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What can a Technology Provider of Solutions with 6.4/6.3 Technology Readiness Levels, in Design and Digital Manufacturing, learn from some customer insights?

Master's Thesis in the Master's Programme
Entrepreneurship and Business Design

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Lastly, to my reader, I can state that I truly tried to make this piece a worthy read and learning experience. I hope that it will be a learning experience that you can pass onwards.

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Abstract

This thesis is an exploratory study of learnings from customers that benefit Technology Providers of solutions with 6.3/6.4 TRL in DDM. The thesis answers the question; what are some ways a tech providers of solutions with 6.4, or lower, Technology Readiness Level (TRL), in Design and Digital Manufacturing (DDM) can learn from some customer's insights.
There are lots of ways this type of tech provider can learn from consumer insights; in summary, this thesis argues that for Low TRL solutions (6.3/6,4 and lower) in DDM it is important to:

(1) Understand the technology solution's context for which it is going to be placed in

(2) The challenge/problem it is solving

(3) Plan for/Understand the Market Trends

The results suggest that these insights should be used in a sustainable manor. For this reason, the thesis argues that it is important to use these insights to *Produce assessments of the technology* for future cases, to ensure higher likelihood of successful outcome.

These factors are essentially what the thesis argues as most important to consider for a tech provider to meet the needs of industrial manufactures by selling technology solutions at TRL 6.3/6.4. There is a challenge in understanding the risks of investing in early staged technologies, especially in the stringent industry for manufactures, and applying the hints of needs of a customer (Customer Insights) into business practice.
A tech provider is a knowledge-intensive organisation that operates by primarily intellectual assets, i.e. by licensing out technologies, services other organisations with knowledge or tools for R&D (tools in this case means skills, intellectual property, necessary technology solutions or capabilities).[8]
The three factors that are argued by this thesis, of being important factors that influence the success of selling this type of solution to a client, are gathered by the aid of four cases. These cases are based on the experiences of business developers, senior managers and researchers working in a knowledge-based company (Company X) that sells technologies of solutions with 6.4, or lower, TRL in DDM to consumers. Lastly, the point of the thesis is to highlight the critical factors, using the cases, to aid tech providers of this sort, in the practice of selling these forms of solutions to consumers.
The critical factors of understanding the technology are answered by using the cases and the theories of authors that have published work for this type of practice. To highlight and evaluate these factors the thesis mainly uses the work of John C. Mankins to provide overview and clarification of how well the factors presented as critical by Mankins for this practice were used and influenced the outcome of the cases (see analysis). All four cases indicate that the three critical factors mentioned above have influence over the outcome and should be learnt from for this form of practice.

Key Terms: Low TRL, Technology Provider, Design and Digital Manufacturing

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Introduction

What can a Technology Provider of Solutions with 6.4/6.3 Technology Readiness Levels, in Design and Digital Manufacturing, learn from some customer insights? Today, many manufacturers still operate with solutions dating back to 80 years ago (2016 Manufacturing). When research and technology solutions that could significantly impact the efficiency of a factory exists, why has this industry not adopted them to a larger extent? What have the technology providers of these solutions missed? This thesis explores four cases where technology providers from Company X, a top global research centre, have sold early staged Design and Digital Manufacturing (DDM) solutions to customers. This thesis explores these cases to see what a technology provider can learn from some customer insights. The thesis is highly interpretative in nature, which means that the conclusions reached from the research requires an add-on deductive study, considering the justifications and conclusions drawn and their relationship with successful cases in practice.

Why should Technology Providers (TPs) learn from customer insights? The reason technology providers should learn from customer insights is because these insights can aid the success of selling a solution. There seems to be a gap, considering the case outcomes, technology providers input, and the industrial manufacturing trends, in adopting high tech and low technology readiness levels (6.3/6.4 and lower). The cases explore various aspects in different experiences with the focus on the customer interactions from the technology providers side.

Why Technology Readiness Levels 6.4/6.3? Because the challenge of marketing a technology before knowing it's commercial application was found through the nature of the empirical study, mostly inductively. That means that the way the research was approached was by exploring the issues that generically existed for early staged solutions in DDM. Following the stages of researching innovation challenges within manufacturing, the question of why some highly-effective and innovative solutions had not been adopted was raised. Which lead the thesis into the research area of the pre-market phases of The TRL measurement system (6.5 being Market Ready) [10] which was 6.4 and 6.3.

Purpose Statement

The purpose of this thesis is to explore, through the aid of relevant cases, and help tech providers (TP) of solutions with 6.3/6.4 TRL in Design and Digital Manufacturing (DDM) understand how they could learn from some customer insights, in regards to selling a solution with 6.3/6.4 TRL in DDM.

The thesis uses a mixture of relevant theories and cases to achieve this aim, with the guidance of research questions and aims.

Research Aim

The research aim of the thesis is two-fold:

(a)To gather relevant data from cases that aids the thesis to fulfil its purpose (b)Provide the reader with relevant tools to understand the cases

Research Questions

To fulfil the purpose of the thesis, the paper needs to be guided by research questions. These research questions will guide the paper towards including the necessary information that aid the reader in understanding the relevant context and the writer in including the relevant analysis of data.

Research Question 1)

What are some of the insights of consumers in design and digital manufacturing that could impact the success or failure of selling a 6.3/6.4 TRL DDM solution?

To fulfil the thesis purpose, the understanding/definitions of what the customer insights are, their impact on the case outcomes and the way of influence are needed. Using a mixture previous cases, the thesis presents and identifies common critical insights that existed in both failed and successful cases.

Sub Research Questions

I. **What are the important considerations to have when selling this form of solution, in regards to customer insights?**

This question aims to guide the paper by asking what important considerations exist. This is done through the guidance of relevant theory for low TRL solutions and users of DDM. The cases, however, are fundamental for answering this question. Each case is divided into sections; Background, Project Initiation and Purpose, Interactions with Customers and outcome. The reason being that this clarifies how and if learning about consumer insights contributed to the outcome.

II. **How can tech providers learn from their target customer's needs when selling a solution?**

This sub-question considers how tech providers (TPs) can learn from the cases. This is primarily presented in the Key Learnings of the cases. The key learnings section uses the claims from the business developers/senior managers/researchers (whoever the case perspective is from). This section aims to clarify what lead to the specific outcome, and by understanding this, the TPs is on the first step towards learning form their target consumer's need. The next steps would be using the insights in practice.

Background

This section acts as a tool to fulfill the purpose of the thesis. The background chapter highlights the socially-constructed terms that the reader needs to "take for granted" when reading the thesis (see Method of Collection for more information). This section, therefore, includes an overview of what the thesis refers to as "Customer Insights" and is what the reader needs to accept as a socially-accepted and constructed term, viewed as an institutional fact, (see Method of Collection) to fulfil the purpose of this thesis. It also provides an overview of the technology areas included in Design and Digital Manufacturing, this will enable the reader to understand the solutions being sold in the case studies as well as the discussion, analysis and conclusion of the thesis. Like customer insights, these areas need to be accepted as part of the technology area of DDM both for fulfilling the aim of the thesis; *to explore, through the aid of relevant cases, and help tech providers (TP) of solutions with 6.3/6.4 TRL in Design and Digital Manufacturing (DDM) understand how they could learn from customers insights, in regards to selling a solution with 6.3/6.4 TRL in DDM*, as well as the clarification of dependency/validity of use for the reader, or tech provider planning to use the findings in the thesis for business practice.

Customer Insights

When referring to customer insights, the thesis is referring to relevant learnings that a technology provider of 6.4/6.3 TRL in DDM, will gain from its customer. By "relevant" this thesis refers to how the concept that is being sold to the customer will be adopted by the customer. The point of understanding customer insights is two-fold; to aid adoption the solution and to tool the tech provider for higher rates of successful outcomes (success being the ability to sell the solution to the customer). Therefore, a customer need [13] can be a "customer insight" as well as addressing a method that helps the tech provider sell a solution to a customer. The reason the latter is a customer insight is because the nature of the practice entails customer insights. The technology itself can already be classified by a given maturity level as well as technological description of function, but the assessment that the thesis refers to is the assessment that includes a criterion of the commercial/customer needs that need to be "checked off" for the consumer to adopt the solution. This assessment is presented in the analysis and conclusion chapter, created from exploring and interpreting the technology providers of "Company X" (See Empirical Results for more details) experiences, and combined with a brief cross examination of John Mankins findings for this topic in *Technology Readiness and Risk Asses*sments.

To clarify the definition provided above, as well as the analysis method of the cases provided in the empirical results, an example is provided below; (NOTE: this example is entirely fictional, and created only to aid in clarifying the definition provided in the passage above-)

"*The customer told us, after a few months of negotiations and technology development, that using this technology was more costly than beneficial to them. Perhaps if the customer had gained an understanding of what technology they would be dealing with at an earlier phase, they would have given a clearer answer earlier, and we wouldn't have wasted as much capital. Moreover, perhaps there was a chance of compelling the customer in seeing the value of using the technology in their system if* *we had gained the information about their systems earlier and had time to iterate the technology to fit their context."*

The customer insights from this passage are the following;

A) The customer's system

B) How the technology would have fit into the specific customer's environment

C) There is more will of adopting a technology that the function of the technology alone, it needs to fit the system it is being adopted into

D) Applying these learning to the same/similar solution to fit the need of a future customer

Points A to D, are based on scientific values and opinion of the insights that a tech provider could gain from this type of situation. The insights are simplified and generalized to provide the reader with clarity and room for discussion.

What Technology Areas are included in DDM?

The technology areas included in DDM can vary, depending on the researcher. To clarify to the reader of what the thesis refers to as DDM and what is included, the thesis provides an overview of definition and technology areas.

The technology area of Design and Digital Manufacturing (DDM) is the use of integrated, computer based (smart) systems composed of simulation, 3D visualisation, analytics and other collaboration tools to create product and manufacturing process solutions. The evolution of DDM is a result of the use of manufacturing initiatives such as design for manufacturing (DFM), computer integrated manufacturing (CIM), flexible and lean manufacturing and other processes that emphasize efficiency and collaborative measures for product and process design. Digital manufacturing systems allow engineers to create complete definitions of a manufacturing processes in the virtual environment, some of these include; tooling, assembly lines, work centres, facility layout, ergonomics and resources. The purpose is to use simulation of production lines and transform them with the intent of re-using knowledge and optimize the processes before the products or commodities are manufactured. (Software, Siemens 2017)

The following areas are the technology areas that are recognized as DDM in this thesis:

Data Analytics (DA), (solution used for Digital Manufacturing), is the process of extracting and evaluating data sets that enables the user to draw conclusions regarding the information gained. The use of software in this domain is becoming increasingly popular, and important to aid the feasibility of the process. The purpose of using data analytics technologies is most commonly used to enable managers to make well-informed decisions/actions, as well as researchers for the validation of models and theories. (What is Data Analytics (DA)? 2017)

Condition Based Maintenance (Solution used for Digital Manufacturing), CBM, is a maintenance method that monitors a condition of a commodity/technology/asset. The use of

CBM is to aid workers in deciding what maintenance is required. CBM is governed by indicators that show signs of deterioration or just decreased performance, the workers will check these indicators and be guided to the needed area of work. The usage of CBM is beneficial as it includes high level performance data from tests that is non-invasive. CBM can also include visual indicators of the assets' performance level. The data can be fathered at different intervals, or through a continuous basis. (Condition Based Maintenance And Monitoring, 2017)

Internet of Things (IoT) This thesis recognises that as IoT becomes more popular, it is also a technology area in DDM. The concept in this context implies a "connected" factory, linking the factory/machines to a digital platform where other digital tools can link and produces data from/to. (2016 Industrial Manufacturing Trends)

Figure 1 provides a graphical example of how these areas are connected in this thesis.

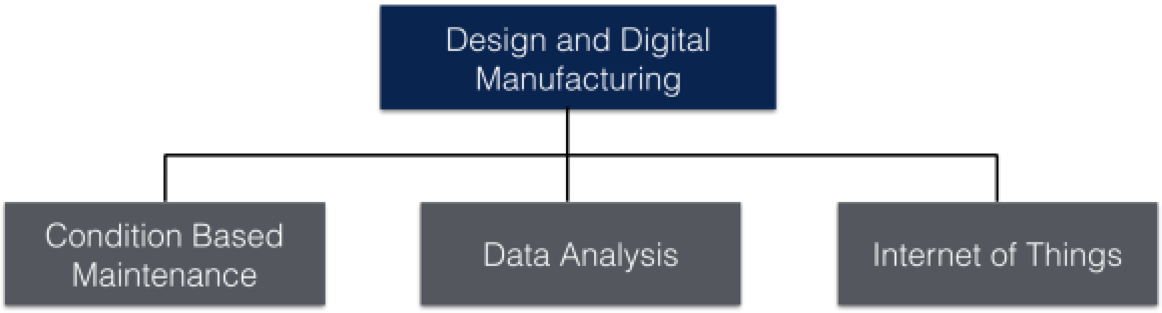


Figure 1: Technology Areas in DDM

The reason the thesis includes both technology areas in this analysis is because both technologies are relevant features of design and digital manufacturing. To reach a solution that is optimal, both before the digital implementation and after, data analytics and condition based maintenance are needed. One provides an overview of the condition at hand, making it easier to create a solution that is valuable for the user, the other can be used as a solution to maintain the high-quality production method.

Framework of Theory

The purpose of including the framework of theory section is to tool the reader in interpreting the empirical results, discussions, analysis and conclusion the framework of theory presents the overview of relevant theories and explanations of the environments that tech providers of 6.4/6.3 TRL solutions in DDM, will face. In addition to this, for the sake of dependability and validity of results, the findings presented in this section are what the reader needs to interpret as institutional facts. These findings are what the thesis refers to socially-constructed and accepted facts that the reader, and writer, takes "for granted." The concepts of what needs to be "taken for granted" are; the trends, challenges and nature of the DDM industry, technology readiness level measurement system, nature of Technology Providers/knowledge based businesses and customer insights.

Design and Digital Manufacturing

This section highlights the nature and trends of DDM. The relevance to this is related to the considerations the tech providers would need to have when working in this industry. To aid with this, this section specifically looks at trends of technology investments and overviews of the challenges of adoption of new technology solutions in Manufacturing. This will aid in providing an overview of the nature of business the case studies took place in, as well as general challenges tech providers face for this industry.

Looking back as far as 2001 to 2008, the industrial manufacturing sector has been under pressure to keep up with technological changes and demand. The global economic expansion had pushed industrial manufactures to invest in new technologies/solutions, designed to improve factory performance. When the market crashed, the investors paid a price without seeing a payoff for their investments. PWC's study on the 2016 trends of the Industrial Manufacturing industry, suggest that this crash could be the reason why industrial manufacturers take tentative steps in investments today. PWC argued that the board decisions of taking losses by taking fewer risks, is a false choice, that manufactures are facing a challenge during technological renaissance. The industry is under pressure to transform systems and processes for the modern factory. Embracing the changes are now a competitive necessity against rivals, plant productivity, keep up and meet the changing demands of customers seeking innovative solutions. PWC argues that industrial manufactures are facing a "data-driver factory" in the future, meaning that all internal and external activities are connected through the same information platform. Customers, designers, and providers would share information from initial concepts, installation to performance feedback throughout the cycle. Providers/operators would access information/data/materials on demand, work with robots for productivity, and use with victual work instructions presented at the point of utilisation. Assembly lines would create highly unique, functional, and personalized products. (2016 Industrial Manufacturing Trends)

The DDM industry, in general, is facing political turmoil which could influence buying behaviour. Ripple effects could occur during the negotiations for Brexit, followed by the risk of the American Political environment. The United States could undergo further undermine of free flow of goods, creating greater uncertainty and uneasiness upon manufacturers. Per PWC, many manufactures will take a "wait and see" approach, and could face a decline in capital expenditure investment until the political turmoil eases. (2017 Industrial Manufacturing Trends)

The figure below provides over to the manufacturer's buying behaviour and willingness to investment in R&D and information technology. The figures are based on the PWC Manufacturing Barometer, 2017. Per the findings, the political turmoil could be influencing the willingness to invest in new technologies.

	3Q'15	4Q'15	1Q'16	2Q'16	4Q'16
Percent planning to increase spending (net, next 12 months)	82%	86%	80%	80%	98%
New product or service introduction	48%	44%	55%	52%	67%
Research and development	37%	41%	50%	40%	52%
Information technology	22%	36%	35%	30%	42%
Facilities expansion	20%	22%	18%	20%	33%
Marketing and sales promotion	10%	15%	17%	20%	27%

Note: In 4Q 2016 total respondents = 60. Data not available for 3Q 2016.

Source: *PwC Manufacturing Barometer*, January 2017

Figure 2 (2017 Industrial Manufacturing Trends)

The data suggests that few manufacturers (42%) are planning to increase spending on information technology, and up to 67% are looking into spending on new product and service introductions and 42 % on R&D.

Trends & Challenges

The following technological concepts are what PWC determined as the solutions that industrial manufactures will adopt and factors that these manufactures consider important for implementation. These findings are based on the 2016 & 2017 research on the pressure that these factory owners are under to keep up with the market and demand of their customers. The technological areas are presented with an overview of what the area would mean in terms of implementation for the manufacturers, the investments that already exist within the industry, and lastly, the aspects that are beneficial for the manufactures to consider before implementation. The reason that this is included, is because it provides an understanding of what these manufactures face and demand of new technological solutions, which is important to consider when introducing a new idea to this customer.

Internet of Things (IoT)

The internet of things (IoT) concept has become much of a buzzword. The concept in this context implies a "connected" factory. This idea has been evolving over for the past few years, with the purpose of expanding the power of the internet, to connect machines, sensors, computers and humans, to enable new levels of monitoring, collection, analysis and methods of processing. The purpose is to deliver more precise information and translate collected data into information that could, for example, help determine the amount of maintenance material needed to reach the relevant efficiency level of the machine or/and determine how specific factors that impact performance, such as; temperature, pressure and humidity. (2016 Industrial Manufacturing Trends) Stanley Black and Decker, a fortune 500 American manufacturing company of industrial tools (About Us, 2017), adopted IoT for their plan in Mexico. The investment was made to monitoring the status of the production lines in real time via mobile decides and WIFI RFID tags. This investment lead to increase of 24% in equipment effectiveness, 10% in labour utilisation and 10% in throughput.

PWC predicts and recommends that for industrial manufactures, the next IoT technology should be able to go beyond real time monitoring of connected platforms that uses data and analytics to deliver higher levels of quality, durability and reliability of products. General Electric (GE) has kept up with this trend and one can see this through the wind turbines manufactured by GE. The wind turbine entails up to 20,000 sensors, producing 400 data points/second. This immediate and ongoing analysis of high level data enables GE, and customers of GE, to optimize performance and make clear decisions regarding maintenance and replacement.

Prior to investing in IoT, industrial manufacturing companies are recommended to determine what data is most valuable to collect, as well as tools that the analytical frameworks will use to assess the data. (2016 Industrial Manufacturing Trends) In regards to what the tech providers should consider, is that the next generation equipment for the manufactures will require a next generation of skilled workers, which includes employees who can design and build IoT products as well as capable individuals that can analyse output. (2016 Industrial Manufacturing Trends)

Robotics

During the last decade, China has emerged as a strong player in automated manufacturing powerhouse field, with labour costs increasing accompanied by booming industrial demand, industrial robotics experienced a dramatic growth. Since 2013, shipment of multi-purpose industrial robotics levels has doubled. In 2015 the Chinese market was leading, with 68,600 units sold, China exceeded the volume sales for all European Markets combined (50,100). The total sales of industrial robots are predicted to increase by 20% between 2016 and 2019, which on average is more than means a volume of 40,000 units by 2019. This sales figure would account for up to 40% of the world-wide market volume of industrial robots. (World Robotics Report 2016)

The common fear for some manufactures are however, that the more automation is introduced, less innovation will occur. Robotic implementations are evolving nonetheless, to develop ideas that improve processes and products and complement the worker, rather than replace. Nonetheless, this concern should be addressed by the tech provider.

The concept of robotics collaborating with human workers is called Co-Robotics, and is growing more popular through successful implementation and outputs. These solutions focus on ergonomic challenges, and mainly exist within aerospace and automotive industries. (World Robotics Report 2016)

Augmented Reality

The trends of augmented reality involve developed advances in computer vision, computer science, information technology, and engineering enabling manufacturers to deliver real time information and guidance for the time of use. Users of the solution follow the text, graphics, audio and virtual enhancements experienced through goggles or real assemblies as they perform tasks on the factory floor. The tools can simultaneously analyse the efficiency and timing of the tasks and notify the user/operator of quality risks.

These technologies have been known to be used to provide hands-free training, enable lower response time to maintenance requests, track inventory, increase safety and provide real time views of manufacturing processes. In some cases, these solutions are sold as add-on services to the equipment, creating a new stream of revenue. These solutions can reduce mistakes that result from fatigue or pressure on human workers. (World Robotics Report 2016)

3D Printing

3D printing is a method of manufacturing that produces solidified objects from a digital design. This is done by accumulated layers of plastic, resin and others materials to form a specific shape determined by the operator. 3D printing is still in the early adoption phase, but the users of this solution are utilising to manufacture parts for product prototypes, to reduce design to manufacturing cycle times and iterate the economics of production by reduction of time waste.

For the tech providers in DDM, PWC suggests that for the successful output of the solution to occur, the industrial manufactures are required to plan for incorporation. This means that the industrial manufactures need to apply the solution to prototyping processes and product development to learn and understand the solution in their own context. (World Robotics Report 2016)

Technology Readiness Level

The Technology Readiness Level (TRL) of a solution refers to a measurement system used to assess the maturity of a technology. Typically, technology project is typically measured using the parameters of the technology level and is assigned a TRL, based on its progress. A project can be assigned a level between 1 to 9, where TRL 1 is lowest and TRL 9 is highest. The TRL measurement system is a commonly accepted measurement technique, used by ranging industries to government. The metric shows how far the invention is from commercialisation and wide-spread user application, as well as the associated risks with developing the technology. A TRL determines how ready the technology is to be used by an industry or public, and with it, can determine the relevant resources i.e. time, money and intellectual

Technology Readiness Level Definitions

TRL	Definition	Hardware Description	Software Description	Exit Criteria
1	Basic principles observed and reported.	Scientific knowledge generated underpinning hardware technology concepts/applications.	Scientific knowledge generated underpinning basic properties of software architecture and mathematical formulation.	Peer reviewed publication of research underlying the proposed concept/application.
2	Technology concept and/or application formulated.	Invention begins, practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture.	Practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture. Basic properties of algorithms, representations and concepts defined. Basic principles coded. Experiments performed with synthetic data.	Documented description of the application/concept that addresses feasibility and benefit.
3	Analytical and experimental critical function and/or characteristic proof of concept.	Analytical studies place the technology in an appropriate context and laboratory demonstrations, modeling and simulation validate analytical prediction.	Development of limited functionality to validate critical properties and predictions using non-integrated software components.	Documented analytical/experi-mental results validating predictions of key parameters.
4	Component and/or breadboard validation in laboratory environment.	A low fidelity system/component breadboard is built and operated to demonstrate basic functionality and critical test environments, and associated performance predictions are defined relative to the final operating environment.	Key, functionally critical, software components are integrated, and functionally validated, to establish interoperability and begin architecture development. Relevant Environments defined and performance in this environment predicted.	Documented test performance demonstrating agreement with analytical predictions. Documented definition of relevant environment.
5	Component and/or breadboard validation in relevant environment.	A medium fidelity system/component brassboard is built and operated to demonstrate overall performance in a simulated operational environment with realistic support elements that demonstrates overall performance in critical areas. Performance predictions are made for subsequent development phases.	End-to-end software elements implemented and interfaced with existing systems/simulations conforming to target environment. End-to-end software system, tested in relevant environment, meeting predicted performance. Operational environment performance predicted. Prototype implementations developed.	Documented test performance demonstrating agreement with analytical predictions. Documented definition of scaling requirements.
6	System/sub-system model or prototype demonstration in an operational environment.	A high fidelity system/component prototype that adequately addresses all critical scaling issues is built and operated in a relevant environment to demonstrate operations under critical environmental conditions.	Prototype implementations of the software demonstrated on full-scale realistic problems. Partially integrate with existing hardware/software systems. Limited documentation available. Engineering feasibility fully demonstrated.	Documented test performance demonstrating agreement with analytical predictions.
7	System prototype demonstration in an operational environment.	A high fidelity engineering unit that adequately addresses all critical scaling issues is built and operated in a relevant environment to demonstrate performance in the actual operational environment and platform (ground, airborne, or space).	Prototype software exists having all key functionality available for demonstration and test. Well integrated with operational hardware/software systems demonstrating operational feasibility. Most software bugs removed. Limited documentation available.	Documented test performance demonstrating agreement with analytical predictions.
8	Actual system completed and "flight qualified" through test and demonstration.	The final product in its final configuration is successfully demonstrated through test and analysis for its intended operational environment and platform (ground, airborne, or space).	All software has been thoroughly debugged and fully integrated with all operational hardware and software systems. All user documentation, training documentation, and maintenance documentation completed. All functionality successfully demonstrated in simulated operational scenarios. Verification and Validation (V&V) completed.	Documented test performance verifying analytical predictions.
9	Actual system flight proven through successful mission operations.	The final product is successfully operated in an actual mission.	All software has been thoroughly debugged and fully integrated with all operational hardware/software systems. All documentation has been completed. Sustaining software engineering support is in place. System has been successfully operated in the operational environment.	Documented mission operational results.

Figure 3: Technology Readiness Levels Criterion Adopted from NASA (Technology Readiness Level Definitions, N.d.)

potential/property. (2.2 Technology Readiness Levels (TRL), N.d.) Per the assessments done by Nasa, each level has a criterion that determines the level, along with an exit criteria, the requirements that need to be met to progress to the next level. (Technology Readiness Level, N.d.) Figure 3illustrates the 9-different maturity levels a technology can have and criteria they hold.

The technology solutions that this paper analyses is Technology Readiness Level 6.3/6.4. At this stage, per NASA, the prototype should hold the ability to be demonstrated on a problem. It should, partially, have the characteristic of being applicable with existing software/hardware. In this case, it means that the technology should be able to integrate with the systems of the client. (See Empirical Results).

Knowledge Based Organisations

This thesis analyses the factors that tech providers of solutions with 6.3/6.4 TRL in Design and Digital Manufacturing (DDM) understand how they could learn from customers input, in regards to selling a solution with 6.3/6.4 TRL in DDM. To achieve the aim of the analyses, the thesis needs an explanation of what constitutes a tech provider in this context. In addition to this, the cases provided in the empirical findings are primarily based from the perspective of a knowledge-intensive organisation (KBO). The reader should not be confused by the terms; tech provider and knowledge based organisations, as in this context, both terms constitute the same meaning. This section will explain what constitutes a "knowledge-based" Organizations (KBO) using two methods. Firstly, by highlighting the nature of a KBO, and secondly, highlight the primary feature of a KBC, namely, the value creation method that a KBO will operate with.

To start off, a knowledge based organizations are typically categorized as those organisations with offerings that are knowledge-intensive. These offerings go beyond products and services, the complicated characteristics of a KBO include the manor and nature of how the organisation operates and the vast utilisation of knowledge opportunities extending beyond product and service offerings. For example, the purpose and process by which the company operates by. A knowledge based organisation will not only understand that there exists value in the manor of which the company is built and operates by and aims to utilise this in various fields. To simplify an example is used, an organisation operating by the means of licensing out intellectual property rights to use an invention in a certain field or domain, may come to find that the brand of the organisation also has a strong equity value, which per the findings of Keller (2001), would also have the possibly to be utilised for numerous financial rewards.

Another form of understanding the nature of KBOs is to understand the process of which a KBO operates by. The "Intellectual Value Chain" by Petrusson and Heiden (2009), is a framework that adequately explains the value creation existing in knowledge-based businesses. Per the framework provided, in a knowledge based business, value is created by the management of intellectual assets, also known as intellectual property and capital. It becomes simpler to understand the nature of creating value in a KBO by starting with providing the difference between a material-based value chain vs the intellectual value chain. The material value chain is based on the phenomenon that capital, the means of creating value, is primarily based on physical assets and property. This process has traditionally been illustrated by Michael Porter (figure 4). The traditional, industrial value chain is divided in the structure provided in figure 4, with primary and supporting activities organised in chronological order of operative use.

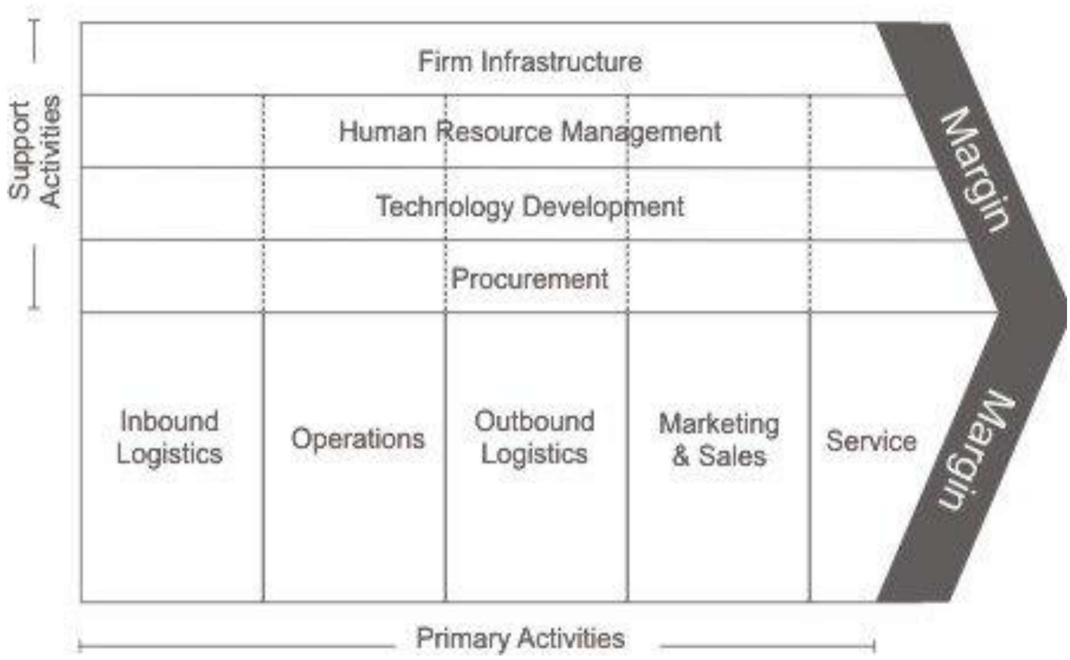


Figure 4 (Porter's Value Chain, N.d.)

In the intellectual value chain (IVC), the view that value creation comes from of knowledge and intellectual assets and are generated in forms of know-how, relationships, inventions and so on. Figure 3 is the illustrative model of intellectual value chains. (Berman Chapter 1-5)

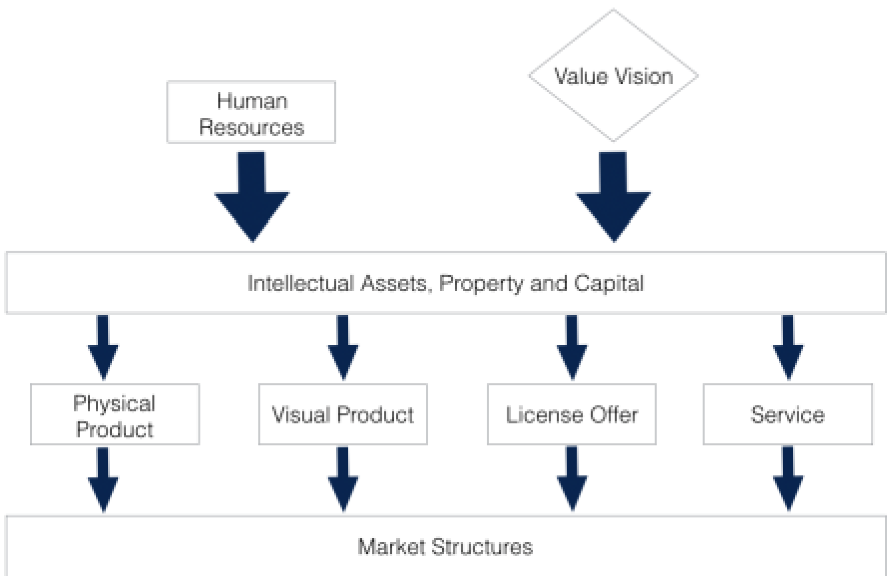


Figure 5 (Berman Chapter 1-5)

Despite the notion of the IVC (Figure 5) that a KBO operates with primarily knowledge intensive processes and offers intangible products and services, the IVC also argues that physical products are not excluded. Taking the example of a laser paper printer, the actual printer is a physical component and can be used for more than one market field. If we now take the intangible aspects into consideration we start to understand that the laser feature of the printer is a “value in itself.” The value becomes separated into intellectual assets (know-how), property (i.e. Copyright and trade secrets) and capital, not just a feature of the laser printer. The intellectual asset becomes a commodity that the developer or organisation can own, distribute or use for further development. For example, licensing out the laser solution to other market applications or organisations that can use the laser feature in new ways, for example medical use. Suddenly, competitive advantage is defined by the ability of the organisation to recognize these opportunities and managing the threats accompanied by its recognition and utilisation. (Berman Chapter 1-5)

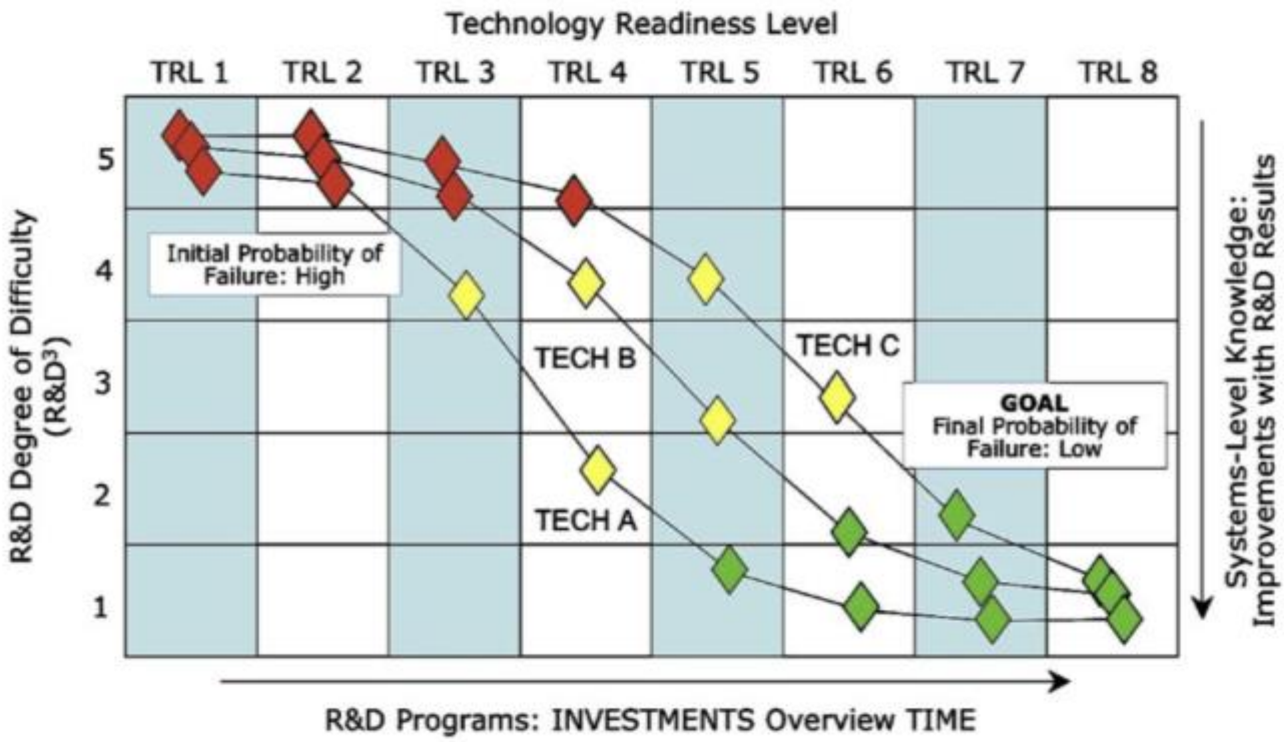
Considerations for Low TRL Solution Investments

To answer research question 1 C; how can tech providers use the insights in assessing the solution that will be sold to a consumer? John Mankins, Founder and President at Mankins Space Technology wrote a compelling piece on Technology Readiness and Risk Assessments, arguing forth that the systems which depend on the application of a new technology face various challenges in implementation, and technology research and development programs typically base their argument of use on that these investments will take away the uncertainty from performance, schedule to budget (the three major challenges faced during development). If the research and development, however, if implemented poorly, then the system that intended to use the new solution will suffer from cost overruns, schedule delays and erosion of initial performance objectives. The critical factor that will determine success is how well the technology risk and outcome has been evaluated. Mankins argues that understanding the risk and to be able to determine the different outcomes and be prepared to respond hence-forth, is extremely important for senior managements. As the common challenge for these systems and technology managers is to make clear, well-documented assessments of the technology's readiness and risks, and to make these during the key points of the lifecycle of the program. (Mankins 1208-1215)

There are different methods that are used to assess a technology's maturity and risk level to understand the associated risks with the project. The ideal approach, though not heavily practiced in combination, to Technology Readiness and Risk Assessment involves the following; (1) *Clarit*y (2) *Transparency* (3) "*Crispness*" (4) *Useful in program advocacy*. The Clarity characteristic refers to the process of the project maintaining a clear decision criteria for determining risks and technology readiness. These criteria should be analysed based on a method that enables individualistic evaluation and verification of results. Second, the transparency characteristic refers to how the process of technology risk and readiness assessment should be formal, avoiding strict bureaucracy, and consensus-based. Third, the "Crispness" criteria refer to how decisions during the TRRA should be made by or/and with the ownership of senior management. The decisions must be crisp, correctly timed and keyed to annual R&D and system program budget planning requirements. The last assessment should be the usefulness of the program; this refers to the processes of making TRRA decisions to produce the basis for support material of the result. (Mankins 1208-1215)

Mankins weighs in on some insights for any technology R&D efforts. For any investment in R&D, the project should result in development in the appropriate parameters for the new technology. Ex) an increase in speed, efficiency or improvement for the intelligence of robots etc. Second, an investment in technology R&D efforts should results in the technology maturation. This could imply that new materials should be incorporated into old devices, new devices could be integrated into new components and components into sub systems and so forth. And lastly, the investment should result in reduced risks for subsequent R&D/technology system in question. Figure 6, illustrates this concept. The figure provides the common challenges program/system managers face, which is that different technologies are likely to mature with different outcomes (TECH A, B & C). This means that one technology could lead to more progression in performance, another in risk reduction etc. The point is that the managers should understand the three factors of assessment and use them during the project as much as possible. A broadly used management tool is the assessment of uncertainty and consequences. (Mankins 1208-1215)

Figure 6 Generic View for Tech Development (Mankins 1208-1215)



Figures 6 provides an illustration of the relationship between R&D program's investment will change over time, improvements with the R&D results and, lastly the degree of R&D difficulty. John Mankins argues that depending on the type of technology (TECH A, B,C) the maturity/development pathway will go in different ways. Some might progress more in performance and others in risk reduction. The argument is that the team/manager/implementer should understand these factors and prepare for the program outcome. (Mankins 1208-1215) This is yet another risk consideration that is important to acknowledge for technology providers of low technology readiness levels.

Method of Collection

The research approach this thesis took is interdisciplinary. This chapter highlights the framework of the findings was created and extracted, deductions, justifications, evidence and conclusions that compose the thesis. The main approach taken to this paper was taken to fulfil the aim of the thesis, for this reason, the strategy and approach followed the frameworks that enabled finding, providing and analysing the research that could best achieve this. The reader should note that the data and analysis presented in this thesis are based on two pillars. First, the thesis presents data was extracted and guided by empirical findings, two, it follows the analysis by providing research and academically based theories as exemplification tools, connected to the findings. This thesis is not a critical paper on the relevant theories occurring in this form of business practice, rather, it acts as a tool for understanding the nature of this business and the reoccurring actions that build successful cases. This is done by the nature of the thesis being exploratory of the business practices of selling 6.3/6.4 TRL, Design and Digital Manufacturing (DDM) solutions. This nature, per Bryman and Bell, can be classified as an explanation of observed regularities. This is so that other businesses, academics or individuals either practicing the provision of early based design and digital manufacturing technological solutions, can understand, learn and apply to their own fields for analysis and re-iteration for a new use. (Bryman and Bell Chapter 1-15)

The chapter is divided into and includes the following:

> **Research Approach** (a) the provision of relationship between theory and results (inductive & Abductive approach) (b) Epistemological & Ontological issues / considerations
> **Research Strategy** (a) the strategy used to achieve the purpose of the essay: overview of the qualitative nature and the considerations of using this research
> **Research Design** (a) overview of Case Study Design (b) Reliability and Validity of the presented results, which is used as criterion of assessing the quality of the research. The assessment consists of: Internal validity; external validity; and ecological validity.

(Bryman and Bell Chapter 1-15)

Research Approach

Relationship between Theory and Empirical Results

The research approach explains the relationship between the theory and the results. The theory can be an outcome of the research, which is known as an: inductive approach, or the research can be an outcome of results, which is known as a: deductive approach. This explanation is simplified however, the lines between what constitutes an inductive study are messy. The definition of what makes up inductive studies are results that are not 100% certain, but still strong in explaining the cause of something ex) statistics. (Bryman and Bell Chapter 1-15) As such, characterizing the method of a study is difficult. By the definition provided by Bryman and Bell, this thesis is mainly composed of inductive methods, due to its exploratory / interpretative nature. However, the thesis uses abductive methods to provide likely causes and explanation (through theory) of deductions made in the empirical results. Which means that the thesis was guided by observations and findings to create theories (inductive). (Deductive, Inductive and Abductive Reasoning - TIP Sheet - Butte College)

Inductive, Deductive and Abductive Reasoning

As Bryman and Bell argues, the research is rarely a "clean cut" between inductive and deductive methods. Usually a writer will use a combination of both to gather the relevant data to answer their research question. This thesis started its journey through conducting "open interviews." The observations gathered from those interviews created interpretations, which became the ground of theories and the best possible explanations of events that impacted the outcome of the cases. (Bryman and Bell Chapter 1-15) However, to understand the empirical results, the thesis needed a foundation of theory to start from, which is why the thesis is not fully "clean cut" between the approaches. Figure 7 provides an illustration of the process of reasoning the thesis used to present the "key findings." Once

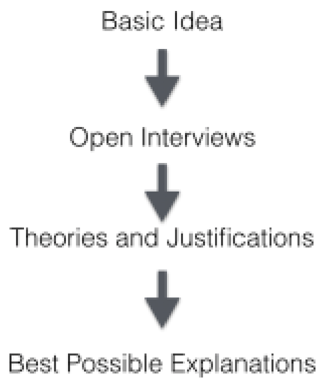


Figure 7

the key findings were presented, the thesis used a deductive method to analyse/compare the cases to John Mankins assessment of Technology Readiness and Risk (Analysis Part Two). The reason this was done was to validate the findings from the cases; that there was a link between customer interactions and the success of the case. The new method became as figure 8 shows:

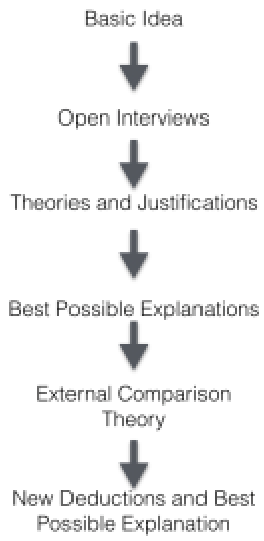


Figure 8

The deductive method used in the second part of the analysis and discussion, uses a minimalistic abductive method of validating the learnings presented both in the empirical results and first section of the analysis. The deductive method is based on John Mankins's work on Technology Readiness and Risk Assessment. The method includes using the assessment presented by Mankins and evaluating the cases based on whether the four-factor assessments were carried out or met in the cases. This evaluation is arguably epistemic subjective. The reason for this is that the concepts presented in John Mankins work such as "*clarity,*" are highly ambiguous and give room for subjective interpretation. This also makes the second assessment subjective.
From the second assessment, the thesis concludes what learnings are most likely relevant and which are not (abductive reasoning). (Deductive, Inductive and Abductive Reasoning - TIP Sheet - Butte College)

To deduce the necessary primary findings, the thesis used contingency theories. These theories rely on assumptions that guide the research. Per Bryman and Bell, many researchers in the field of leadership, have applied this thinking in solution seeking focuses, providing a guide for management based actions that best solves and issue. This approach was both effective and limited, in the sense that by using this approach the paper gained valuable information of key success and failure factors in the relevant field being studied, however, this approach leaves out other external factors (outside that research field) which could have also influenced the findings. For this reason, the next step for the user of the findings presented in this paper, would to use another approach with a wider horizon.

Epistemological & Ontological Considerations

"*There are portions of the real world, objective facts in the world, that are only facts by human agreement. In a sense there are things that exist only because we believe them to exist. I am thinking of things like money, property, governments and marriages. Yet many facts regarding these things are "objective" facts in the sense that they are not a matter of your or my preferences, evaluations or moral attitudes*…" (Searle 1995)

Per the framework provided by Searle's theory and research, this thesis is composed of "*institutional facts.*" Institutional facts are created by assignment, performed by collective intentionally of an agentive function of non-casual types to an object. Agentive functions are those that are dependent on an interest of conscious being (ex) "That's a table!"). Some functions contrast, depending on the object's property, and the performance of others depend on the social acceptance of a specific status of the object (ex) a citizenship or a five dollar bill). The latter functions are known as *non-casual types* (Searle, 39-41,123-124)

The argument that Searle uses that while we have "institutional facts" (ontologically subjective) the facts, by Searle's definition, become epistemically objective. (Searle 1995) This leaves room for argument, nonetheless, as Searle does not provide a quantifiable reference or criteria that categorizes a fact into "epistemically objective" or "epistemically subjective" facts. Searle's argument is that an object is epistemically objective when it does not depend on attitudes, beliefs, or opinions of the judgers. (Searle 1-3, 8-9; Grewendorf and Meggle 271-286) However, to make this judgement, it is required that the conscious mind judges the fact as "epistemically objective," leaving room for criticism of this philosophy. Nonetheless, the thesis uses Searle's arguments and method of categorization to classify and clarify the concepts used throughout the paper. The nature of the thesis is ontologically subjective (epistemically objective), since it is a natural science (this means that the thesis mainly uses institutional facts).

Figure 9 represents the concepts that are used in the thesis to fulfil the purpose. Since this thesis studies natural sciences, the concepts and research does cannot fall under the scope of Ontologically Objective Truths. Two concepts that are used in this thesis fall under the scope of Epitomic Subjectivity (as well as Ontological Subjectivity) due to their definitions, and the lack of universal acknowledgement of the concepts. These two concepts are; Knowledge Based Businesses and Customer insights.

	Ontologically Subjective	Ontologically Objective
Epistemically Objective	Technology Readiness Level Technology Risk & Readiness Assessment	*(NOT USED)*
Epistemically Subjective	Knowledge Based Businesses Customer Insights	*(NOT USED)*

Figure 9

The concepts used in this paper can be argued to be different in categories of Searle's truths, depending on the justification. The concepts that are placed in the Epistemically objective (Ontologically Subjective) field are; TRL and TRRA. These concepts are placed here based on their universal acknowledgement and credibility, and regardless of the reader's judgement they will stay the same (they are not concepts which depend on the judgement of the judger). (Searle 1995) In contrast to these two concepts, Knowledge Based Business and Customer insights have been placed in the Epistemically Subjective & Ontologically Subjective field. The reason that Knowledge Based Business (KBO) is placed in this field is because the concept is not a fully acknowledge concept. The concept of KBOs are still relatively new, and its definition in this thesis is a combination of scholarly articles and writer's opinion, which was done to achieve the purpose of the paper. The second concept; Customer Insights, is highly debatable, due to the definition. The definition of "*customer insights"* is provided by the writer as a tool to understand the cases and the analysis of the paper. (See What are Customer Insights? for more information)

Hermeneutic Nature

Per Bryman and Bell, an epistemological issue, concerns whether the subject or question of "what is" and regarded as accepted knowledge in a field or discipline. This paper is characterised as hermeneutic in nature, which means it studies the natural-social reality. However, this claim is arguable and complex. As Wright (1971) argued there is a clash between positivism and hermeneutics. Hermeneutics, concerns itself over the theory and method of interpretation of human actions. This statements puts an important distinction between the explanation of human behaviour and the understanding of human behaviour, this thesis contains both phenomenon. It becomes difficult to make a "clean cut" between the two, as the understanding of the decisions made by the business developers requires the explanation of the actions taken, as well as the link to the result of the case. This was also argued by Max Weber (1864-1920), which he described as the Verstehen approach. Nonetheless, the findings and nature of the thesis falls scope in the natural sciences, which also provides foundation to categorizing the research into what concerns the social reality. Per Bryman and Bell, the term: positivism, constitutes that a study must contain the following principles; (1) only knowledge confirmed by the "senses" can be categorized as knowledge (2) The purpose of theory is to create a hypothesis that can be tested, and enable explanations of laws to be assessed (deductive principle) (3) knowledge is create through the means of collection facts that provide a basis for laws (inductive principle) (4) Science must, and can, be conducted in a method that is value free (objective) (5) There is a strong distinction between scientific and normative statements as well as the belief that the former is the true domain of science, this being because the truth (normative statements) cannot be confirmed by the senses. Due to the principles that constitute Positivism, the thesis cannot be classified as Positivistic. Pugh (1983), best describes the phenomenon used in this paper as using the collection of data upon which to base generalized propositions to test in a field on. As such, one should note that the findings and conclusions presented in this paper should not be treated as a science or scientific. The relationship is positivistic in nature **only** to the extent that it follows the second and third principles of what positivism entails.

Research Strategy

Per Bryman and Bell, Qualitative research is the strategy that emphasises explanations of words rather than quantification through the collection/accumulation of data. Typically, qualitative research as a strategy is inductivist, constructionist and interpretivist, which is true to this thesis. The thesis is also true to the three common features of qualitative research, per Bryman and Bell.

(1) Carries an inductive view/approach to the relation between theory and research (where theory is generated by research)
(2) Carries the nature of being interprevistic, which means that, in contrast to the natural science model used for quantitative research, it emphasis the understanding of the socially-constructed world via observations/interpretations of the world and its participants.
(3) Has an ontological position which is described as constructionist. This term implies that social properties are outcomes of the interactions between individuals, rather than its external "outside the bubble" phenomena, separated from social construction.

It is difficult to stipulate what is qualitative and non-qualitative research, Per Gubrium and Holstein (1997) there are four traditions of qualitative research; Naturalism, Ethnometholodgy, Emotionalism and Post Modernism. This thesis concerns itself with *Naturalism*; seeking to understand social reality in its own terms; "as it is" and provides rich descriptions of people and descriptions of people and interaction in natural settings. The thesis used a collection of data from qualitative interviewing, studying the interactions between technology providers and customers. (See Cases and Interviews for more information)

Exploratory & Interpretative Nature

Per Bryman and Bell argues, qualitative research usually concerns itself with interpretative research, this means conducting a research question, exploring data and creating theories as an outcome of this. The aim of the thesis is to explore, through the aid of relevant cases, and help tech providers (TP) of solutions with 6.3/6.4 TRL in Design and Digital Manufacturing (DDM) understand how they could gain from the insights that come from working with customers (what the thesis defines as "Customer Insights"), in regards to selling a solution with 6.3/6.4 TRL in DDM. To achieve this aim, the thesis uses an exploratory method. As the thesis does not have a hypothesis to guide the findings, the thesis achieves its aim by collecting a large accumulation of observations for business practices in selling 6.3/6.4 TRL, DDM solutions, these findings created theories of most likely causations/explanations. Building on purpose of achieving the aim of the thesis, the thesis had to use an approach that did not eliminate possible observations that would be useful for the reader or user of the results. For this reason, the inductive and abductive method was the best approach to use. Prior to gaining the results, the writer did not have the knowledge of events and learnings that could have influenced the outcome of the cases, thereby, influencing the conclusions of the thesis. The thesis, therefore, relied on "open interviewing" (also referred to as Semi-structured interviews) with a focus on the customer interactions, to see if understanding, learning and using the knowledge (of understanding customer needs), gained from customers impacted the success of cases. (Inductive and Abductive approach).

Typically, inductive research is linked to qualitative research, which is even true to the analysis & discussions of this paper. The paper had little use of quantitative data, as the findings were based on the knowledge and experiences from relevant experts. However, that is not to say that the use of quantitative research would not have added a layer of depth to the paper. The paper could have used frequencies of events to collect data and generalize the actions most took to get a favourable outcome. Nonetheless, this approach, would not have given the necessary depth for one primary reasons, the access of the experts was limited. The experts existing in this highly-skilled based field is less common, which made it difficult to get access to experts existing outside of the working environments directly exposed. If this thesis was to be done again, or if a researcher decided to continue this research, then the recommendation would be to include a quantitative study of the other rare experts existing in this field.

The method of creating the analysis and conclusion of this paper was to use both observations (section 1), guided and framed by the basis of the knowledge gained from the Master's program that this thesis is categorized in; Intellectual Capital Management at Chalmers University of Technology. The observative foundation was based on collected data from secondary research of design and digital manufacturing usage in modernized production, as well as interviews guided by questionnaires. These questionnaires were guided on the methods of identifying knowledge presented by Ulf Petrusson in Research and Utilization, 2017. (To read more about the nature of the interview data collection process see Cases & Interviews)

Research Design

The following section studies the research design of the thesis. This includes looking at the types of evidence and credibility to the conclusions drawn in the paper.

The results included in this thesis classify as qualitative data, per Bryman and Bell. The research includes qualitative interviews, deductions and the collection of qualitative analysis from the tech providers. This data helped generate the cases presented in this thesis. Another reason the research conducted for this paper is classified as qualitative data is due to the principles for research that qualifies as qualitative data; (a) inductive view of the relationship between theory and the research/results, where the former is an outcome of the latter (b) an epistemological position that is described as interpretivist, implying that, in contrast to the adoption of a natural scientific model, which one would find in using a quantitative approach, the emphasis is in interpretation of the social world through studying the interpretation of that world by its users (c) An ontological position classified as constructionist, which means that the social properties are outcomes of the transactions between individuals, rather than what is not involved in its construction. This thesis fulfils all principles that classify qualitative data.

Multi-Case Design

The thesis uses a multi-case study design. The multiple case study analysis, is a commonly used research approach for business and management studies. This method is argued to aiding the quality of building theories/deductions from the results.

A "case study", per Bryman and Bell, concerns itself with providing an in-depth clarification of the research objective. A case study, is unique in the way the researcher can clarify distinctive features of the case, which in this case is ***customer interactions***. This is known as an idiographic approach. Since the research design is cross-sectional and employs a qualitative research strategy, the relationship is inductive, per Bryman and Bell.

The cases in this thesis are known as *revelatory cases.* These types of cases exist when a research wants to observe and analyse a phenomenon which was previously inaccessible to scientific investigation (a new research area). (Yin 1984:44) The conclusions drawn from the thesis are drawn based on the new knowledge gained from cases of experiences that the tech providers have, and focused on the interactions the providers had with their customers as well as how this had an influence on the outcome of the case.

To add depth to the study the thesis also uses comparative design (analysis part two). This is done by assessing the cases to John Mankins theoretical framework for successful implementation / selling of early staged TRL solutions. The comparative design approach entails a study using identical (more or less) methods of analysing two or more cases. The reason for using this design method is to add a layer of credibility to the research as the reader can understand the social phenomena better when it is being compared in relation to another case or theoretical framework.

In the cases provided in this thesis, researchers, business developers and senior managers from a top research and innovation institute (company X) are followed. These specialists offered solutions in different commercial fields, however, worked within the domain of design and digital manufacturing. In addition to this, all specialists offered solutions with TRLs lower than 6.4, to illustrate the low levels that this figure constitutes one could compare it to the market ready level a technology of minimum 6.5. If the solutions that could most effectively improve the tools currently being used in manufacturing are at levels below 6.4 and solutions need to fit into the customer operations effectively, then we are faced with a negative feedback loop: (1) the creativity of the researchers being limited (2) the lack of customer insights controlling the development of a researcher's idea leading to the cost of not being implemented for its intended application, ultimately failing its purpose.

These cases were chosen based on the following; (a) the case must have had impacting consequences of the manor of operations for future cases at company X (b) the case had to include technology solutions within the domain of DDM (these include data analytics and condition based maintenance) (c) the case had to be operated by specialists with previous or current entrusted (by senior management) authority of implementation of management, as this served as an indicated of the legitimacy of the developer's experience

Cases & Interviews

During the primary investigation stage, circa 40 interviews were conducted with 15 experts in design and digital manufacturing. The aim of the interviews was to provide the empirical data with what the technology providers had previously learnt from their customers and how they applied this to the case.

As previously stated, the strategy that the thesis used was qualitative, which per Bryman and Bell, typically entails inductivist, constructionist and interpretivist nature. This thesis used the typical approach with qualitative interviews (Semi-Structured/Open Interviews). The open interview method is a term that refers to a context where the interviewer has a range of questions which are in in the general form of an interview schedule, but will vary in sequence. The questions are generic in terms of form of reference, compared to a structured interview. The interviewer usually has leeway in asking further/add-on questions in response to what is said in the interview. This results in a range of observations which the thesis generalizes into explanations/theories) (Inductive and Abductive approach). (Bryman and Bell Chapter 1-15)

The interviews done for this thesis had much flexibility. The study conducted was done to understand the customer interactions, how the technology providers had learnt from their customers and if this influenced the outcome of the case. The approach the interviews had was "open ended," exploring the cases of Design and Digital Manufacturing that the tech providers had experienced and the different variables that could have influenced the outcome of the case. These interviews were done both through online video calls and face-to-face meetings. The focus was broad and exploratory, both via the form of questions asked and the findings from the interviews/conclusions drawn.

Based on the premises of qualitative research methods presented by Bryman and Bell, the interviews were based on understanding the "whole experience" from the technology provider's eyes. (Bryman and Bell Chapter 1-15) This was done by constructing questions that aimed at understanding previous cases the experts had worked in, in regards to DDM. Per Bryman and bell, this type of qualitative research is known as Naturalism; *seeking to understand social reality in its own terms; "as it is" and provides rich descriptions of people and descriptions of people and interaction in natural settings*. This means studying a socially constructed reality, and observing it as it is (not questioning what is). The cases presented are socially-constructed realities from experts existing in this field.

Regarding the interviews semi-followed guide, the questionnaires were based on the method of extracting knowledge transactions from Research and Utilisation by Ulf Petrusson. Research and Utilisation (2017) gives a strong overview as to how the knowledge in an organisation moves and impacts output. (Petrusson, U. 2016) Though the book focuses on how Swedish Universities can manage and utilize research results, it is a good foundation for investigating how research and knowledge moves and drives the development process of early stage software. The questionnaire uses both principles of mapping knowledge transfers, via understanding key knowledge creators and carriers.

Nonetheless, an example of the questions that were used for the cases is as following;

Interviewer: "*Can you tell me about a time you had a successful case? How did it start? What type of interactions did you have with your team and your client*"

The investigation required follow on questions, for the interviewer to learn as many perspectives of the values, beliefs, relations, places, emotions, behaviours and so on, of the interviewees and the others involved in the case. The different types of the questions looked like the examples provided:

Value Questions: "*Regarding the railway case we spoke about last interview, can you tell me if you think the relationship you had with the clients played a big role in the success of the case? Why do you think it's important?*"
Belief Questions: "*What other aspects do you believe played an important role?*"
Behaviour & Encounter Questions: "*How much did you interact with the customer?*"
Formal Roles: "How were the meetings with the customers composed, what roles were involved?"'
Formal Roles: "What is your work title? What was your work title during the case?" (Bryman and Bell Chapter 1-15)

Other Tools Used

Chalmers Library Database the library data provided journal articles and books that aided greatly in the completion of the thesis.
Online articles were used for more simplistic functions and uses, such as definitions or access to famous literary works in open innovation
Published Literary Works were used for case studies and understanding technical innovation, strategic relations and more in relation to the theory of high tech collaboration
Online Skype Meetings videos were used for some case studies.
Major Magazines were used as sources for case studies, giving both an overview of non-analytical and analytical data
Secondary Primary Data such as interviews conducted by others for purposes beyond this thesis. The use of this form of data was mixed, and appears both in the chapters of theory and results.

Grounded Theory Vs Analytical Induction

There are different strategies of analysing qualitative data; Grounded Theory and Analytical Induction. This thesis used Grounded Theory. Grounded theory, is not a straightforward matter, it is complicated and used in different ways. Many theorists argue that grounded theory means that the analyst has induced explanations for data rather than observing the data, (Glaser 1992) others argue that it implies that the analyst has grounded their theory onto the data. (Gilbert 1977) This thesis means to use grounded theory to highlight the iterative process of data guidance, collection and analysis. The thesis uses a mixture of analytical approaches. The first (Analysis Part One) uses analytical induction. This section provides explanation to the four cases, by including key learnings and overview of how the customer interactions might have influenced the outcome of the case. The second (Analysis part Two) uses a theoretical concept and conceptualizes a relationship between the interaction of customers in the cases and the Technology Readiness and Risk Assessment provided by John Mankins.

Reliability & Dependability

There are different ways of measuring the reliability and validity of a research paper LeCompte and Goetz (1982) proposes four measurements of reliability and validity provided below:

(1) External Reliability; *measures the degree of which the study can be replicated. This is typically a challenging criteria to meet for qualitative studies, since it is not possible to freeze a social setting.*
(2) Internal Reliability; *refers to when there is more than one observer, member of the research team agrees on what they see and hear. This term is similar to inter-observer consistency*.
(3) Internal Validity; *refers to whether there is a good match between the observations done by the researchers and the theoretical ideas they develop. Lecompte and Goetz argue that internal validity is a strength of qualitative research, due to the prolonged participation in the social life of a group over time, which allows the researcher to ensure a level of congruence between the concepts and observations.*
(4) External Validity; *refers to the degree of which findings can be generalized across social settings. Lecompte and Goetz claim that, in contrast to internal validity, external validity is an issue for qualitative researchers because of the tendency to use case studies and small samples.*

Due to the nature of the thesis, the framework provided above is useful. The thesis approach was done using qualitative research, studying socially constructed phenomenon. The alternative criteria for evaluating qualitative research measures the trustworthiness and authenticity of the research (also in relation to reliability and validity). Lincoln and Guba (1985) and Greene and Lincoln (1994), propose that for quantitative research one needs to terms that are separate from quantitative measurements. They propose two criteria; trustworthiness and authenticity.

Trustworthiness is composed of a four measurements;

Credibility; *refers to internal validity*
Transferability; *refers to external validity*
Dependability; *refers to reliability*
Confirmability; *refers to objectivity*

Meanwhile, authenticity concerns itself with a wider range of political impact of the research. The Authenticity of a research paper refers to the following; (Guba and Lincoln 1985)

Fairness; *Does the research represent different viewpoints amongst the members of the social setting being studied, and is this done fairly?*
Ontological Authenticity; *Does the research help members to arrive at a better understanding of their social environment?*
Educative Authenticity; *Does the research help members to appreciate better the perspectives of other members of their social setting?*
Catalytic Authenticity; *Has the research acted as an impetus to members to engage in action to change their circumstances?*
Tactical Authenticity; *Has the research empowered members to take the steps necessary for engaging in action?*

Figures 10 & 11 provide assessment of the Trustworthiness and authenticity of the thesis.

Figure 10 Trustworthiness (Lincoln and Guba (1985) and Greene and Lincoln (1994))

Criteria	Assessment
Credibility	The common issue with using qualitative research methods is the risk of subjectivity and/or biased perspectives. It is for this reason the two following steps were taken to aid credibility (1) the use of various work roles to get perspectives outside one direct field, this meant interviewing workers that both had and had not worked on cases together, in addition to this, perhaps worked in the same field but with distinguishing methods. (2) Respondent Validation Methods. (Bryman and Bell Chapter 1-15) The use of respondent validation was key to creating both credibility and validation to the research results and the business strategy recommendations. This was mainly done by conducting second to third run interviews, which contained questions that would validate statements previously made, along with interpretations by myself. In addition to this, during the face to face interviews, interactive methods were used by providing paper and pen so that the respondent could draw out chains of events and transactions across processes. Lastly, during the last stage of the research gathering, after analysis of the results and theories, an online survey was sent out to the top 6 experts in this field which were previously interviewed. The survey required the respondents to validate the findings of key success factors and value propositions, which validated the key success factors and value propositions presented in this thesis. Nevertheless, a research study is never completely done, in my point of view, and the use of a larger pool of respondents could add more depth to the study.
Transferability	The aim of the thesis is to aid tech providers of 6.3/6.4 TRL DDM solutions sell solutions to customers. For this reason, the context becomes limited to tech providers for solutions with this nature, however, the thesis uses a combination of general theories / concepts (TRL, KBOs, DDM etc.), which means that there is a scope outside of the tech provider's bubble that can use the findings presented in this thesis to conduct new, more focused research.
Dependability	The dependability criteria, per Lincoln and Guba, refers to establishing merit of research, which the authors approach using "auditing" (keeping records of notes, interviews recordings etc.). Which means that this thesis is weaker in this aspect. The thesis was conducted on the premises of anonymity, which means records of the interviews and notes is non-accessible. This, arguably, jeopardizes the dependability of this thesis. On the other hand, the thesis uses the both theoretical, published, content and empirical results to draw conclusions, which strengthens dependability.
Confirmability	Confirmability refers to the ability of the writer to show that the research was done in good faith and did not allow personal vale or theoretical inclinations to manifest in the thesis. This thesis recognizes that the conclusions are not completely objective, and that it is extremely difficult to create objective justifications for qualitative research. This is because explanations and analysis is necessary to fulfil the research aim. That said, another researcher may have drawn similar, though not identical conclusions. A way to measure the confirmability of the paper is to conduct similar investigation(s) of this research field and compare new conclusions and results to the ones in this thesis.

Figure 11; Authenticity (Guba and Lincoln 1985)

Criteria	Assessment
Fairness	The empirical findings use a large range of view-points through interviews with senior managers, researchers and business developers. This was done to establish fairness amongst the members in this business setting. However, the research could benefit from more interviews taking the customer direct perspective. Due to the tools and time provided for completion for the thesis, this aspect was not included in the empirical results. Nonetheless, to deal with this fall back, the thesis includes the perspectives that the tech providers had gained form the customers they had interacted with, and this perspective is included in the empirical results.
Ontological Authenticity	The research aim to aid tech providers of 6.4/6.4 TRL DDM solutions when selling a solution of this nature to customers, all theories, findings, results and conclusions are drawn on the premises of this aim. If the research was not helpful for the members of this business setting then the thesis fails in achieving its aim.
Educative Authenticity	This criterion cannot be calculated at this time as it needs validation through trial. A Note to the reader; this thesis is exploratory and interprevistic, which means its use in this field is to acknowledge the social settings and how the tech providers have previously been learning from customer interactions. The next step would be to use these findings to create a deductive study, which would be after the thesis has been used and studied by members of this business setting.
Catalytic Authenticity	This criterion cannot be assessed at this time, as the motivation to use the research depends on the user and reader. After the thesis has been studied by members of the business setting the business setting's members should refer to the catalytic authenticity of the thesis.
Tactical Authenticity	Like Catalytic authenticity, tactical authenticity is also a criterion that is unable to be assessed at this time. Only after use and study by the relevant members can this assessment be completed.

Empirical Results

Considerations & Note for the Reader

The following cases are based on real-life experiences from business developers, seniors and researchers working at Company X. Company X is a technology provider of DDM solutions with 6.3/6.4 TRL, the company is also a Knowledge-based business (see Knowledge Based organisation for more information). For each case, one or more Business Developers, Researchers or Seniors are chosen to highlight the experience of selling a 6.3/6.4 TRL or lower DDM solution to a customer. Some cases are success stories, and some are failures, both worth noting for learning purposes.

The reader should note that the events, analysis and opinions highlighted in the cases are direct derivatives of the interviews conducted with the business developers, researchers and senior managers. This means that the conclusions drawn in the cases are conclusions that the Business Developers, Seniors and Researchers made during and/or after the duration of the case. The analysis of the cases is discussed in the Analysis & Discussions chapter.

Nonetheless, the cases are presented based on their ability to emphases and answer the research question; What are some insights of consumers in design and digital manufacturing that could impact the success or failure of selling a 6.3/6.4 TRL DDM solution? Based on the exhibited cases, what are some important considerations to have when selling this form of solution, in regards to customer insights? Each case highlights a unique experience where the narrative explores the ways of interacting with customers, and how this impacted the outcome of the case. From this, key learnings are created. The key learnings are based on an inductive strategy, where after highlighting the cases, key theories can be drawn to understand the cases and create new learning grounds for the future practitioner.

Case Alpha

Background

Case Alpha follows the journey of a business developer who marketed a solution, previously used in printing, as a design and digital manufacturing solution to a client unfamiliar with this solution. This case, like the case of Beta, is written based on a business developer working for, what the thesis refers to as “company X,” and following the journey of the creation of this new solution, which is now a relevant trend in manufacturing. Per Mckinsey, major manufacturers looking at integrating, or have done so already, this solution to be able to optimize operations, quality and utilization, and reduce energy usage. This solution would enable factory managers a better view of the raw materials and the manufactured commodities that move through a manufacturing network, aiding the scheduled operations and product delivers in cost reductions and increased efficiency. This solution also aids in anticipating demand and maintained, which ultimately aids in better designed merchandise. [2] Case

Alpha is an example of a case that did not reach an agreement, and was chosen due to the business developer's insightful outlook on the common factors that the case lacked and has, in the experience of the business developer led to successful cases. (see What is a Key Success Factor?).

Project Initiation and Purpose

Company X might have been one of the first ones working on using the existing solution for production planning and control using digital manufacturing in the market application of industrial manufacturing. Digital Manufacturing had a strong track record of being successfully used by Company X in another market application and was now ready to be used in a new, less traditional, commercial domain. As such, the software that company X was working with was not a new solution. It was a known solution with a large surrounding portfolio of intellectual property for Company X. As such, Company X had two important factors to contribute to the success of the case already; (1) freedom to operate in a technology area (2) extensive knowledge in using this software. Freedom to operate in a technological area would give both company X and the client of company X the possibility to seek opportunities in a technological area with a strong tool that aids in; navigating the field, legal protection against potential new entrants and, lastly, aid potential dominance for a commercial application. Though, the reader should note that owning intellectual property in a field is not enough to ensure the benefits that accompanies it. Every owner of an intellectual property carries the responsibility to maintain both the validity of the IP (through administrative costs), as well as competitive landscaping in the technology area. This can be done by regular conduction of due diligence of threats from both new and current competitors. In addition to this, one should consider that there are several business strategies to maintain dominance through reputation of past litigations, ensuring that new/old competitors are more reluctant to infringe on the owner's rights. All in all, there are several conditions that need to be met to gain the benefits of holding intellectual property rights in a technological field. In regards to the second success factor, and what is important to mention at this early stage, is that company X already had extensive know-how existing internally. Since, for this field of work, having an extensive knowledge of software usage and function will aid in the ability to not only seek opportunities in a new field, but carry out greater levels of potential, in terms of functionality, then by logical reasoning, Company X had another competitive advantage in any commercial field that had yet to introduce this method of production. For the sake of an argument, one could claim that though company X had extensive technological knowledge of the solution, the fundamental factor determining the success of the technology in the market would be understanding/evaluation of the commercial value of the technology.

Business developer Z was the first, at company X, to think of using design and digital manufacturing for large scale packaging machines. During this time, the developer had to face several barriers to introducing this new concept, as both the audience user and management at company X were new to the idea of using the software in the late stages of the production line, which is where the intended use lay. The way the machines of automation had been set up, which remains true from 80 years ago to cases today, was to incorporate solutions into the machine that relied on predictability and repeated solutions. The issue with this was during the late stages, the product line moved so quickly that the actions taken by human intervention were too highly un-anticipated for the machine to be able to carry out the role. The production line was not fully capable of carrying out the full assembly line independently. What the business developer and his/her team did was; identify the opportunities where something un-predictable occurred (outside of the production of repeated processes) and start looking at ways to integrate the software solution they had with this type of production line. The idea was to enable the machine to route and put together raw materials for a desirable outcome in real time, from a planning and re-planning perspective. It was this opportunity gap that had yet to be utilized by players in the market, which also became an issue when presenting the new idea to potential clients, as the idea was under-developed for its intended use. Appropriate market knowledge and understanding became vital to obtain. For this reason, the business developer decided to market and gain valuable insights for the idea, of using this solution in manufacturing, at a leading global packaging conference. Historically, company X had used experts as the necessary resources to provide frameworks of both performance and cost requirements existing in the market today and where the solution should be focusing its efforts on.

During the conference the business developer was introduced to a packaging expert that had extensive connections in the packaging field. The expert took a strong interest to the new solution and marketed it to a top global food company (company Y). What is interesting about this is that, the decision to bring in the expert had two important influences over the success of the case; (a) it provided an outlook of the market, making it easier to package the idea appropriately, for the right clients (b) it provided the business developer an "in" to the market. Since the expert had extenuating experience in the manufacturing industry, it meant that the expert was packaged with both knowledge and the connection to the appropriate network that company X needed to utilize to reach the correct user. These two factors were such as important components of the cases' success, that they became another two key success factors.

Interactions with Customers

The following stage was meeting company Y and discussing the production lines existing within the company. Company Y had been producing up to millions of frozen pizzas, selling in world-wide markets using a mix between machinery and human capital in their assembly line. For the majority, the assembly line was fully automated, until the end of each production line where human intervention was needed. The workers would stand at the last stages of production to receive the randomly placed flow of pizzas, moving in a line, and wrap the pizzas in a 90-degree ramp that would move the pizzas into the machine that wraps plastic around them so that it could be placed into its box. This process had not been automated yet, as this stage was too fast and advanced to be solved by any of the solutions that company Y knew about. The situation at hand was not a great financial cost, but the time-consuming factor made the assembly line run at lower than full efficiency levels. The next step towards finding a solution was to look at where the issue lay. Looking at the production line the business developer noticed that there was a massive volume of throughput coming out of the machines at such high speeds that up to 8-10 stations of workers were needed to deal with the volume.

Outcome

The final idea was to introduce a high-speed automate conveyer and sorting mechanism. However, the challenge was that this solution required company Y to either replace and/or modernize the flow wrappers, making the solution costlier than the situation at hand. This is a highly interesting aspect to consider, as the business developer had a solution that could have solved the issue of speed and efficiency, but by neglecting to consider the production system in whole, the value of that solution could not be extracted.

With experience from working as co-founder and VP in business development for commercializing software from start-up scene, the business developer argued that in the lean start up methodology, most workers concern themselves with the risk of over-investing in an MVP, spending too much time and money on a concept headed for market failure. He/she argued that a greater invest in MVP through learning about the customer would have determined the success of the case. The challenge is that, by underinvesting in an MVP, the business developer argued, you are highlighting only a small glimpse of the whole problem that companies might have, which is not enough to compel a potential partner. This causes a loop to occur, where the encouragement of getting partners to collaborate depends on how well the concept proofs its use in a whole system, however, to do the technology's developers need the necessary domain knowledge.

Summary

- The case follows a business developer that used an already existing technology solution in printing for the food manufacturing sector
- The business developer faced several barriers to introducing the new concept as the market segment was new to the idea of using this product as the production line that the business developer recommended
- The business developer claimed that networking and outside council aided in understanding this new market segment
- By the end of the case, the client claims that the solution does not take the client's system into consideration and though the technology fulfils technical requirements; solves the need and reduces waste of resources, it's implementation would be costlier than its benefits
- The implementation required the client to replace all current machinery in the assembly line
- The business developer claimed that his/her team had under-invested in the MVP, inevitably leading to the failure of the case

Case Omega

Background

Case omega follows a business developer (BD) (Business Developer A) working within the technology field of Condition Based Maintenance (CBM). The business developer has worked 7 years at company X, selling solutions with technology readiness levels of 6.1 to 6.3 for various commercial clients. (see Challenges and Opportunities of Low Technology Readiness Levels). Case Omega is about a "raw" technology that business developer sold to client to improve the client's existing operating system through effective maintenance without the need of human intervention. What one should consider early on in this case is the definition of what "*success*" meant to business developer A. The BD decided that the success of a project would mean reaching a deal and agreement of a service that company X could carry out for the client (the client in this case is referred to as client B). Nonetheless, this goal did not exclude the importance of carrying out the project with successful results, meaning that the client needs/requirements would be met by company X (see Case Omega Key Learnings for more information)

The client of this case was a railway company, which was operating in a fragmented market. During this time, the railway industry had recently been privatized into different groups. The group that the business developer was working with was responsible for the commercial passenger rails services in metropolitan regions. The client had been interested in developing a software that would enable them better maintenance and operations of their equipment. Since the client was also under pressure improve quality of operations and eventually replace human labour, due to declining supply, with the help from computers and machinery, they started equipping their infrastructure with sensors to start collecting data from their services. After the collection, the client was faced with the challenge of not having the high-skilled capabilities to analyse and gain the relevant insights from the data, this is where the developer's offerings become useful.

Project Initiation and Purpose

To start, we need to go back to the strategy that business developer A would use during his/her 7 years at Company X, to fit new technologies to commercial use. On a routinely basis, business developer A would investigate the research conducted at Company X to get an overview of what was being developed. The reader should note that at this stage, the business developer had extensive experience working in a start-up. Nevertheless, after finding a technology at a level ready to be sold in a market domain of interest to the business developer. The business developer would conduct research to understand the type of innovative trends in the market, educated guesses for the major players and the type of issues these companies could be facing around technology and innovation. After narrowing down the scope to a few companies, business developer would look to validate the hypothesis of the issues the companies could be dealing with. A way to do this research is through experts and contact references.

At this stage, the developer would compose a hypothesis of what type of project company X and the client could do together. But it's more complicated than this, before completing a proposition, the business developer needs extensive research to back up his or her validations, as what is being sold is at low readiness levels. Sometimes the business developer would claim that what he/she sells isn't more than research or algorithms designed to improve a software system. But this makes valuations straightforward. The business developer would ask; how much does it cost to develop this idea combined with the expected margin of return, to come up with an appropriate price.

Interactions with Customers

Early in the interview for this case, the business developer claimed that the most important aspect of success in a case is the sustainment or growth of network/relations. The developer claimed that they do various things, such as travelling to this region at least twice a year to meet with a potential client and explain new ideas to the client face to face, to maintain the good relationship with clients that the developer has previously worked with. In this case, the developer had worked in the same region as the client, prior to joining company X. This, per business developer A, played an important role in building trust and, thus, influenced willingness to work with company X. This, the brand of Company X and the client satisfaction of previous projects that the developer has done for them, or for other organisations closely related to the client, will also play a part in fostering the willingness to work with the developer. Another reason, as argued by the business developer, that trust is so important in this case, is due to the nature of the technology and the challenge in foreseeing the market value. He/she claimed that in the case of technologies with low readiness levels, getting a client to agree to adopt the solution and use it in the means of producing a commodity for the end user, is uniquely expensive. The client is investing in a project that is usually unknown to them, since the solutions are in most cases new to the world, which makes the circumstances surrounding its use more difficult to foresee. For this reason, having an established trust with the client, means that the client, even if it is being introduced to a new to the world project, will feel less reluctant to adopting it due to the ability to trust the developer's/company X's capabilities. (See more in Key Learnings of Case Omega)

After business developer A had decided to sell the technology idea, which was then at a level of 6.3/6.4, the business developer travelled to the region of operations for the market he/she was targeting. The developer brought with the researchers that had originally been involved in developing the technology over at the facilities of company X, to the geographical region of the client, where they presented the idea through a set of seminars. This was where the business developer first met client B.

Outcome

The business developer had learnt that the client needed a model that could (a) determine the condition of the equipment and (b) inform the client if there was something wrong with the equipment. These issues varied in nature, for example: (i) the lubrication of the equipment has gotten old and needs to be re-lubricated (ii) the infrastructure has gotten dirty, limiting the movement of the equipment, and needs to be cleaned (iii) the doors of the service is bent, causing too much friction, and needs to be replaced. The issue was that these problems weren't always apparent to the people working with it, since the doors of the service could still be operating but with minor setbacks that could eventually become a big problem without maintenance. Nonetheless, the client needed skilled workers that could analyse the large collection of data, so when the developer first started interacting, the developer ran a “feasibility project.” Per the developer, these seminars have played an important role in strengthening the trust between the client and company X’s capabilities to deliver the solution. In fact, the developer believed that trust in a relationship plays such an important role that the developer offered both the client in this case and future clients, smaller projects to start off with. The nature of these projects cost proportionately less than the large solution projects, and would play a two-folded role (a) familiarize the client with company X’s capabilities and establish a trust to move forward with (b) familiarize Company X/the technical solutions team with the client. The latter reason was immensely important, as this action would enable the team to understand what type of issues the client was having, perhaps simultaneously gaining insights for generic field-related problems. The smaller projects are open discussions for the clients and company X to engage in and, for both parties to teach the other about either the capabilities available to offer or the situation and issues prevailing at hand. At the end of these smaller projects a report was conducted, for the clients and company X’s keeping. From there onwards, the developer had exchanged information regarding the issues that the client was facing, and gained the trust of the client. During the next trip, the client had a better understanding of the capabilities that company X had and how it fit into their system. It was during this meeting that the developer presented the analysis the team had conducted, to the CTO, R&D, strategy and planning teams of the client. The client had become impressed with the analysis that the business developer’s team had conducted in the amount of time they had, per the business developer, that they asked the developer to analyse bigger sets of data and come up with models that they could use, which became the big project. The big project went on to be so successful in terms of deliverance, that the clients asked the business developer to continue with new big projects for the following four years to present day.

Summary

- The client of this case was a railway company experiencing challenges in maintenance of operations
- The business developer conducted routinely visits and seminars for the client and other potential clients to meet with the business developers team
- The seminars enabled both the business developer and the client to learn about each other
- The client learned about the capabilities of the business developer’s team, meanwhile the business developer learned about the problems that the client was facing
- The business developer claimed that relations and reputation were key for compelling the client to work with the business developer
- The first projects were a success, which lead to several follow up projects carried out by company X
- The success was measured through the satisfaction of the client and the willingness of the client to work with the team again.

Case Zeta

Background

This case follows two business developers that worked with selling a solution below 6.4. Both Business Developers work at Company X and have experience in selling Design and Digital Manufacturing (DDM) solutions. Case Zeta is a success case, meaning that the business developers could reach an agreement with the client, and deliver to the needs of the client by the end of the project. The business developers are referred to as business developer T and L. The case follows mainly business developer T, with post-reflections from both business developer T and L, and is about a recent project for a manufacturer of aircrafts (Client R).

Project Initiation and Purpose

To start off, Client R's local R&D team was looking at solutions in design and digital manufacturing (DDM). The challenge the R&D team was facing was that the existing big manufacturing software developers, that the client was working with, cost Client R millions and continuously failed to understand the needs of the client. The other issue was that the client's manufacturing was highly dynamic, which meant that the system went through continuous changes of internal processes. For this reason, the client had sought other strong solutions, and ended up seeking company X's capabilities. Client R had no previous experience working together and had found both company X and its capabilities through own measures. Client R had searched for a relevant and skilled provider of their needs and had found out about company X through word of mouth and, had then understood some of company X's relevant capabilities through company X's website. Client R claimed to have read articles on the web-page regarding the specialised knowledge and success company X had had in technology areas, specifically related to DDM. From this, Client R had become compelled enough to seek company X's help. Client R then requested a sit down with company X to discuss the DDM solution they needed.

Interactions with Customers

During the first meeting, Business Developer T met with client R to discuss what capabilities he or she could offer client R and the requirements that needed to be met for client R. The meeting took place with a range of specialized workers and researchers from both ends. On company X's side three to four researchers participated by providing their insights on digital manufacturing from a software perspective. The client was compelled by the insights that the researchers provided, whom at this stage was satisfied with moving forward to the next stage of negotiations, despite the lack of demonstration of the results/solution, and asked for further sit downs to go over the DDM solution/capabilities in greater detail. For the next couple of meetings, the client asked the business developer's team to create a demonstration of the solution through requirements set by the client. Eventually client R agreed to work with the business developer's team.

Outcome

The first project was done shortly after (less than 6 months), which was a small-scaled project. A small-scaled project (which is what company X refers to as the “phase 1” of the client project). This project is defined as a small project due to the level of investment that the customer has to make; circa 200K USD. In this case, the small-scaled project was proven successful, which proved both technological feasibility and the capabilities that the team had. From this, the client felt compelled to continue working with the business developer and decided on the next large scale project that tackled their dynamic-system issue. The first project also enabled the team to learn about the systems and issues that the client had been battling with. By the end of the second project the team of researchers and business developers from company X had used their learnings from the previous interactions with the customer, and successfully developed a dynamically-changing software in DDM, which solved the issue of dynamic manufacturing. The benefit with the solution was that it enabled the user to add and delete processes seamlessly, per both the business developer and the client.

Summary

- In the case, the client (Client R) approached company X, rather than vice versa, with a clear problem in mind that needed solving
- The interactions with the client included meetings with key researchers and business developers from both ends
- The client felt compelled to work with company X early in the relationship, despite lack of demonstration at initial phases. After further meetings, the client asked company X to demonstrate / prove the solution they were suggesting
- The first proof of concept was done through a small scaled project, this project proved feasibility of the solution and the capabilities of the team.
- The team used the first project as an opportunity to learn about the client’s system and problems and applied this to the big project.
- The outcome of last project was successful

Case Beta

Background

Case Beta follows three C-level individuals; Senior A, B and C, all working for Company X. All three seniors had experience working with DDM in the Metal Machining Industry. This case is a success case, meaning that the team reached an agreement with the clients and sold a solution that solved the needs of the client, per the seniors from both customer and provider. The case strongly portrays the importance of understand and utilising customer and end-user insights for solutions in DDM. In the case, this success is exhibited by highlighting the evolution of the idea from a non-adopted technology into adopted solution for its intended target.

Project Initiation and Purpose

10 years ago, an original idea by Company X of a commercial, online exchange system was introduced to a potential customer (Client D). Senior A had envisioned building a market place that allowed buyers and machine shops to meet. The idea with the new solution was to enable machine shops to more free-time, specifically in regards to cost estimations, and provide a high-level process planning for the customers and end users. The technology solution was not new to the world, nor was the relationship with the client (Client D). To the dismay of company X, the idea was rejected, and it was only with extensive development that the idea was eventually adopted 10 years later.

The research conducted by the team is important to point out, per Senior A. The input that the team had highlighted was that there was an issue with the original proposal, the users (machine shops) feared that this idea would commoditize the market. The biggest challenge came from the machine shops, whom would have had to publically place their names on the exchanges. This sparked the fear that publically placing their names on the exchange platform would imply displaying the highest and lowest bidders, undermining the machine shop's price for the current client relationships and reputation of quality. This created a negative loop, as the machine shops were willing to sell their over/idle capacity in this exchange but were not willing to state their names in the process.

Interactions with Customers

The team worked towards compelling client D to collaborate with company X, and did this through proposing a new idea, with the same solution but alternations following end user input. Senior A claimed that the team conducted several end-user insights studies, with qualitative focus in discussions and interviews. Seniors A & B sought input from machine shops asking a series of questions to get an idea of the validity and quality of the technology in the perspective of their operations. Eventually, Senior A contacted his/her senior contacts in Client D, with a brief pitch of the new idea that included the insights gathered from their studies. This was followed by a face to face meeting between Senior B and client D, and another meeting with Seniors A, B & C, the research team and Client D.

Outcome

After presenting the new ideas and the iterations that had been done from the first solution to the new solution, the client finally felt compelled to work with company X. The first agreement signed was based on the feasibility study, which meant testing and altering the idea in the machine shop's context. Following the learnings gained from the first phase the team could move onto the second phase, which was the creation of the minimal viable product (MVP). The MVP included all insights from the research phase along with the original idea. the second agreement was signed the following year from the first. The third and last agreement was the selling of the intellectual property rights of the solution to the client, to use the IP in provided technological field.

Summary

- The idea that the case follows is an online market exchange platform where machine shops and end users could meet.
- The first idea was rejected by Client D (the customer), 10 years ago. This means that the idea was not new and was already known to client D.
- The team underwent extensive research to find a way around the issues that the user had with the platform
- After learning about the issues that the user saw and researching possibilities that would work for the user, the team presented the idea to the client and an agreement was reached

Analysis & Discussion

The analysis and discussion chapter uses the findings presented in the empirical results analysis and the results are using a two-folded method. The first, looks at the key learnings of the chapters. The key learnings are the insights that the tech providers gained from interactions with customers. These interactions, as advocated in the cases, impacted the results in unique ways. The key learnings section highlight the learnings and how the learnings influenced output. This section also aims to answer the first and second sub research question: (1) *What are the important considerations to have when selling this form of solution, in regards to customer insights?* (2) *How can tech providers learn from their target customer's needs when selling a solution*? This is done by using an abductive method, exploring the observations provided in the cases and making the best possible assumption of what learnings stand out and are important to consider in this type of business practice.

The second section aims to answer the same sub-research questions along with the main research questions: *What are some insights of consumers in design and digital manufacturing that could impact the success or failure of selling a 6.3/6.4 TRL DDM solution?* This analysis is done using a deductive method. The thesis uses the criteria of successful implementation for early staged TRL solutions, created by John Mankins and analyses the thesis based on: Clarity, Crispness, Transparency and Usefulness of Program Advocacy. This provides evaluation of findings and strengthens dependability of the learnings presented in the thesis. (See Method of Collection Chapter for more details) In this context, dependability is based on how well the data could help the technology providers in the practice of selling 6.3/6.4 TRL DDM to customers. For the intended user, the usefulness of the analysis presented is based on the foundation that the reader accepts John Mankins four factored assessment method is an epistemically objective truth (or institutional fact). It is helpful if the reader "accepts" this theory as justification to the conclusions drawn in this thesis, which the learnings that the thesis claims to have impact on the business practice and are important to consider. [18]

Analysis: Part One

This section will highlight the key learnings from the empirical results: cases. The key learnings have a focus of understanding the role of customer insights by understanding what influenced the outcome of the case.

NOTE: The analysis and discussions provided in this section are based on scientific values and opinion from the point of view of the writer and the technology provider of the case in question.

Key Learnings from Case Alpha

Customer Insights

An important insight that the technology provider in Case Alpha highlights is understanding how the minimal viable product should be framed and the parameters that are necessary to fulfill. In this case, the developer had the solution ready, with strong technical merit, appropriate for the system and that could solve the issue of handling large volumes of the products at high speed. The solution would reduce the need of having as many work stations for human intervention, enabling the workers to place their skills in other areas instead. Nonetheless, the team was not able to compell the client to use this solution, as using the solution would mean too high costs in reconfiguration of the system at whole. This is interesting in the sense of how it mirrors how these types of cases look even today.

The business developer for this argued, in the interview, that there is both a difference of complexity and similarity in creating a minimal viable product (MVP), the minimal option that meets the requirement of the consumer (The Lean Startup), for a software-based versus a hardware-based idea. For the hardware side, company X typically must show that the physics of the technology works and not just assimilation of components that make up the technology. There is strong similarity to the hardware side for software based ideas, as they have underlying algorithms and architecture that can be scaled, which is written in java or python. This is done so that it doesn't have to be re-implemented, meaning that what is being created on the software side is something that can be taken by the receiving client with ease, without having to add complicated changes or go through the struggles of implementation trial and error. Per business developer Z, this is where most value was and continues to be captured and created. Taking out all the "un-knowns" from the client's point of view and they are left with is what they have experience with, this makes it easier to work the solutions that company X provides. Simultaneously, business developer Z realised that company X needed to find companies that the adoption of a solution is dependent on the complimentary expertise that the client has with what company X is working on. During an interview conducted March 1st 2017, Business Developer Z stated; "*We should talk to people who have the same expertise as we do, because they will actually understand how novel our solutions are.*"

At the same time, the offerings Company X have historically provided were so novel in the sense that the client would not be able to find the same solution else-where, so a company looking to solve an issue using a company X solution would not find the same solution on the market or in internal R&D. This is also where both the hardware side and intellectual property portfolio differs even more from the software side, because on the hardware side company X has scarce/rare resources clients will not find else-where and it is valuable to enforce patents and create market opportunities. The challenge lies in the inability to do the same with software, other precautions are necessary, and having long term parents benefit greatly in this aspect. The reasoning being the communicative aspect, a long term strategic partner understands the intangible value of the software and after working with this area from experience, eventually it becomes simpler to compel a partner to use the solution in the client's setting. By the year of 2009, after numerous trails and errors, the business developer realised that the MVP needed to be constructed by frameworks that made it easier to market the solution to potential partners. Business Developer Z claimed that the MVP needed to take into consideration; **Design Elements**, **Simplicity of Presentation, Strong Architecture**, **Application of Use**, **Proof of Feasibility** and **Ability to be Scaled**. The proposals are important in this aspect, as it is the proposal that is presented to the client, showing the consideration to the client's context and use. To fulfil the criteria of design, simplicity, architecture, use and feasibility, the proposals are written by both the researchers and the business developers. This gives the proposals more depth, as it has taken several, technical, research and business aspects into consideration. Another reason the use of inter-disciplinary roles becomes important is to create accountability. By having the researcher's input in the proposals, both the business unit and client can understand what technical solution will be applied, simultaneously, researchers can provide an outlook of what they can create in a certain time frame.

Key Learnings from Case Omega

Link to Risk and Brand

Per the business developer, the foundation of trust is important factor than impacted the success of this case. The reasoning for this is, due to the nature of the technology and the challenge in foreseeing the market value. One can claim that in the case of technologies with this level of readiness, compelling a client to agree to adopt the solution and use is expensively in terms of time, resources and money. In this case, the client was investing in a project that was unknown to them the value of the technology was un-known making the risk of investing in that technology high. For this reason, the established trust with the client, played a huge role in compelling the client to work with the business developer. The relationship enabled the client to trust the capabilities of the business developer, rather than the viability of the technology.

This brings one to the argument that a successful case constitutes success implementation and execution, but it also includes management of 1) risk perception and (2) brand recognition and reputation. As these factors were inheritably key for the success of the case.

Key Learnings from Case Zeta

Customer Insights

During the interview with business developer T, he/she claimed that in their experience their clients have responded the need to wanting to test the algorithm themselves, and due to the early staged nature of the solution the clients are themselves unable to do this. This makes the demonstration of solution challenging, and ultimately also makes singing a deal with the business developer a "huge leap of faith" (Business Developer T, Interview, 15th February 2017) What the developer believed lead to the success in this case was that the client had a clear idea of the solution it needed; a dynamically changing software in DDM. From this, the team could work on a solution that fit this need.

The developer also went on to claim that by being surrounded by other world-class researchers in the community that are at the dispense to be used by other major tech companies, company X faces the competitive disadvantage of not having more mature technologies. "*Clients want a technology that goes beyond just a research phased solution. Typically, these clients want to get their hands on the code, see the code and run the code, accessing them through a set of APIs and expect company X to hand off a demonstration through a license agreement.*" Business Developer T, Interview, 15th February 2017. The reason for this, per business developer L, is because the clients want to be able to take a piece of the data/results that the developer presents and alter it to their own use. What the developers deal with, per business developer L, are the "brains" or the "crude code" of the software, and at this stage the code does not have an application yet. For this reason, the clients want to understand the results so that their own developers can use it for their chosen applications.

Key Learnings from Case Beta

Timing and Choosing the Right Partners

Since we know that the solution had, in most its form, been around for 10 years, one can speculate different factors that could have influenced the journey of the idea eventually being adopted. Firstly, 10 years ago the market might not have been ready for this solution. During the recent years, transparency and accessibility have become major trends for low TRL solutions, this may have influenced the decision to eventually adopt this solution. (Mankins 2009) This factor also points to how timing to market can affect the willingness to adopt an un-known and low maturity levelled solution in DDM. Second, the case points to the importance of using the correct value chain partners. In the case, Senior A describes that the machine shops saw the risks of transparency by using the solution. The machine shops feared that the solution would have resulted in commoditization of the market. Since Client D worked as the supplier of the machine shops, the client was naturally not interested in working with Company X without the approval of the solution's user. After conducting research in regards to customer insights, this included understanding and integrating the needs of the users into the solution and changing the solution the fit the newly found insights, Client D became interested in working together with Company X. This points to the importance of choosing the correct partners and integrating the learnings from customers to the solution.

The Technology is Greater than the Sum of its Parts

There are several considerations that both parties, the tech providers and the industrial manufactures (customers of the tech providers) should to be aware of. These considerations can be classified as relevant customer insights that aid the tech providers in selling the technology (6.3/6.4 TRL) in DDM to a customer. Per the findings from the empirical results and the theoretical framework studying the behaviour of industrial manufactures, the tech providers should consider the concept of the “concept being bigger than the sum of its part.” All findings point to the fact that the tech providers need to understand the costs and the investments that would have to occur because of implementation. The technology alone cannot survive implementation in a new context, if it is not handled with skilled and knowledge labour and either fits into the assembly lines already existing or if it does require dramatic change of machinery, the benefits need to outweigh the long-term costs.

Analysis: Part Two

TRRA Analysis

This section (Part two of analysis) provides analysis of the empirical results, guided by the work of John Mankins, Founder and President at Mankins Space Technology, (ARTEMIS Innovation 2008) on Technology Risk and Readiness Assessment, created for guiding early-staged TRL technologies towards success. The reasoning that Mankins uses is that early staged TRL technology in most cases fail to meet the needs of its user. By using this form of assessment that evaluates a project, based on a four-factored criterion, the technology provider could be more successful. (Mankins 2009) Mankins, argues that the following four factors need to be met and assessed for a technology provider to experience success in their projects;

Clarity characteristic refers to the process of the project maintaining a clear decision criteria for determining risks and technology readiness. These criteria should be analysed based on a method that enables individualistic evaluation and verification of results. (Mankins 2009)

Transparency characteristic refers to how the process of technology risk and readiness assessment should be formal, avoiding strict bureaucracy, and consensus-based. The project description, use and steps/process should be simple to follow and understand by operators, managers, independent observers and participants. (Mankins 2009)

"**Crispness**" criteria refer to how decisions during the TRRA should be made by or/and with the ownership of senior management. The decisions must be crisp, correctly timed and keyed to annual R&D and system program budget planning requirements. (Mankins 2009)

Usefulness of the Program Advocacy; this refers to claim that the processes used to make TRRA decisions should also be the basis for advocacy of the result. (Mankins 2009)

Figures 12-15 aim to answer; how well was the criteria was met in the cases. The reason this analysis is done is to gain credibility of results and claim that these factors are important to consider for this type of business practice. The analysis also aims to use the theoretical framework to explore whether gaining learnings from a DDM customer strengthens the likelihood of adoption.

	Case Alpha	Case Omega	Case Zeta	Case Beta
Clarity	This criterion was met. Both the results of the technology in the implementation context, and the readiness level of the technology were clear, per the business developer. The solution could increase efficiency and complement the human workers at the factory. With this new technology, the solution would have solved the problem of diminishing rates of return for human labour at the factory.	The business developer had numerous meetings with the client, including ethnographic studies of behaviour to study the implementation context. The pre-project phase included various tests phases, and the results were formally presented to the client in meetings which also included key researchers of the technology solution. This process enabled the individuals involved to verify the technology in the appropriate context. In addition to this, the business developer clarified the readiness and risks of using the technology by the successfulness of previous and smaller projects with the same/similar technology and client.	The "clarity" criteria was met during the later phases of the project life-cycle. During the early phases, the client had a strong idea regarding the problem that needed to be solved, but not the appropriate solution. Company X clarified the solution through demonstration and smaller projects, enabling both parties to become more familiar with one another. Decisions were made at the start of all projects, which indicates a level of trust a clarity that was prevalent prior to signing the agreement.	There was a clear decision criteria in this case. The negations and singing phases prove that both sides needed to evaluate the risks, readiness and commercial viability of the solution. Similar to "transparency," clarity was a fundamental factor for compelling the client to work with company X, as all sides (user, senior managers and client) were able to reach a consensus after the investigation of user requirements, which was then presented to both the users and client through an iterated solution/demonstration.

Figure 12 (Mankins 2009)

	Case Alpha	Case Omega	Case Zeta	Case Beta
Transparency	Per the business developer, there was no strict bureaucracy, however, perhaps the transparency of technology risk was not clear evident during the beginning phases of the project. The customer claimed that the technology would mean massive re-investment in capital, the customer would have had to change their assembly lines to fit the function needs of the technology and not vice versa. If this deal breaker was known earlier on in the project phase, there is a chance the project wouldn't have reached its end so far done the project life.	The process of the project assessment took place prior to agreeing to a project. The business developer followed formal procedures, with routinely scheduled meeting to introduce the technology, as well as seminars with various personnel, skilled workers and senior managers to provide explanation of the technology's use, which was followed by more focused-to-the-project meetings with seniors and key researchers from Company X.	During the case, several decisions and conclusions were made on consensus. This was the outcome of several follow up meetings and methods of proving feasibility and trust.	Transparency was key for this case, both in terms of what the user deemed as being the biggest issue with the solution and how the project reached the phase of agreement. The team had to make sure that all parities could understand and were in consensus with the solution. The risk of not having this consensus would have meant no adoption by the client, this is proven by the fact that it was only after the team gained insights from the user and iterated the solution that Client D agreed to adopting the solution.

Figure 13(Mankins 2009)

	Case Alpha	Case Omega	Case Zeta	Case Beta
"Crispness"	The ownership was clear, however, the solution was not necessarily times to the client's annual R&D. The case provides evidence that the technology most definitely did not meet the client's system budget planning requirements (as this was the grounds for rejection of the project, per the business developer).	The ownership of the technology, per the business developer, was determined through intellectual property rights, which as a standard for company X, are given for a field of use, following a non-disclosure agreement to provide protection for trade secrets, business transactions and risk. The ownership of the decisions were all made with the senior managers of the customer-company, and were strictly consensus based, time keyed and fell in line with the program budget requirements.	The decisions and investments that client R made were in line with the system program and R&D budget. This is proven by the success of the first case and the end results which both parties were pleased with.	Ownership of intellectual property was made clear during the last phases of negotiation, nonetheless, these were crisp and relevant. Ownership of decisions were also made clear when the idea was initially rejected by the client and, later reject by the user. The idea was adopted only after adapting to the needs of the client and end user.

Figure 14 (Mankins 2009)

	Case Alpha	Case Omega	Case Zeta	Case Beta
Usefulness in program	The project was never able to reach adoption. This means that this assessment is not able to be carried out for this case.	The process used to create the Technology Readiness and Risk Assessment (TRRA), were proven as advocacy of the results and the first projects lead on to several follow-on projects. This indicates that the transparency, crispness and clarity of the project were all strong and satisfactory for both party ends; the tech provider and client.	The usefulness of the assessment (though this is perhaps not something that was obvious during the lifetime of the case) was proven by the fact that the team compelled the client to agree to a new project. If the three criterions were not met, then the likelihood of not working together for a new project would not have been high. Based on this assumption, the processes used to fulfil the criterions were also the basis of advocacy of the first project result, which turned into a new project.	The results of the three criterions were proven helpful for the result of the solution as it was after all three criterions that the client felt compelled by the solution and saw the value of the project outcome.

Figure 15 (Mankins 2009)

Assessment of the Model

For all cases, clarity was a priority for the technology provide. However, the stages of when the Clarity Criterion was met differ, for case Alpha, this was only the case for both parties after meeting the client, researching the factory and suggesting an idea to the client. For the other cases, the *Clarity* Criterion was met rather early on, even in the Case of Zeta. For Case Zeta, the client had an idea of what the technology was going to be used for before approaching company X.

The Transparency Criterion, was met in case Omega, Zeta and Beta. However, only in the second attempt was this criterion met, this became a turning point for the project. The transparency criterion was not met in Case Alpha. Based on these findings Transparency, is very important to consider and may “make or break” the success of the case. The “Crispness” criteria was challenging to assess, since the interviews did not cover this topic to the extent that a strong assessment requires. Nonetheless, based on the knowledge acquired from the cases, the ownership and field of use of the technologies was clear and strictly consensus based. However, this feature did not make or break the case. On the other hand, this creation may be necessary to meet to reach a level of agreement with the client, but is not a top priority that makes or breaks the case. The *Usefulness in program* was present in all case, except Case Alpha. The relationship between this assessment and the success of the case unclear and perhaps irrelevant for this assessment, as the cases study the success of selling a solution, and not the implementation process. On the other hand, Case Zeta suggests that there is a need to understand and excel in the implementation process as this will influence the willingness of the client to start a new project with the same team.

Conclusion

The purpose of this paper was to explore, through the aid of relevant cases, and help tech providers (TP) of solutions with 6.3/6.4 TRL in Design and Digital Manufacturing (DDM) understand how they could learn from customer insights, in regards to selling a solution with 6.3/6.4 TRL in DDM.

The research questions were:

> **What are insights of consumers in design and digital manufacturing that could impact the success or failure of selling a 6.3/6.4 TRL DDM solution?**

<u>*Sub Research Questions*</u>

III. **What are the important considerations to have when selling this form of solution, in regards to customer insights?**
IV. **How can tech providers learn from their target customer's needs when selling a solution?**

The thesis used four cases to answer these research questions, all highlighting how the customer interactions and learnings from customer interactions impacted the outcome of the case. Three of the cases were successful and one was not (case Alpha). Success was categorized as the ability to sell a solution to the customer. Each case had impactful learnings, and were applied to create the success of the case in different ways. The cases highlight that there are different learnings a tech provider can gain from customers; this is what the thesis refers to as customer insights. However, the customer insights can take different forms, and depending on the ability to understand the insights, learn from, and apply the learnings in practice the technology provider will experience success or failure.

The following section provides an answer to all three research questions, main and sub, and follows the second purpose of the thesis: *to gather findings that aid the ability to achieve the research aim*. The major key learnings from the cases are listed below;

> *(1)* Understand the technology solution's context (which it is going to be placed in): *How well does the technology fit into the consumer's context? How costly is it to change it? Does it need changing?*

Case Alpha was a strong example of the need to include this thinking when selling this type of solution. The solution was ready, had strong technical merit and could reduce the production costs that the client was experiencing, however, due to the current production system in place, the client rejected the project. This suggests that it is important to understand the context of which the technology is going to be placed in. The business developer of Case Alpha referred to this, due to their experience from working in a start-up, as the start-up Minimal Viable Product. The business developer also claimed that there are parameters that the MVP must meet. Some of which are the following; Design Elements, Simplicity of Presentation, Strong Architecture, Application of Use, Proof of Feasibility and Ability to be Scaled.

(2) The need of using proper assessment of the technology before its implementation: *how clear is the use of the technology for the client and what are the risks?*

Case Omega gave strong indication that there is a link between establishing trust with the client. The business developer in this case had undergone extensive meeting schedules to ensure that the client recognized both the business developer's and the technology's capabilities. Both Case Omega and Zeta case suggest that there is a need to understand that these investments are very risky for the customer. In both cases, the business developers had success when this consideration was acknowledged and addressed. In Case Zeta, the business developer ensured using the key researchers in the meetings with the client and that the clients knew what the technology was going to be used for and what the implementation would entail for both company X and the client.

(3) The challenge it is solving: *What is the actual challenge that tech provider is solving, what gives it its competitive edge?*

All cases provided strong indication that there is a need to understand the actual dilemma the technology is solving. The reason this is important to consider, is because this will aid in presenting the technology to the customer and compelling the customer to adopt the solution.

(4) The ability to continue using the solution: *How complicated is it to use the technology after company X? What are the opportunities?*

Case Zeta provided the experience of two business developers that claimed that customers of these complex solutions want to be able to use the data that company X provides and test it using their own methods. There is a need to understand the results so that the client can see the opportunities of using the solution.

(5) Planning for the market and partners: *Which partners have we considered? What outside knowledge do we need for this case to succeed?*

Case Beta clearly points to the importance of choosing the correct partners and planning for the market. The team initially had no success with selling the solution due to the lack of knowledge of the user, and most likely, the market readiness. This was also the case for Case Alpha, initially the business developer had argued that this solution had not been implemented in industrial manufacturing yet, which made it difficult to convince experts in the field of the use of the technology. Moreover, as the technologies being sold are at low technology readiness levels, the investment becomes even more risker for the client, as the client cannot predict (without specialists) the outcome of the investment and has little to benchmark the solution with. These factors are important to consider, and finding alternative that strongly aid the clarification of use/function/opportunities of technology becomes vital for success. Trends in industrial manufacturing indicate that investment in R&D is increasing, which means that the market may be more ready to accept high level technologies, (2016 Industrial Manufacturing Trends) however, this is also dependent on the other insights/requirements provided.

The thesis also uses John Mankins Technology Risk and Readiness Assessment to create depth of analysis and credibility to the conclusions of what entails success for this business practice. John

Mankins claims that for any solution with very low technology readiness level (6.4 and lower), risk becomes important to consider. The customer is faced with enormous risk of investment, which makes the assessment of the risk of technology vital for the selling the solution. John Mankins uses four criterions that need to be checked off; *Clarity, Transparency, "Crispness,"* and *Usefulness of the Program Advocacy.* (Mankins 2009) The thesis used the framework and conducted a cross-case study, comparing how well the criterions were met in the cases, to see if these criterions are what make or break the case. After the assessment, the thesis concludes that Clarity and Transparency are of absolute necessity to include in this business practice. However, this criterion needs to be met before the technology has been presented to the client. For Case Omega, the business developer had undergone extensive meeting schedules and seminars to educate the clients and ensure clarity of the technology and business developer's capabilities. This lead to many follow-on cases and much success. This was also the case for Case Zeta, where the client had Clarity, prior to working with the technology provider and transparency became vital for both sides to move on to agreement of the project. The thesis concludes that "Crispness" is not a vital feature that needs to be met, however, it also acknowledges that this criterion was not adequately covered in the interviews. For this reason, the thesis recommends, that research of understanding this criterion in greater depth and the relationship between this criterion and the success of the case should be conducted. Lastly, Usefulness of Program Advocacy is also a feature to take into consideration, and is most strongly presented in Case Omega. Case Omega suggests that successful implementation will influence the customer's willingness to work with the same team / similar technology again.

Future Research

This section highlights the areas that a future researcher for this area needs to consider.

The nature of the thesis acts as a limitation itself. To achieve the purpose and aim of the thesis, an exploratory and interpretative view needed to be taken. This was done to ensure that a large perspective was taken and that important variables were considered. However, for the future researcher, this approach should not be taken, instead a deductive method could be used to study research and apply it in the practical setting. This is also important as it would provide stronger grounds for Educative, Catalytic and Tactical Authenticity of the research. (Guba and Lincoln 1985) The aim was to explore, through the aid of relevant cases, and help tech providers (TP) of solutions with 6.3/6.4 TRL in Design and Digital Manufacturing (DDM) understand how they could learn from customer insights, in regards to selling a solution with 6.3/6.4 TRL in DDM. Therefore, if the findings are not tested in practice and proven to be helpful for this business setting, the aim will not have been completely achieved. The argument of the nature chosen for the thesis is based on the claim that acquiring and structuring knowledge from this business setting will aid the technology provider when selling a 6.3/6.4 TRL DDM solution. However, the specification of how this should be applied in practice is not clarified at this time. The other argument of the thesis is that the technology provider should understand, learn and apply the knowledge gained from customer interactions (customer insights) and apply this when presenting and working with the solution with the client, but the success of this practice can be more effectively achieved through deductive studies of each customer insight provided in this thesis along with an analysis of the value chain process of technology provider. This brings us to the next delimitation of the thesis, the thesis produced generic recommendations based on the focused case studies of company X. For the future researcher; one should take into consideration that the use of the customer insights are specific for Company X, and if one wishes to use it for another company setting(s) then a deductive method should be used. This study can be conducted using different methods, for ex) (a) Studying the insights for future implementation: Quantitative study of success of applying the insights and outcomes. (b) Comparative Case Studies: Using old case studies and measuring/comparing the insights presented in the thesis compared to the insights used and acknowledged in the cases.

Moreover, if a researcher decided to continue this research, then the recommendation would be to include a quantitative study of the two suggestions given above, and use other rare experts existing in this field.

In conclusion, there are many branches of focus fields that can derive from this paper, but the main consideration for future researchers is that the insights need to be tested in another context (practice or case studies) to strengthen dependability and confirmability.

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