need analysis tool-kit for the construction industry. This tool-kit should meet requirements of the construction market and at the same time, the requirements of the companies, which develop equipment for this market.

Further, more research on the decision making units in construction industry and their drivers is also needed.

Finally, the fast pace of urbanization leads to growing construction business, which sets stronger demands on companies to develop products that would satisfy the construction market needs and therefore, the attempt of the thesis to meet this challenge, should be followed up with deep studies in various sectors of the construction market.

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APPENDIX A: REPERTORY GRID GUIDE AND TEMPLATE

Script for interview using the Repertory Grid Technique (RGT)

Step 0 – Introduce the task. (2 min)

Step 1 – Ask the interviewee to name 6 (min. 4) different drilling equipment manufacturers whose equipment he has used most. The manufacturers should produce DTH-hammers, casing advancing systems or both. (2 min)

Step 2 – Write down each of the 6 different examples on a piece of paper and give each a random number from 1-6. (1 min)

Step 3 – Present the interviewee with a set of three cards (a triad). (1 min)

Step 4 – Ask the interviewee: "Why using equipment from two of these companies (elements) similar and different from the third?" Make the interviewee aware that not only the drilling process is relevant the processes of procurement, service, support, communication and etc. are also relevant. (5 min)

Note the way in which the interviewee differentiates between the elements in the triad as it reveals how the different manufacturers´ equipment and product package is perceived. The positive difference should be considered as the "attribute" while the negative should be considered as the "pole"

Step 5 – When the interviewee has given an attribute by which the use of manufacturers' equipment differs, it may be needed to ask the interviewee to explain the attribute further. (3 min)

Step 6 – Ask the interviewee to rate the three initial elements against the attribute on a 1-5 rating scale (positive-negative). Note with (*)-symbol the elements in the triad which generated the attribute. (2 min)

Step 7 – Ask the interviewee to rate the rest of the elements against the same attribute on a 1-5 rating scale. (2 min)

Step 8 - Present the interviewee with a new unique set of three cards. (1 min)

Step 9 - Ask the interviewee "Why using equipment from two of these companies (elements) similar and different from the third one?" The interviewee is not allowed to name an attribute that has already been named. (3 min)

Use the following card sequence: **123**; **456**; **135**; **246**; **125**; **346**.

Attributes	**Card 1**	**Card 2**	**Card 3**	**Card 4**	**Card 5**	**Card 6**	**Poles**

APPENDIX B: CLUSTERS OF SURVEY ANSWERS

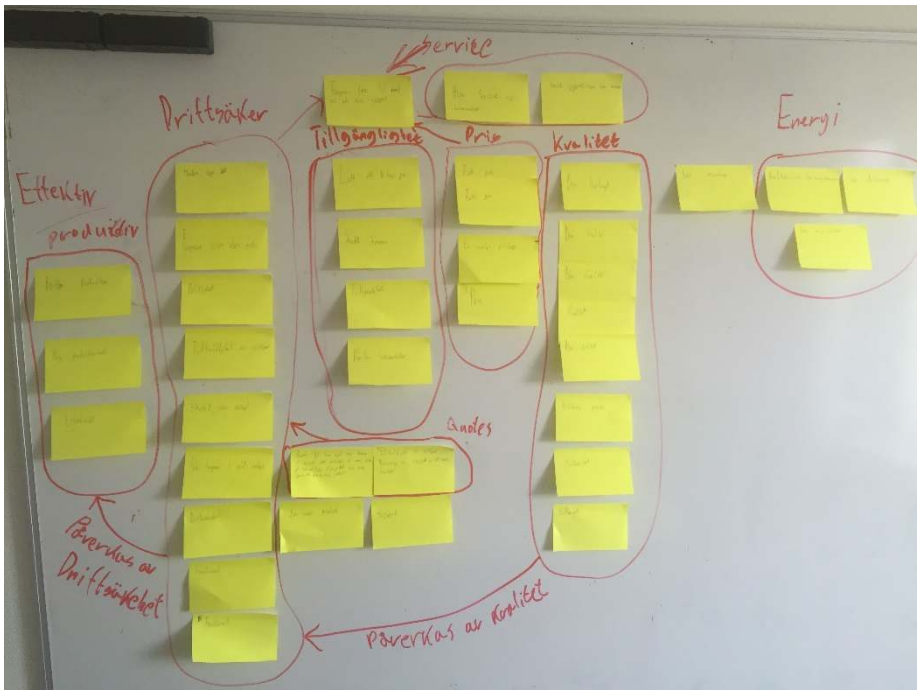

Figure B1. What do the customers require from a drilling system?

Figure B2. Who is included in the DMUs?

Figure B3. What does efficiency mean for the respondents?

APPENDIX C: SURVEY GUIDE

Undersökning av rördrivnings-marknaden

Sida 1

Hej!

Tack för att du har tagit dig tid att svara på denna undersökning!

MVH Igor Kordas

KTH Industriell produktutveckling

Vilket sorts företag representerar du? *

- ☐ Huvudentreprenör
- ☐ Underentreprenör
- ☐ Konsult
- ☐ Annan

Vilken borrning håller du främst på med? *

- ○ Grundläggning
- ○ Värmehålsborrning
- ○ Annan

Din befattning på företaget: *

Sida 2

Uppskatta hur stor del av rördrivnings-projekt (casing advancing) som du har deltagit i var utförda med sänkhammarborrning (DTH-hammer). *

%

Uppskatta hur stor del av rördrivnings-projekt som du har deltagit i var gjorda med excentriska system (ex. Symetrix), koncentriska system (ex. Odex, Tubex) och andra system (nämn då även vilka).

	%
Excentriska system	
Koncentriska system	
Andra system	
Ange namn på andra system	

Var vänlig och dela upp 100 poäng mellan följande alternativ. Sätt "0" för alternativ där inga poäng ska tilldelas.

Vilka är de viktigaste faktorerna för dig när du väljer eller föreslår en borrsystem-tillverkare?

Pris	
Tillgänglighet (lätt att få tag på, snabb leverans)	
Pålitlighet (krånglar sällan, går sällan sönder, jobbar som den ska)	
Energiförbrukning (dieselförbrukning)	
Miljöpåverkan (ljud, luftpartiklar, CO2)	
Paketlösning från samma företag (rördrivningssystem + DTH-hammer + rigg)	
Kontroll över borrningsförloppet	
Effektiv service (enkel att serva själv, snabb support från företaget)	
Varumärke	
Inskrivna metoder eller krav	
Förutsättningar (formationen, sitens utseende och lokalisering)	

Föreslå gärna en egen faktor:

Sida 4

Vilka är de största kostnaderna i ett borrprojekt enligt dig?

Vad betyder effektivitet för dig i ett borrningsprojekt?

Görs en riskanalys vid val av ett borrsystem/fabrikat(varumärke) på ditt företag? *

- ☐ Ja
- ☐ Nej
- ☐ Vet ej

Hur viktigt är det att minimera risker vid val av ett borrsystem/fabrikat (säkerställa hål, minimera ställtider etc.)? *

	1 inte viktigt									10 mycket viktigt
Hur viktigt?	○	○	○	○	○	○	○	○	○	○

Vilka personer (befattningar) är med och bestämmer angående val av borrmetod samt fabrikat på ditt företag? Vem har störst påverkan? *

Sida 5

Vilka av följande borrsystem för rördrivning använder ni oftast? Här kan ni skilja på DTH-hammare och rördrivningssystem. Vänligen kryssa i respektive ruta (om möjligt skriv modellen)

	DTH-hammare	Rördrivningssystem
Atlas Copco		
Sandvik		
Halco		
Mitsubishi		
Robit		
Everdigm		
Bulroc		
Wassara		
Sysborh		
Numa		
Mincon		
Top Drill Korea		
Rockmore		
Hanjin		

Sida 6

Vilka önskemål har ni överlag från ett borrsystem?

Vilka behov har ni av följande service för DTH-hammare? Kryssa en eller flera alternativ *

- ☐ Snabb support av produkten från leverantör
- ☐ Kunna enkelt serva den själv
- ☐ Experthjälp från företaget vid val av lösning som passar specifika projekt
- ☐ Utbildning i användning av DTH-hammaren
- ☐ Sitenärvaro i tidigt skede av projektet

Sida 7

Hur anpassade är borrsystemen som finns på marknaden gentemot era behov? *

	1 oanpassade									10 helt anpassade
Anpassningsgraden	○	○	○	○	○	○	○	○	○	○

Hur kan anpassningen bli bättre?

» Redirection to final page of eSurvey Creator (change)

APPENDIX D: INTERVIEW GUIDE

Start

1. Till at börja med, kan du berätta lite om er bransch? (Trender du ser både när det gäller er produkt, men även omkringliggande saker som ex. borrmetoder, standarder, vanligaste anledning till rördrivning)
2. Som jag har förstått är varje borrat hål mer eller mindre unikt. Men om du skulle beskriva ett vanligt förlopp på ett borrnings-projekt, hur ser det ut? Hur går det till stegvis?
3. Hur ser en typisk rördrivnings process ut under ett grundläggningsprojekt?
4. Vilka är de viktigaste faktorerna att tänka på under en borrprocess?
5. Vilka är de vanligaste serviceärendena för er under ett projekt och specifikt när det gäller rördrivningsprocessen?
6. Vilka är de vanligaste problemen som uppstår under ett projekt och specifikt under rördrivningsprocessen?
7. Vilka är anledningarna till att dessa problem uppstod?
8. Händer det att ni får samma problem flera gånger under ett projekt? Vad brukar vara anledningen?
9. Vilka svårigheter (om några) har ni stött på under era senaste rördrivningsprojekt?

Frågor angående borrmetoder och rördrivning i Sverige

10. Vad har ni för krav och önskemål gentemot ett borrsystem?
11. Vad har ni för krav och önskemål gentemot tillverkaren och/eller återförsäljaren?
12. Vilka positiva samt negativa erfarenheter har ni av tillverkare och/eller återförsäljare?
13. Vilka borrsystem (räkna upp företag) har du arbetat med? Vilka är deras nackdelar och fördelar, styrkor och svagheter?
14. Brukar ni på ert företag ofta byta borrmetod/system eller försöker ni hålla er till ett? Varför?
15. Vilka positiva samt negativa erfarenheter har ni från arbete med rördrivning?
16. Vad är du nöjd samt missnöjd med, rent generellt för borrsystem på marknaden?
17. Har du behov eller idéer av/om olika service runtom produkten?
18. Har du behov eller idéer av/om olika attributav en DTH-hammare samt rördrivningssystem?
19. Hur viktig är kompatibiliteten mellan olika komponenter från olika företag för dig? Hur är kompatibiliteten just nu?
20. Hur svårt är det för kunden att samla hela paketet som behövs för att utföra en borrning? Hur går den processen till?
21. Vilka medlemmar har ni i en Decision Making Unit (DMU)?

Frågor angående kunderna på den svenska marknaden

22. Hur priskänslig är grundläggningsmarknaden?
23. Hur ser trender ut för rördrivning i Sverige?
24. Vilka är svårigheterna med att borra i Sverige?
25. Vilka standarder finns det inom rördrivning på ert företag? (Storlek på rör, m.m.)
26. Vilka är enligt dig de mest uppenbara behoven som kunder (ni)/marknaden har?
27. Hur ser du på de framtida behov som kan tänkas uppstå på marknaden?
28. Vilka är de innovationerna i borrtekniken som enligt dig har förändrat marknaden som mest?
29. Har du några fler kommentarer eller synpunkter?

APPENDIX E: SERVICE AND COMMUNICATION PACKAGE

The service and communication package proposed in order to satisfy the uncovered hidden needs includes following attributes and policies:

- Well-equipped fleet of DTH hammers for loan.

  To ensure the customers´ operation is always in progress and stimulates the smaller companies to choose Wassara.

- Develop an in-house organization capable for servicing hammers fast.
- Employ staff able to travel to the site, optimize and teach the use of Wassara.
  - Solve problems that can appear during drilling fast, by so making the customer feel secure and more satisfied.
  - Show interest in customers by traveling to the site on different project stages, gather and analyse their feedback.
- The customer should never need to be sent to another staff member more than once, if the customer should be sent to a partner deal with it yourself.
- Promote customer satisfaction and empathy as one of the main company goals.

APPENDIX F: MARKET UPDATE

Proposed approaches to market update and measures to communicate the market information internally:

- Compound the information gathered from Drilling Equipment events;
- Compound information from site-visits and direct customer/user interactions;
- Invite non-conservative consultants and stakeholders such as drillers, drilling experts, site managers and other relevant people to a Workshop/Discussion meetings;
- Try to get good relationship with aforementioned stakeholders to make them willing to take part in the meetings regularly.
- Present the gathered information to the whole company every quarter or half-year depending on the amount of new information.