Data-Driven Business Model Strategy Development for Incumbents in B2B Markets

by

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Submitted to the MIT Sloan School of Management and
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Abstract

Maschinenfabrik Reinhausen is an incumbent manufacturer in the electrical power equipment industry, engaging in business-to-business (B2B) sales with a strong market position and successful products interested in pursuing the development of new, data-driven business models to generate new sources of revenue. This effort requires both development of hardware products that can provide relevant data and a business model to effectively generate, deliver and capture value for the firm.

Based on case studies, interviews and assessment of the status quo at MR, this project posits a framework for data-driven business model development strategy. This project concludes that while extending connectivity to wider range of sensors through an Ethernet interface would be beneficial, there is no "recipe" or outwardly clear optimal business model structure. However, there is evidence that the internal environment in which incumbents develop new business models has a strong relationship with their success, and there are consistent characteristics across successful examples. Focusing on culture, process, governance, and the use of the right metrics leads to more successful outcomes.

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Chapter 1

Introduction

As digitalization continues to generate new opportunities across industries, incumbent businesses are faced with the challenge of deciding if and how to adapt their business models to take advantage of rapidly changing technological possibilities. Some industries, such as media, have already undergone fundamental shifts in industry structure, with wide-reaching ramifications. Other industries are just beginning the process.

Incumbents with business-to-business (B2B) business models in industries earlier in the digitalization process have an opportunity to adapt to and leverage the new possibilities of digital and data-driven businesses. The goal of this thesis is to propose a framework for data-driven business model development at a successful incumbent manufacturer in a B2B context. Incumbents have unique advantages and obstacles in developing their data-driven business model strategy, so a framework that takes into account the specific opportunities and challenges of stable, successful incumbents is a valuable tool for developing a robust business model development strategy in this context.

While the focus of this thesis is on a firm positioned as a high quality supplier in the energy equipment and services industry, the themes explored may provide insight to incumbent manufacturing firms in other industries looking to develop a digital or data-driven business model strategy.

1.1 Maschinenfabrik Reinhausen

Maschinenfabrik Reinhausen (MR) is a German manufacturer of components for electrical transformers, and a range of other products and services for the electrical power grid. Dr. Bernard Jansen invented the high-speed resistor-type tap changer in 1926, allowing the on-load adjustment of the transmission ratio for transformers. With the Scheubeck brothers, the product was sold worldwide and gained a reputation for reliability and efficacy. In 1973, MR introduced the on-load tap changer and in 2000, brought the first vacuum type tap changer to market. MR continues to pursue innovation in products and process [24].

MR is headquartered in Regensburg, Germany, and employs 3500 employees worldwide across 45 subsidiaries and 4 affiliated companies [37]. The core business of MR is the regulation of power transformers through tap changers. MR estimates 50% of the world's energy supply flows through their products, and has found success by pursuing excellence in global niches of electrical energy engineering [37].

While MR began as a hardware manufacturer, the company has also developed significant strengths in solutions and services, providing customized solutions and service offerings, including field service, laboratory analysis and design services. As MR continues to pursue the mission to provide reliable, innovative solutions, the company is also looking to develop new business models that leverage newly available transformer data to provide additional value for the customer and make MR a trusted partner throughout the life-cycle of assets in service.

More context about MR, specifically developments in the business model and types of products and services relevant to this thesis is provided in 1.3.1.

1.2 Transformers and role in grid

Alternating current is transmitted at varying voltages throughout the grid in order to save energy and distribute electricity to users efficiently. For transmission over long distances, higher voltages are more efficient. Power loss due to resistance in the

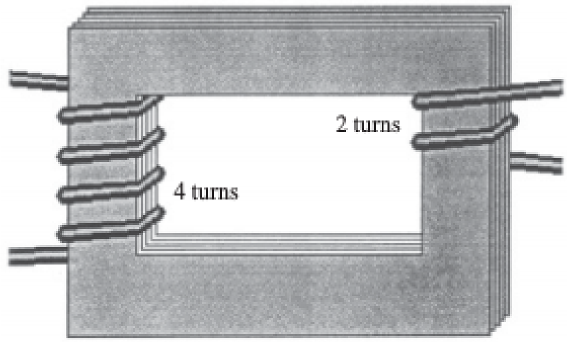

Figure 1.2.1: Diagram of basic transformer relationships[9]

conductor is related to the square of current, $P = I^2R$, so electricity at a higher voltage and lower current is more efficient. Voltage loss is linearly related to current, $V = IR$, so a lower current across the same segment of wire, achieved at higher voltages, reduces the the voltage drop and makes voltage regulation throughout the grid easier to achieve. Generation and use of the electricity occur at lower voltages. In order to step voltage up and down, electrical transformers are installed at the relevant points within the grid.

Transformers work using the principle of magnetic induction. Transformers consist of two coils wrapped around a core. The voltage step up or down is determined by the ratio of primary to secondary windings, which are wound around the magnetic core. The primary windings are on the incoming side, and the secondary windings

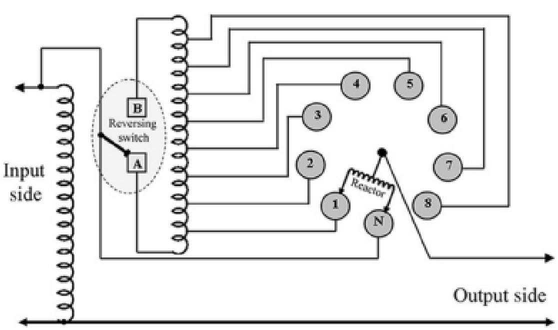

Figure 1.2.2: Diagram of On Load Tap Changer (OLTC)[9]

are on the secondary side of the core. However, load in the grid is not static, so a primary function that must be performed at the transformer is power regulation through adjusting the ratio of primary to secondary coils using a component called a tap changer. The on-load tap changer (OLTC) is a component enabling voltage regulation at the transformer by adjusting the ratio of primary to secondary windings in response to a change in load. As the load fluctuates, the OLTC adjusts to provide a consistent output voltage from the transformer. Other major components of the transformer are the housing, bushings, oil, insulation, and control systems such as the voltage regulation.

Transformers range from high voltage (hundreds of kV) to smaller distribution transformers providing the final step-down for electricity provided to end-users. Transformers are a critical grid component, and are monitored to determine their health on a regular schedule. Table 1.2.1 describes important dimensions of transformer health and how they are assessed. The physical parameters measured include temperature, humidity, capacitance, voltage, current, and vibration. Sensors employed range from simple analog gauges for visual inspection to intelligent Dissolved Gas Analysis (DGA) sensors providing on-site assessments of the concentrations of various gases in the transformer oil, have a touchscreen HMI and SCADA or Ethernet connectivity.

The frequency and detail of inspection of transformers and other power assets is highly variable based on location, use, how critical the device is, consequences of failure, age, and other factors. Advances in digital technology in the last decades now provide the possibility for more frequent, automated monitoring through more intelligent sensors, and more meaningful and actionable analysis of that data in order to make more informed decisions about repair, maintenance, and replacement of assets in the power grid. A previous thesis at this company focused on developing and validating a business model based on integrating inspection data and real-time transformer health data into actionable insights for customers[28]. Implementation of this work raised questions about how to approach business model development for data-driven business models in this context more generally. That is to say, given there are multiple ideas for business models to pursue, and more than one of them may be implemented, how should the company think about the process of pursuing

Category	Sub-Category	Parameter
Primary Functions		Output voltage (3 phases) Output Current (3 phases) Detected Failures in Primary Functions Device Status
Supporting Functions	Voltage Regulation	Online Tap Changer (OLTC) Position OLTC Motor Current OLTC Vibration
	Cooling	System Status Cooling Fan Motor Current(s)
Protective Functions	Oil (Core & OLTC)	Oil Gas Concentrations Moisture in Oil Oil Level
	Bushing	Calculated Capacitance
	Insulation	Insulation Level (based on Withstand Voltage Tests)
	Monitoring	Functions active/inactive
Environmental	Windings	Temperature
	Oil	Top Temperature Bottom Temperature
	Surface	Maximum Hot Spot Temperature
	Ambient	Temperature

Table 1.2.1: Major parameters for transformer condition monitoring [28]

the development of a new data driven business model and what can be learned from previous experiences, internally and externally?

1.3 Digitalization in the energy industry

The terms used to discuss the impact of digital technologies on business are not always precisely defined and clearly applied. In order to maintain clarity, the following definition of the terms digitization, digitalization, and digital transformation is used.

"Digitization" refers to converting information and products to to digital format. "Digitalization" refers to the evolution and innovation of business models and

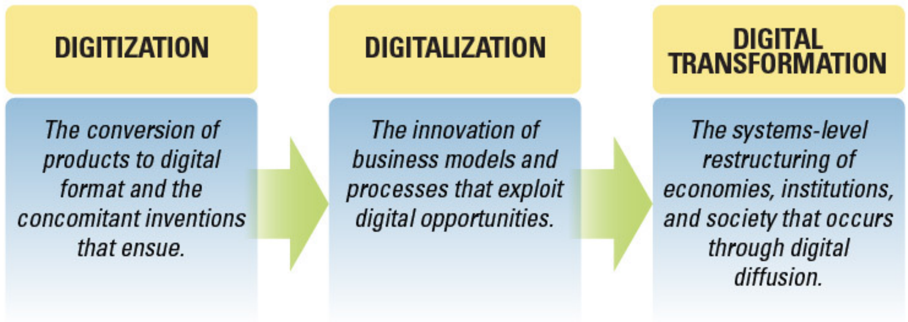

Figure 1.3.3: Digitization, digitalization, and digital transformation refer to differing scales of impact of digital technology [32]

processes in order to exploit the possibilities digital technology enables. "Digital Transformation" is a deeper, system-level restructuring of the firm, industries, and economies that occurs as a result of the proliferation of digital technology. Developing data driven business models, as discussed here falls into the "digitalization" category. These three levels of impact are a way to separate the discussion of which dynamics are at play, and at what scale digital technology and data are impacting a business or industry.

In the energy industry, digitalization does not mean equipment will be replaced entirely by software, rather, the digital transformation of the energy industry is centered around increasing connectivity of components of energy generation, transmission, and distribution systems. The rise of the Industrial Internet of Things (IIoT) brings the possibility to collect, analyze and draw insight from more real-time and detailed data than previously available. As an example, transformers are inspected on a schedule ranging from months to a few years between visits depending on how critical they are. With new hardware and sensor products on the market, there is now the possibility to monitor key assets multiple times per day.

Digital technologies and connectivity have been improving energy systems worldwide for decades, and the pace of change and adoption continues to increase rapidly; global investment in digital electricity infrastructure and software has increased over 20% annually between 2014 and 2017, spurred by declining costs of sensors, huge leaps in the power of advanced analytics, and access to faster and cheaper data storage and transmission [17].

These developments present a significant opportunity for companies to create value within the electrical energy sector. The International Energy Association's 2017 report on the impact of digitalization on the energy sector predicts the power sector has the potential to save over 80B USD (5% of total revenue) per year through efforts to reduce operation and maintenance costs, extend the life of assets, increase efficiency and reduce downtime and outages through digital technologies. Collecting information about components and assets in the power system is not new, but digital sensors sufficiently lower the cost barrier such that a wider range of assets may be monitored, and increase the types of measurements and data that can be recorded about each asset, allowing more nuanced and efficient operation, maintenance, and control of systems [17].

While data-driven business models and digitalization present a significant opportunity to enhance revenue or reduce costs, "many companies struggle to capitalize on the potential" [18]. Gebauer et al.(2020) refer to this phenomenon as the digitalization paradox. Any new business model development must address that tendency and have a strategy to navigate this pitfall.

1.3.1 MR & Data-Driven Business Models

MR is primarily a supplier of On Load Tap Changers (OLTCs) to transformer Original Equipment Manufacturers (OEMs). MR also sells hardware such as sensors to OEMs or directly to the end-user, typically grid operators or heavy industrial customers with significant power management needs. While the core business remains sale of hardware products such as OLTCs, MR has introduced additional services such as design consulting, solution design, and transformer service over the last decade.

MR has a strong market position, but company leadership is wary of becoming too complacent, and set up the Digital Ventures group to investigate and pursue opportunities to develop new business models based on the increasing amount of data available to MR. The goal was for this group to identify opportunities to develop new revenue streams through new offerings that do not fit into the existing business model (sell components to OEMs). Digital Ventures assessed and then pursued a range of possible ideas, and by late 2019 there were three business models being developed within the group. These business models, generally speaking, are based around selling access to analysis of transformer data to help customers make more informed decisions around operational and capital expenditures to keep their networks operating.

The Transformer Automation division was created in 2019 to drive revenue from the integration of existing transformer automation technology with the fledgling business models developed in the Digital Ventures group. By integrating the new ideas in Digital Ventures with other work being done in the Automation division, the goal was to accelerate the introduction of Digital Venture's business models and to start to generate significant revenue. While previously the Digital Ventures has reported directly to the Managing Directors, the group is now housed inside the Automation business unit. This business unit consists of groups working on "standard" sensor hardware, firmware and software design and development, as well as the AI group and the Digital Ventures group. This project was conducted inside Automation.

Products

The Automation division is responsible for the design and development of solutions for transformer and substation automation. MR divides these solutions into the following levels:

- Process Level: sensors, both intelligent sensors such as a Dissolved Gas Analysis (DGA) sensor and more standard or simple temperature, pressure and humidity sensors

- Field Level: functions such as voltage regulation, monitoring, and safety functions, particularly through the ETOS architecture. ETOS is MR's Embedded Transformer Operating System, an open operating system for smart transformers. This system standardizes the functions used to control and monitor transformers, and integrates process level data into a consolidated location.

- Control Level: through the integration of field level information with SCADA (Supervisory Control and Data Acquisition) systems and cloud-based applications to extract more value from the data included.

Data-driven business models in development

The Digital Ventures group is focused on developing new business models that drive revenue growth at the Control Level of the hierarchy we describe above. Critical questions include, how can MR provide additional value to asset managers, OEMs and operators? How can MR leverage operational data available from the Field and Process Levels in order to enable better decision making, higher reliability, and better maintenance.

As of April 2020, there are three primary business models under development within the Digital Ventures group.

- TESSA Asset Management Suite. The TESSA Asset Management suite ingests real-time data from connected assets and provides alerting, trend analysis and other desirable features. The business model is based around a subscription for continued access to the application.

- Fleetscan 2D uses offline measurements gathered by field technicians during regularly scheduled maintenance to help asset managers make more informed decisions about balancing operational expenditure (Opex) and capital expenditure (Capex) and interventions. This business model is based around a base subscription, augmented by add-on services for further analysis of transformer assets that need more detailed investigation.

- AMC is a platform connecting service providers and asset managers in regions where MR does not have a significant service presence.

As MR continues to pursue data-driven business models, there is a need to identify a consistent framework for evaluating and driving development of these business models within the existing organization.

1.4 Problem Statement

In a successful incumbent with a strong market position, where the primary business focus is the B2B sale and manufacture of hardware components, what are the key dimensions to consider as the business develops new business models enabled by data? As opposed to simply translating startup strategy, or relying on existing understandings of the core business, the key questions addressed are what are the key dimensions of data-driven business model development for a company such as MR, how do they intersect with technology choices about hardware development, and in what direction does the framework suggest MR move for further development?

Chapter 2

Existing Frameworks and Best Practices

This chapter provides an overview of the existing literature related to business models, sources of competitive advantage in B2B environments, and use of data and how they relate to the development of new business models. This literature review focuses on the application of business model literature to the development of new business models in existing companies, and discusses how they are relevant to the problem at hand.

2.1 Business Model Concept

The business model fits into the conceptual understanding of an enterprise between the levels of strategy and a specific business plan. Whereas strategy describes the choices a firm makes about where and how to compete, the business model describes "the logic of a how a firm creates, delivers, and captures value" [8]. Business models and business model innovation as a critical component of strategy are at the forefront of executive's minds: in 2005, an EIU Executive Study found a majority of CEO's considered business models a larger source of competitive advantage than new product or service offerings [66]. The precise definition of the business model, its structure, and relationship to other aspects of the business such as strategy and processes is widely discussed but a single definition has not yet emerged [14].

2.1.1 Existing Frameworks

While the precise definitions vary, authors have converged in agreeing that the purpose of a business model framework is to provide a conceptual map to describe how the different aspects of a business' structure, relationship to the market, suppliers, partners, key resources, and others, fit together. The figure below shows three different business model frameworks found in the literature.

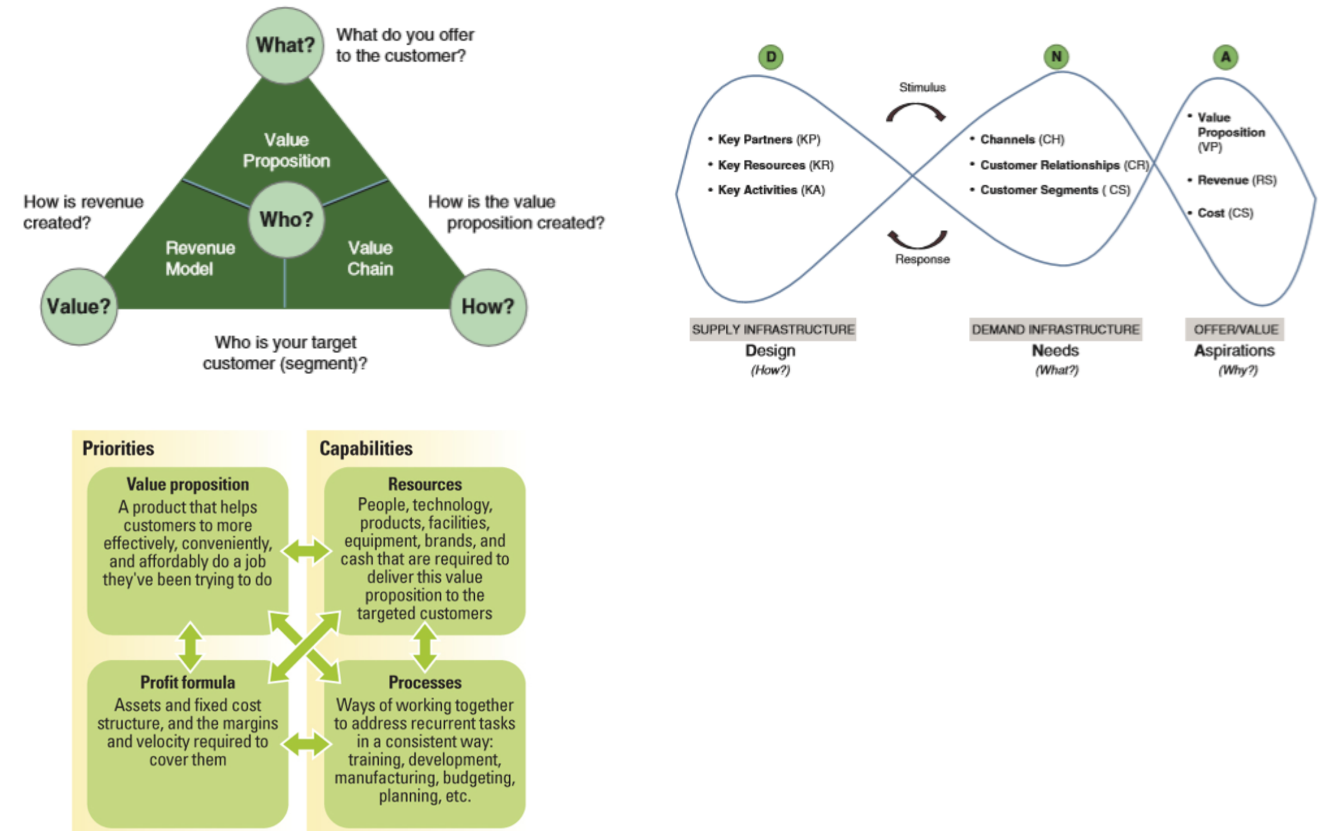

Figure 2.1.1: The St. Gallen Business Model Framework [2], DNA Business Model Framework [2], and a framework posited by Christensen and Bever [8]

There is no agreement on a single business model framework, rather, academics and practitioners use frameworks that illustrate the necessary dimensions for the type of analysis, idea generation, or planning being undertaken [33]. Lambert argues clas-

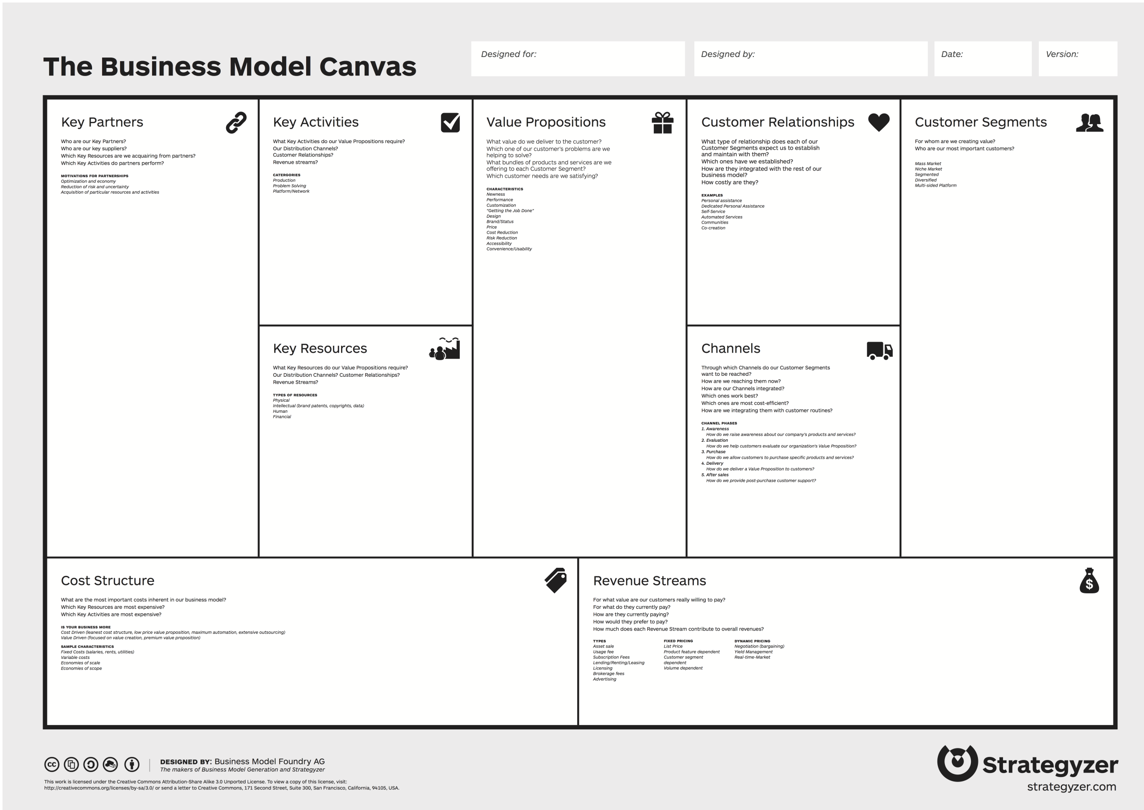

Figure 2.1.2: Business Model Canvas template. Source: strategyzer.com

sification is critical to generating mid-range theories leading to specific actionable insights, rather than theorizing on a grand scale. The different models are useful in different contexts. One of the most important functions of a framework to describe business models is providing a common understanding and vocabulary to communicate around the topic. The company within which this project was conducted already uses Osterwalder & Pigneur's Business Model Canvas. As the Business Model Canvas is used both within the company and in many other contexts, particularly corporate startups, it is the business model framework this project will use as the basis for describing business models and categorizing and conceptualizing aspects of various business models into components that can be compared and contrasted.

The Business Model Canvas consists of nine components arranged on the canvas to indicate the critical interactions.

1. Key Partners - describes organizations, companies, and other entities that are

outside the firm but nonetheless critical partners in the creation, delivery, or capture of value in the value chain.

2. Key Activities - the primary activities that create value for customers, key activities the firm performs.

3. Key Resources - resources controlled by the firm used to generate or deliver the product or service offering.

4. Value Propositions - what a firm provides the customer, the job done for the customer.

5. Customer Relationships - decisions about what kind of relationship(s) a firm will have with the customer.

6. Channels - How a firm reaches its customers. Could be a single or multi-channel approach.

7. Customer Segments - the specific types of customers the firm is targeting with the value propositions. Again, there may be multiple customer segments, particularly when there are multiple value propositions and/or multiple channels.

8. Cost Structure - decisions about cost structure are related to items 1-4, and describe the costs a firm incurs in order to deliver the product or service to customers.

9. Revenue Streams - describe sources of revenue, once again, there may be multiple, revenue streams represent the various sources of income for the business model.

In 2017, Remane et al. proposed a three-step process for discovering new business models, using an existing framework: first, identify the existing products and services, then deconstruct the business models, then discover new configurations [45]. While this is a useful framework when considering general changes to the business model, it does not account for the introduction of new components such new availability of data, or new potential services in the methodology. The challenge faced by companies by MR is how to specifically address data-driven business model possibilities in their industries. The Business Model Canvas is a useful descriptive framework, but does not provide direction or guidance as to how to determine those components, or how to address them within an existing business.

2.1.2 Stages of Business Model Development

Business model development moves through distinct stages over the lifecycle of the business model. In their article, "The Hard Truth About Business Model Innovation", Christensen and Bever present three stages of business model development, Creation, Sustaining Innovation, and Efficiency. In the first stage, Creation, "the entirety of the business unit's focus should be dedicated to understanding the primary business, accomplished through discovery of the job to be done and "pivoting" of the business model" to address the aspects of that job [8]. In the Creation stage of business model development, there is a particular focus on determining the precise value proposition of the offering, and the resources available and/or needed to provide the value proposition. As managers gather information to validate or disprove initial hypotheses, "being fast in learning and making the requisite adjustments to the model is important" [56]. The chances of good initial designs are more likely with deep understanding of and good listening to user needs, understanding of the value chain, and consideration of multiple alternatives [56].

If the business model is fortunate enough to meet a real unmet job, or address an existing job in a better way, and gain a foothold and initial customers, the business model enters the next stage: Sustaining Innovation. Here the primary value proposition and job to be done are well understood, and the challenge shifts to scaling operations to meet growing demand. In the Sustaining Innovation stage, data are plentiful, metrics are developed to guide decisions, processes are built to bolster operations, and most investment is into increasing product performance in order to grow the top line.

Eventually, sustaining innovations no longer generate sufficient additional profitability and the business model enters the final stage of the business model lifecycle, Efficiency. The business model is stable, well understood, and operates with well-defined processes. The third stage, Efficiency, concerns innovations and initiatives to improve the balance sheet of the business model. Improvements are centered around reducing costs, maximizing efficiency of existing assets, and tailoring the offering to ever more precisely meet the demand of the market.

The three stages presented represent distinct phases of the business model lifecycle, but there are always some efficiency activities occurring during the sustaining innovation phase and vice versa. These stages are important to understand and recognize when evaluating new business model innovation opportunities within an existing firm. Christensen, Bartman & Bever emphasize that when businesses evaluate innovation opportunities, it is critical to carefully evaluate the fit between the current business model lifecycle stage and the innovation being proposed. If the type of innovation does not align with the current stage of the business model lifecycle, developing the new idea in a distinct business unit rather than trying to take on opposing goals within the same organization tends to have better outcomes.

The articulation of the the three stages adds valuable dimension of analysis beyond what is provided by the Business Model Canvas: whereas the Business Model Canvas gives us a common vocabulary and conceptual understanding to describe a business model, the three stages described above provide a way to think about the needs of a business model at different stages in its development, and how certain or rigid each component in the Canvas may be at each stage. Through the lens of these business model stages, the important business model dimensions to focus on for a company like MR, which is developing new business models internally, would be those related to value proposition and resources.

2.1.3 Data Driven Business Models and relationship to hardware revenue based models

In developing new data-driven business models, firms are faced with important decisions about how to integrate the existing hardware-based revenue model with the new possibilities afforded by data-driven business models. As an example, at MR the hardware-based revenue model is the sale of transformer components and accessories to transformer OEMs. The new data-driven business models involve customers paying for access to data or access to analysis of data that helps them make decisions about operations, maintenance, repair, replacement, and more.

Kans and Ingwald (2016) propose a framework describing business model development in four levels. At Level One, the manufacturer's primary business model is to provide hardware to the market, and ongoing service and maintenance is the customer's responsibility. At Level Two, aftersales activities are included in the business, for example a fixed maintenance plan sold alongside the product. At Level Three, the business model shifts to a "use-oriented" model, combining product and services in order to focus on meeting the customer need for a certain level of utility from the product. At Level Four, the value proposition goes beyond the product and services themselves to focus more on the end-need of the customer (or their customer). Here the value proposition is more like a fully integrated black-box, with the service guarantee expressed in terms of the utility to the customer, and is enabled by intelligent systems to predict failures, trigger maintenance actions, and adapt to use [29].

MR's core OLTC business would be described as a Level One offering - the primary relationship is providing hardware to OEMs such as ABB, GE Grid, Wilson, MEPI and Siemens. MR has also expanded its offerings into a Level Two-type service offering, providing various kinds of support for in-service transformers, including lab work for transformer health analysis, and field service. However, one interesting aspect of the way MR interacts with customers is MR has direct relationships with both the OEMs to whom MR sells, and the end-customer who buy products from the OEMS. For example, for OLTCs in critical transformers, MR develops the specifications directly with the end-customer instead of the OEM. The OEM then receives the specification from their customer and orders from MR accordingly, but the design work and consultation with the end-customer has already occurred. This means MR has more insight into the needs of the end-user than if it were interacting only with the transformer OEMs. The new business models MR is considering would shift more toward Level Three or Four, but the exact configuration has not yet been determined. A Level Three or Four business model results in closer relationships with customers and more opportunities to position MR as a trusted, essential partner as opposed to an interchangeable supplier. Because business models based around using data generated either by customers or MR itself inherently result in more feedback between MR and the end-customer, they enable the business to more effectively pursue a business model which Kans and Ingwald would call Level Three or Four. These types of business models also represent a more integrated view of the relationship between MR and its customers, and with other parties in the industry. As the focus shifts toward meeting the end users' real needs, a more comprehensive picture of how to do that can emerge.

The relationship between the levels and dimensions of the business model are described in Figure 2.1.3. The framework is a continuum, and the optimal location for each firm is dependent on many factors specific to the industry, type of product, availability and feasibility of continuous monitoring, value to the customer of ongoing service, and others.

Gebauer et al. (2020) also provide a specific framework for understanding the paths for existing manufacturers in B2B environments to enhance revenue through digitalization. Their work indicates three growth paths for revenue enhancement. These are:

1. Commercializing digital solutions: introduction of a layer of digital solutions that meet customer needs, creates smooth user experiences and personalized touchpoints. The revenue impact comes from generating a new revenue stream through digital solutions. Traps in this pathway are focusing on technical solutions rather than customer needs, developing solutions without sufficient value

Dimension	Level 1	Level 2	Level 3	Level 4
Type of offering	Technology	Mainly product	Product and service	Bundled offerings
Density	Low	High	Dynamic	
Quality dimensions	Mainly product		Combination of product and service	
Business development strategy	Technology-driven	Customer-driven	Utility-driven	Dynamic
Strategic perspective	Inside-out		Outside-in	
View on profitability	Productivity	Customer satisfaction	Customer satisfaction / relationships	Relationships (more or less formal)
View on value creation	The own business in focus	Value chain	Value star/network	Ecology

Figure 2.1.3: Kans and Ingwald's Service Model Development Framework [29]

to the customer, and becoming either too standardized or too customized. [19]

2. Utilizing product connectivity: moving toward pay-for-usage or pay-for-performance models. By extending the relationship with the customer and product to provide ongoing monitoring and maintenance, new interactions with the service team, the manufacturer can secure spare parts revenue, and replace on-off field service revenue with ongoing revenue from the combination of digital and physical service. Traps along this pathway include attracting only highly-demanding and low-usage customers, assuming the new business model will only cannibalize existing service revenues, fuzzy accounting for cost savings. [19]

3. Establishing an IOT-based application business. If customers seek increased access to data, and the data available is actionable and useful, this is a powerful way to identify customers' key problems and provide expertise. Traps include over-reliance on a freemium revenue model, and failure to build trust with partners who could create a successful ecosystem. [19]

For MR, the first and third paths are more aligned with the way the company currently interacts with customers. The second path, moving toward pay-for-usage or pay-for-performance is more available to manufacturers selling directly to the end-user of equipment. For MR, the transformer OEMs are an intermediary, which makes this path less appealing and possible. The challenges discussed by Gebauer et al.

for the first and third paths are important cautions to keep in mind. In both cases, focusing on truly understanding customer needs, and the value the offering provides to a customer can help reduce the risk of falling into the traps described above.

2.2 Sources of Competitive Advantage

Collins and Montgomery argue that sustainable competitive advantage comes from resources that convey a strategic advantage. In their framework, resources (physical assets, intangible assets, or capabilities) are strategically valuable if they are difficult to copy or replicate, they depreciate slowly, the firm controls the value of the resource, they are difficult to substitute, and are superior to similar resources competitors might own or control [11].

If the data owned by a company meets those five criteria, it can be a powerful and valuable resource. In 2020, Hagiu and Wright published an article "When Data Creates Competitive Advantage"[22] discussing why data on its own is not necessarily a source of lasting competitive advantage. For business models relying on data-enabled learning, the important characteristics of data that create lasting competitive advantage are: the data creates significant additional value over the standalone offering, the marginal value of data-enabled learning takes a long time to drop off, user data has long-term rather than fleeting relevance, is not easily copied, purchased or reverse engineered, and leads to product improvements that cannot be imitated without the data. In addition, data is more valuable and more likely to lead to lasting competitive advantage when one user's data can improve the product for all users and learnings from the data can be incorporated into the product during the lifecycle of a user [22]. While data is often valuable, it is important for businesses to clearly understand what kind of value it represents, and to be clear-eyed about whether that value is short-lived, or can lead to a lasting competitive advantage in the industry.

Incumbents' existing, privileged access to resources, knowledge and experience is a reason Swaminathan and Meffert argue incumbents have better chances of succeeding at digital innovation in their industries than startups or outsiders. Established companies have valuable, relevant assets such as deep technical knowledge, customer relationships, and a trusted brand [55]. While these assets are a competitive advantage, there are also challenges, as incumbents do not necessarily have the capabilities in place to capitalize on their privileged position. See Section 2.4 for a more detailed discussion of the organizational factors affecting business model development in existing organizations. This is precisely the challenge MR faces - the company has existing and potential access to valuable data that can be used to provide value to customers, but does not have a clear sense of how to develop those business models most effectively, what kind of business model best leverages the data available to create value and lasting competitive advantage, and which ones are most important to pursue first.

2.3 Value of Data

Data on their own are just pieces of information, encoded for communication. However, data enables higher-level processing and synthesis of information, to provide insight, and decision-making assistance. Willems (2020) describes "Five Worlds" of analytics occurring in sequential order (see also Figure 2.3.4. These are:

1. the data world, where encoded bits and bytes relevant to the problem at hand are gathered
2. the information world, where data is provided with meaning and context
3. the knowledge world, where value can be extracted from information
4. the wisdom world, where knowledge can be communicated to others
5. the enlightenment world, where we can decide the right problems to work on

Willems' framework informs discussions around the types of value propositions to provide customers in new business models. The higher the "world" in Willems' framework, the more valuable the output. As an example: in the information world, operational data about a transformer could tell the operator the current status, the

Figure 2.3.4: The five worlds of data analytics [65]

internal and environmental temperature over the last week, number of times the tap changer has moved, and current input and output voltages of a transformer. At the knowledge level, a data product might be able to provide an estimate of the transformer's overall health and raise flags if data indicate an adverse event may be likely. Moving toward the wisdom and enlightenment worlds, the product would instead ask what are the decisions the customer has to make based on this information and knowledge, and how can we present information and support (or make) those decisions most effectively. Figuring out "the right problems to work on" requires a deep understanding of both what can be learned from the data available, and what the real needs of the user are. MR is fortunate to already have close working relationships with many of the end users, due to the way tap changer requirements get specified. This presents an advantage over newcomers to the industry who would be starting from square one, as long as MR uses those relationships to continue to learn and understand how to turn data into wisdom.

2.3.1 Uses of data in business models

The frameworks found in the literature describe many ways of conceptualizing the relationship of data to business models. Hartmann et al. (2014) provide a taxonomy of data-driven business models in startups that fits in a matrix of key activities vs. key data sources. The key activities are: aggregation, analytics, and data generation. Key data sources are freely available, customer provided, and tracked & generated

[23]. Seiberth & Gruendinger (2018) provide a data-driven business model framework with four dimensions: nature of the data, data source, typical channel model, and generated value added [49]. See Figure 2.3.5 for an illustration of the dimensions. The report from BVDW Research was written in the context of automobile OEMs but the framework for classifying type and source of data is relevant to many incumbent companies in B2B manufacturing environments. The types of business models available to a particular company will depend on the types and sources of data that can be leveraged, as well as how those relate to the channels through which data is made available for customers to use. It is a useful example to think through how one can think about the sources of data available in an industry and the types of analysis, insights, and services those data enable. For MR, the vertical axis could instead be thought of as: internal data (specifications, testing results, material information, etc.), asset level data (transformer sensor data, inspection results, data from assets in service) and grid-level data. The horizontal axis would stay the same.

2.4 Business Model Innovation

Much of the writing in the business literature focuses on the need for customer-driven innovation as opposed to developing products and services based on what the technology can do. That is to say, businesses do a "job" for the customer, and it is important to keep the focus on the value proposition to the customer, rather than on what the technology can do on its own [46]. Thales Teixeira argues that in over 20 industries, the biggest changes were not due to new technologies but rather driven by customer needs. Customer demands shift over time and the available technology accelerates the processes but does not initiate it - customer need is the core driver of change [57]. As opposed to an end in and of itself, technology as a tool, where it is critical to know what problem you are trying to solve before applying it [57]. Shifting from a product or technology-driven development process to a customer-centric development process represents a fundamental shift in culture and approach for a company. While MR has close relationships with end-customers, there is also a strong internal culture

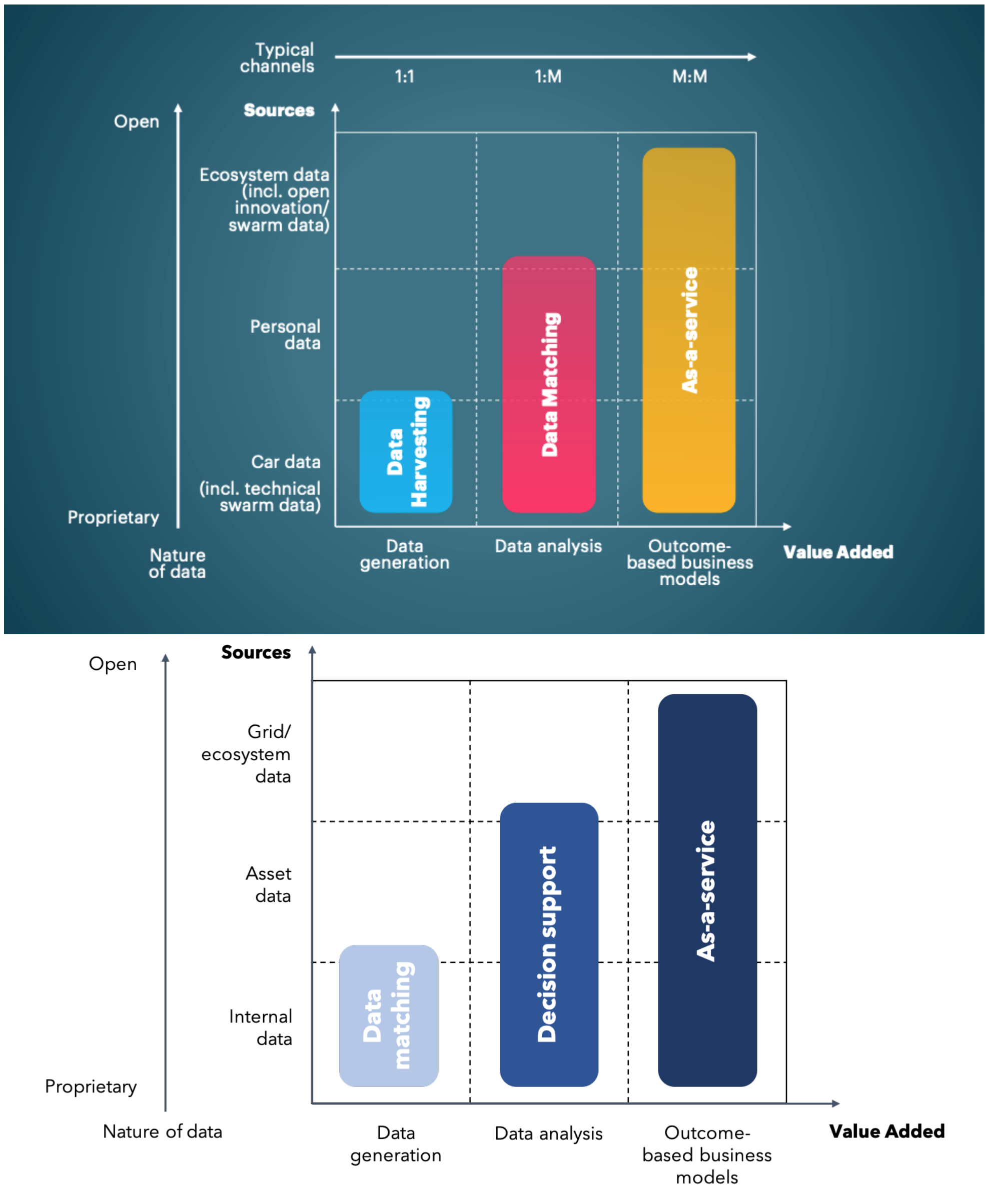

Figure 2.3.5: Three potential data-driven business models for automobile OEMs in the framework from BVDW & Accenture [49] and a proposed translation of the framework for MR

around technical prowess and superiority. MR perceives itself to be knowledgeable, technically excellent, and a leading source of technical development. These are valuable qualities, but particularly when the company is pursuing new business model development, listening closely to the customer and understanding their needs, *then* building products to meet them, is critical according to Teixeira.

2.4.1 Impact of digitalization on industry

In considering the types of data-driven business models MR could pursue, understanding how we expect digititalization to effect the industry is an important part of the context in which those potential models get evaluated and subsequently developed. The impact of digitalization on industries, that is to say the degree and extent of change to revenue models, value capture, and the standard way of doing business in an industry depends on many factors. One important dimension is the extent to which the primary "job" done by companies can be replaced entirely, partially, or not at all, by digital technology. For example, there have been wide-reaching and drastic changes in the print and media industries because digital technology allows us to transmit the same information in new ways. Those new ways do not require the old physical forms (newsprint, books, film reels). The energy industry, on the other hand, will be significantly influenced by digital technology but we cannot replace the need for hardware to generate, transmit and regulate energy flows around the world. While digital and data-driven business models will augment and impact the energy industry, they do not represent a full-on replacement of existing technology now. They could however replace auxiliary systems and change the current "way of doing things" by providing new capabilities and insight, such as visibility into the status of those physical assets.

2.4.2 Economic appeal of digital business models

Digital and data-driven business models provide an opportunity to pursue stable, recurring revenue with lower capital expenditure than traditional manufacturing. When they are successfully implemented, they can reduce costs while providing higher levels of service to customers, delivering more value, and generating higher turnover than hardware sales alone. For all these reasons, in addition to the perceived danger of getting left behind as industry peers adapt to new technologies, data-driven business models represent an appealing opportunity for B2B manufacturers - if they can be implemented successfully.

In "Platform Revolution" (2017) Parker et al. argue that platforms, enabled by data and digital technology outperform pipeline businesses (those focused on delivering a product in a linear manner from raw material to customer) for four primary reasons. Platforms, and data-enabled business models scale more efficiently, unlock new sources of value creation and supply, they use data to create virtuous feedback loops, and users generate more value through network effects [40].

2.4.3 Organizational factors

Culture also has an important impact on the ability of a group to generate, test, and develop new ideas. One framework for driving cultural change is provided by the Katzenbach Center.

According to the Katzenbach Center, a group specializing in organizational culture, based on the work of Jon Katzenbach, the markers of a "Digital Culture" are

- Customer centric
- Lean/agile
- Innovative, willing to take risks
- Results oriented, can-do attitude, with a single minded focus on delivery and execution
- Collaborative and energized, open to building a network of external partners [30]

Culture is difficult, but not impossible, to change. Katzenbach's book, "The Critical Few" describes an approach to shifting a company's culture. The approach focuses on identifying a "Critical Few" behaviors already existing in the culture, and can be used to emphasize a company's cultural strengths. Katzenbach focuses on behaviors because behavior changes faster than mindsets, and it is easier to drive, observe, and track changes in behavior than in mindset. "It is easier to act your way into a new mindset than think your way into a new set of actions"[30].

The method Katzenbach describes has four steps. First, identify the company's digital strategy. Second, leaders must clearly understand the current culture: what are the key traits that define the culture - "how things are done around here". What are strengths that stem from those traits, and what are challenges? Based on those strengths and challenges, then identify a "Critical Few" behaviors that already exist in the culture and can be leveraged to enhance the strengths and address the challenges present in the current culture. Ideally these behaviors are already exhibited within the organization, and leader should focus on just a few - less than five. Additionally, they should be positive (useful rather than forceful) and mutually reinforcing. Once they are identified, leaders work to embed and encourage the behaviors through both formal and informal enablers [30]. Katzenbach's perspective on culture emphasizes it is not what you say, but rather what you *do* that influences culture in an organization. For MR, this means that if there is a desire to have a more innovative culture, that desire needs to be backed up by consistent behaviors, originating from high up in the organization, that model and encourage the kinds of *behaviours* MR wants to see in order to be more innovative. The Digital Ventures group within MR has embraced many behaviors associated with innovative, digital teams - Agile framework for managing work[1], regular brainstorming sessions, an open and collaborative work environment, but the way other parts of the company interact with Digital Ventures is still quite traditional.

For MR, the prevailing German culture also provides a challenge to shifting toward a more "Digital Culture". MR provides international interns and new employee with a "Living and Working in Germany" presentation and workshop where employees

[1]Digital Ventures uses the Agile framework of a two week sprint, planning work on a recurring two week cycle, reviewing what was accomplished, and then deciding which user needs to tackle next.

have the chance to discuss differences between their native cultures and the culture both in Germany more broadly and at MR. The presentation provides an overview of the cultural dimensions, and where Germany and German work culture fall along the descriptors. In general terms, on the cultural dimension of time, Germany falls squarely in the monochromatic end of the spectrum [38], meaning the norm is to do one thing at a time, and people prefer to make (and keep) plans relatively far in the future. Last minute planning and changes of plan are not generally well-regarded. This can be at odds with the cultural ideals of agility and willingness to take risks presented by Katzenbach for Digital cultures. Other dimensions of German work culture that are important to recognize and acknowledge during any effort to affect the culture of an organization are a tendency to be long term oriented, task oriented, individualistic, and have a strong separation of work and private life [38]. These characteristics do not preclude innovation, they are simply important to identify and worth with rather than against.

While Katzenbach provides a roadmap for cultural changes in large organizations, many practitioners and academics point to the difference in culture between established, successful organizations and the culture necessary for new business model development and innovation as a stumbling block for many organizations wanting to pursue new data driven and digital business models. In "The Startup Way" (2017), Ries argues the better an organization is at managing the current, stable business model, the harder it is to incubate a new business model. This dynamic occurs because managers of the existing business are excellent at removing distractions, focusing on the key drivers of success for the business, and eliminating wasteful effort. The activities necessary to successfully generate a new business model are different from that paradigm, and the more efficient an organization is at removing distractions, staying on the correct path and focusing on the mission at hand, the harder it is for a new business to grow within such an environment [46]. Recognizing the challenge is key to being able to address it. As mentioned previously, it is important that efforts to change culture are reflected high up in the organization, not just in the teams doing the day to day work.

2.4.4 Governance factors

In broad terms, there is agreement that when building a new digital business, it is counterproductive to use the same performance metrics as the mature core business. Running a startup is fundamentally different from running an existing business. For an existing business, the conditions for success are well understood. In a startup environment, there is by nature a huge amount of uncertainty. Particularly in the early stages of business model development and business building, Riess (2017) claims standard corporate accounting is almost incapable of distinguishing between a startup, initiative, or new business model that has done tremendous amounts of learning and is on the path to real growth and development, and an initiative that has spent its budget, got no results, and not learned anything. This can lead to decisions about funding, continuing projects, etc, being made on politics and thin evidence instead of a clear, shared understanding of the progress made, the expected final state of the business, and what that means financially [46]. Speer's The High Velocity Edge (2009) provides several examples of how organizations which create an environment where organizational learning is the highest priority, perform better through uncertainty and change [54]. The question is then, is there a rigorous way to quantify and track learning in a way that helps everyone involved make better decisions about developing the new business model? Reiss has a proposal, "Innovation Accounting".

In Reiss' definition, Innovation Accounting is "a way of evaluating progress when all typical measures of success (revenue, ROI, market share, customers) are essentially zero [46]. There are three levels of detail in this framework, and each organization must figure out which level of detail serves them best. The biggest goal is to track metrics that are leading indicators of whether the business model is headed in the right direction, and provide a common framework and vocabulary within the organization to negotiate resource use. Riess advocates for a system of governance for new business models where expectations for what kind of learning should be happening are clear, hypotheses are articulated and tested in a rigorous manner, and the assumptions that need to be true in order for the business to be viable are tested as soon as possible

[46]. These kinds of clear expectations are critical to create an environment where individuals are incentivized to figure out if and how a business model can work as fast as possible instead of needing to protect their reputation, or position within the organization by avoiding the appearance of "failure". Particularly in organizations, such as MR, which have clear processes expected to work every time for other kinds of initiatives, having clear expectations and commitment to gaining more information instead of showing "success" or "progress" is a critical component to dealing with the uncertainty coming with pursuing a business model new to the organization and often also the industry more broadly.

Chapter 3

Approach and Framework

Investigation of successful data-driven business models' characteristics and the manner of their development presents challenges to quantitative analysis. First, as shown in 2.1 there are several different frameworks provided in the literature to describe business models, and the field has not converged on a common understanding of how to describe business model characteristics in a way that lends itself to quantitative analysis. Second, detailed financial performance data for digital business models is typically not publicly available, particularly for data-driven business models developed by incumbents. For publicly traded companies, information about investment in and revenues from digital business model development initiatives are not consistently disclosed, often rolled up within larger segment financials. Many other incumbents are privately held, and therefore do not report detailed financials.

However, there are insights and learnings available from analysis of successful and unsuccessful attempts to introduce data-driven business models in incumbent B2B companies. Tools available for this type of investigation include interviews, case studies, and review of public materials relating to the introduction of new business models over the last two decades. Inclusion of unsuccessful examples is critical to reducing survivorship bias, the tendency to tell only the successful stories and draw incomplete or incorrect patterns from the biased sample [10].

Review of the literature and existing writing on business model development also clearly indicates decisions about the technology used and the business model that technology is used within are linked together. The technology is a resource leveraged to deliver a certain value proposition to the customer. In order to develop a successful business model, these decisions should be made with mutual understanding - what are the capabilities of the technology both current and potential, and what are the needs the business model is trying to address, what capabilities and resources are needed to deliver that value proposition. Does it make sense to develop said technology internally, or should partners or other entities in the ecosystem take on that role? For MR, the key questions on the technology side are: what data is currently available? how does MR generate and capture useful data? how can MR add value to the data, and then sustainably deliver and capture value through a suitable business model?

3.1 Methodology

Given both the lack of consistent quantitative data and the challenge of describing business models in a simple, comprehensive and consistent framework, this project focuses on a comparative analysis using case studies and interviews. Case studies were sourced using the following criteria:

- The company introduced a data-driven business model in a B2B context. A data-driven business model is a business model that uses data, either internally generated, or externally sourced, as a primary way of creating value.

- Sufficient information could be found, either through press releases, company documents, interviews, or other case studies published about the effort in order to describe the business model (revenue model, value proposition, key resources and activities, partnerships, if applicable, and how the business unit was structured) as well as information about the outcome of the initiative.

- Both successful and unsuccessful examples were sought in order to provide a full perspective and avoid confirmation and survivorship biases.

- A range of sizes of company was sought, with an effort to ensure sufficient examples at small to medium-sized companies, for example other German enterprises.

> The types of resources available to a company like MR is significantly different than at large industrials which have order of magnitude larger revenues.

Interviews were conducted with individuals in leadership positions at companies that have previously or are currently developing data-driven business models. Interview participants include the managing director of a new Industrial IoT Platform business developed by a multinational industrial conglomerate, former CFO of a major tech company and current venture capital investor, former CEO of a payment services business operating as a subsidiary of a major airline, and SVP of Sales and Marketing at a mid-size construction services firm in the process of adding digital services. See Appendix A for interview questions.

Based on the literature review, critical dimensions of the business model structure were selected. Value proposition, revenue model, key resources, and partnerships are particularly relevant to development of data-driven business models, and are the sites of critical decision-making. Thus these categories are selected as sites of comparison for the business models identified in case studies. For each dimension, the case studies and MR's current data-driven business models are compared, with similarities and differences noted.

Interview results also point to critical components of the business model development process itself. These factors are relevant to the process of developing a new business model, rather than the internal structure of the business model. When a business model is developed within an incumbent, the way in which that process is approached and governed has significant impact on outcomes. These factors are also compared across interviews, and across case studies for which relevant details are available.

Using the similarities and differences found between case studies, interviews, and MR's current state, a framework for developing a data-driven business model strategy is proposed, with the implications for MR specifically discussed as well.

In order to both understand the existing product development processes and to consider ways to increase availability of data for the data-driven business models under consideration, this project used existing product architecture development processes at MR to specify a recommended architecture for a sensor communication interface.

3.2 Framework

Osterwalder & Pignot's Business Model Canvas provides a framework with nine dimensions. Of those dimensions, there are four particularly relevant to developing new data-driven business models from within an incumbent:

- Value proposition: The promise of value to be delivered to the customer. What kind of product or service can be provided using the data available, and what value does that have for the customer.

- Revenue model: how the business model generates revenue, the pricing model, structure of payments, and relationship to other sources of revenue for the firm.

- Resources & capabilities: which resources are available to the firm, which are necessary for the new business model, and which can provide competitive advantages over existing or potential competitors?

- Ecosystem & partners: for resources and capabilities the firm does not currently possess, which partners and other entities in the surrounding ecosystem exist can provide those resources and capabilities? Is the new business model fitting into an existing ecosystem or defining a new one for the industry?

Successful development of a new business model is significantly influenced by the process and environment in which that model is initiated. For stable, successful, incumbent businesses, there is often a strong preexisting culture and set of processes and norms that do not necessarily align with the best practices for developing new business models [46]. The items discussed in this section are, more specifically, the process of developing, governance of, and culture of the fledgling business model. Businesses make many decisions about how to manage the development of a new business model, how to situate it within or outside the existing business, and how

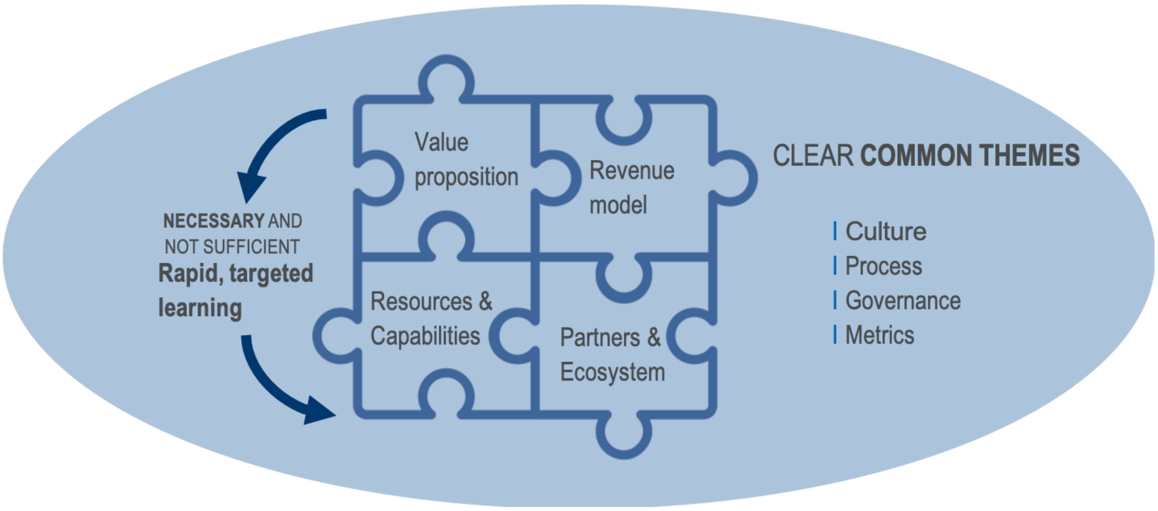

Figure 3.2.1: Framework to approach data-driven business model development

to evaluate progress. By comparing the actions and outcomes of other firms' data-driven business model development initiatives, we hope to identify common factors for success and the source of challenges.

Figure 3.2.1 illustrates the relationship between these components. The four business model dimensions are mutually dependent and intertwined: decisions made along these dimensions need to be compatible with one another. These dimensions are developed through rapid, targeted learning. The necessary, iterative learning is supported by the culture, processes, governance, and metrics used to deal with the developing business model.

The hypothesis we investigate is that analysis of case studies and interviews can provide guidance for key dimensions of successful business model development, and points to a framework for developing a data-driven business model strategy within a B2B, incumbent manufacturer, and the adoption of a lightweight, secure, Ethernet-based interface would help MR both meet customers needs more effectively and generate a richer set of valuable data for use in the data-driven business models under development.

Chapter 4

Extending possibilities for connected hardware

The business models discussed so far are all predicated on the availability of various kinds of data about transformers and other assets. The type, quantity, latency, and availability of data is dependent on the connected hardware used to collect that data. Decisions made about the types of sensors and communication interfaces to develop are tied together with decisions about the kinds of business models a company could, and would like to develop.

The portfolio of products offered by the Automation division can be divided into three categories: conventional sensors, standalone intelligent sensors, and integrated intelligent sensors. Conventional sensors provide analog or simple digital outputs, directly measuring a physical characteristic. This category includes temperature and pressure sensors with analog visual indicators on the sensor and outputs such as 4-20ma, 0-5VDC or binary relays. Standalone intelligent sensors provide more detailed and in depth analysis of multiple sensors; for example a Dissolved Gas Analysis (DGA) sensor that uses temperature, and multiple gas sensors to provide not only the raw readings and individual physical property measurements, but also to do on-site calculation to provide higher level analysis, such as a Duval triangle diagram and alerts based on dissolved gas concentrations that may indicate transformer faults. The standalone intelligent sensors typically have a digital screen that provides on-site access to measurements, and a communication interface that allows connection to an external control and monitoring system. The integrated intelligent sensors have the same functionality as the standalone sensors but are intended to integrate directly with ETOS[1], and typically do not have extensive visualization built into the sensor unit itself as that is handled by ETOS.

Figure 4 lays out a general industrial automation architecture. In this architecture, the conventional sensors exist only in Level 0, while the intelligent sensors span Level 0 and Level 1. The standalone intelligent sensors may fall into Level 0/1/2, combining the sensor function with an HMI (Human-Machine Interface) and a direct interface to the SCADA (Supervisory Control and Data Acquisition) system or other supervisory network. As we consider the options to augment the volume of data available, to increase the number of sources of data connected, to reduce the latency between data collection and to produce knowledge based on that data, there are multiple paths available. One path is to increase the number of connected sensors. Another is to reduce the barriers and complexity of transmitting data from the sensor level to higher levels in the hierarchy. If communicating more data does not incur additional cost (i.e. cabling costs for additional analog outputs) it is easier to collect and use. Digital systems are appealing for their ability to communicate multiple kinds of information over the same physical link. This project does not address where the most effective location to analyse the data is; that is to say we do not address whether a centralized or distributed analysis system is most ideal, but rather evaluates options to increase the number of available data sources and increase the resolution of data available to drive data-driven business models.

4.1 Review of relevant technologies

There are a range of technologies available for industrial communication interfaces. We briefly review the existing standards and contextualize the considerations neces-

[1]MR's open transformer operating system, housed in a control cabinet at the transformer, described in Section 1.3.1

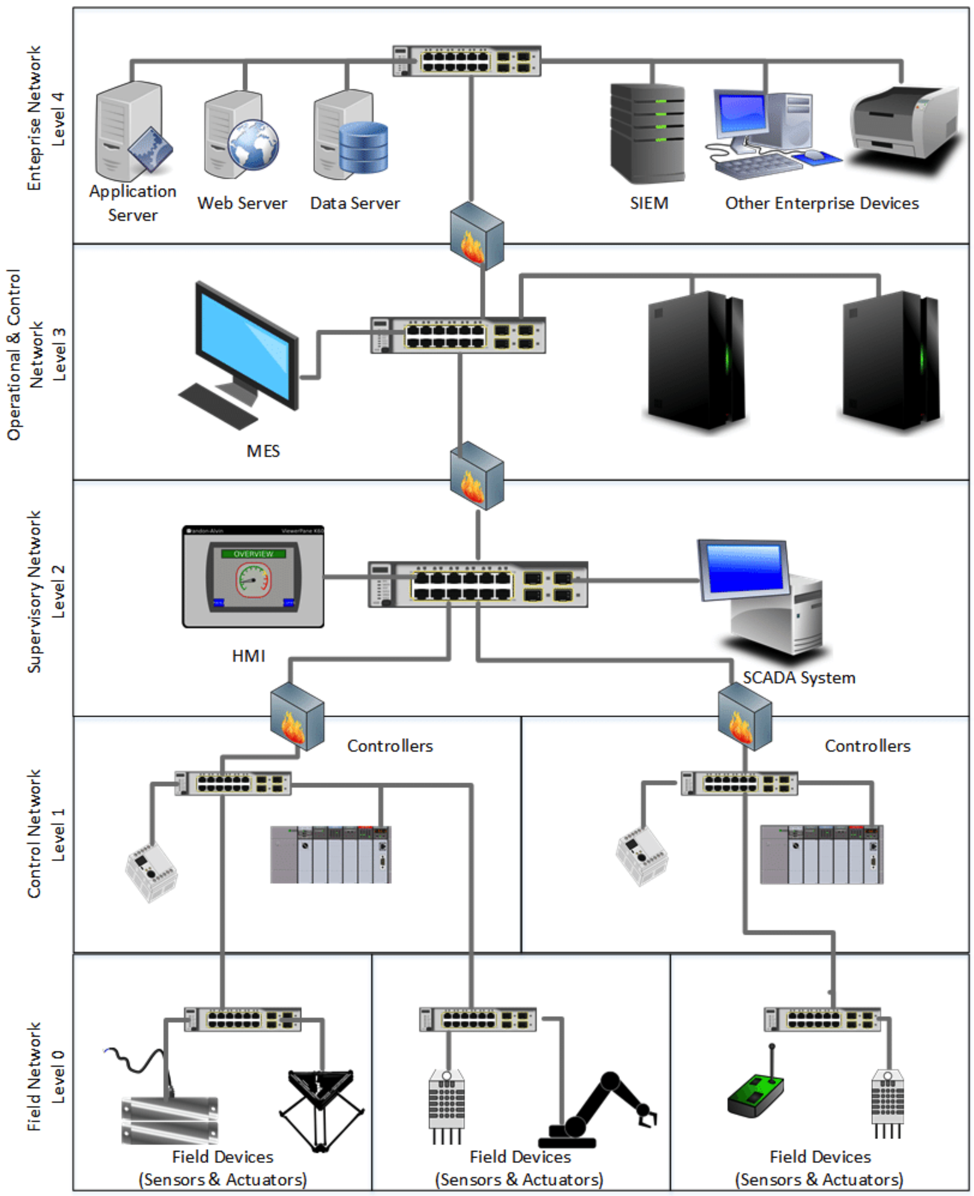

Figure 4.0.1: A general model of industrial automation architecture. The protocols used at Level 0 and Level 1 differ from those used at higher levels [62]

sary in determining a communication interface architecture.

The OSI model in Figure 4.1 provides a way to distinguish between various layers of the communication architecture. Layer 1, the physical layer, describes the physical medium and parameters used for transmission. This includes specifications for the pins, layouts, voltages, performance parameters and more. Layer 2, the data link layer, is the level at which data is sent from one device to another. Layer 3 (network) describes the specifications for the layer at which packets are routed to different networks. Layer 4 is the transport layer, ensuring data is transported correctly, coordinating data rates and verifying error-free transmission. The interfaces and protocols discussed here are relevant to Levels 1-4. Level 1 determines the physical characteristics of the interface with the sensor - including which types of connectors and cables are necessary. Some Level 2-4 protocols are compatible with multiple physical layers. For example, the MODBUS communication protocol can be used with an RS485 physical layer, or over an Ethernet physical layer, with minor adjustments to the protocol.

4.1.1 Physical Layer

First, we provide a summary of the physical layers implemented for communication interfaces within MR's current sensor portfolio, and those considered as part of this project. Second, we summarize the higher level protocols compatible with those physical layers and discuss the corresponding characteristics, benefits, and detractors.

Table 4.1.1 describes the major physical layers relevant to this project. We do not touch on other protocols such as HART or CAN; while they are used in industrial settings they are not common to the electrical and power generation industries.

4.1.2 Protocols

The physical layer enables the use of a variety of protocols on top of that layer. For example, both DNP3 and MODBUS can run on an RS485 physical layer. Therefore, both the physical characteristics of the physical layer, and the protocols it enables

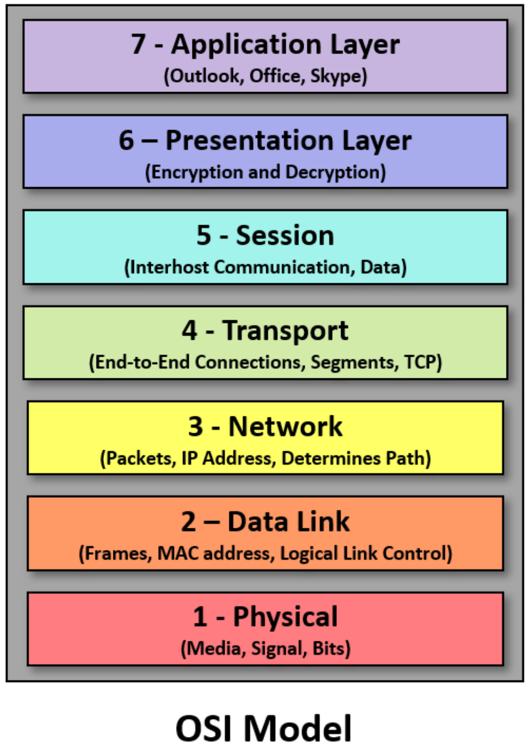

Figure 4.1.2: The Open Systems Interconnection (OSI) Model provides a 7-layer framework to describe networks [1]

	Description	Advantages	Disadvantages
Analog	Output of the measurement in the form of a current or voltage signal Common forms are: 4-20mA current loop, 0-5VDC, relays for binary outputs	Analog outputs are simple, relatively easy to troubleshoot, and are secure	One physical layer can only convey one signal Each parameter measured requires unique conductors to convey the signal
RS-485	A broadly used standard for serial communications in industrial devices. Uses single twisted pair cable, and can support data rates up to 10 MBit/s over short distances. At 50 m, data rate shouldn't exceed 2 MBit/s Typically use terminal block connections.	Multiple units can be "daisy chained" together, extending the breadth of the network, and a daisy chain, or line topology has the lowest impact on signal integrity. Up to 32 transmitter-receiver pairs can be linked on a line network topology. Single twisted pair	RS485 supports single-duplex protocols, meaning data can be transmitted in only one direction at a time. Limited speed Transmission of data between field level and databases or systems used for additional analysis requires conversion to different protocols
Ethernet (4-twisted pair)	Four-twisted pair, data rates up to 10GBit/s over 100m, typical connectors are RJ45 plugs and jacks (for reference this is a standard Ethernet jack). Star topology most common but many possible	Duplex communication Rapid, efficient.	Ethernet at the field level can introduce security risk if not carefully managed More conductors needed
Single Twisted Pair Ethernet	New standard for industrial and automotive Ethernet. Uses a single twisted pair. Terminal or moulded connector terminations possible. Standard connector shape announced during 2020.	Duplex communication Provides possibility of powering device over data lines. Single twisted pair, reduced cable need relative to existing Ethernet standards. Allows for use of single consistent protocol throughout network - field level devices can interface more directly with the rest of the network	Ethernet at the field level can introduce security risk if not carefully managed New standard, limited number of suppliers of key components Limited penetration into market, limited familiarity for customers

Table 4.1.1: Summary of physical layers and their characteristics [53] [20]

must be taken into consideration. There are a wide variety of protocols available, for the purposes of this project we consider only wired protocols that have already been implemented in industrial settings. This decision is taken primarily because reliability and predictability are very important qualities for electrical equipment, and the industry is slow to adopt new standards. Protocols developed with the intent for use in industrial applications have the most compatible characteristics with the requirements of both MR and its customers.

Modbus

Modbus is a data communication protocol initially published by Modicon in 1979 for use with their programmable logic controllers. Modbus is a client-server protocol, meaning the client polls the server for the current status of a predetermined set of bits and registers at a regular interval. Modbus RTU uses RS485, and there is an Ethernet-compatible version of the protocol called Modbus TCP. Modbus has a limited set of error codes. Auto-device recognition is not possible with Modbus, and configuration must be done at the time of installation.

Distributed Network Protocol 3 (DNP3)

Similarly to Modbus, DNP3 can use both the RS485 or Ethernet physical interfaces with slightly different versions of the protocol. DNP3 is primarily used in utilities such as electrical and water companies. The protocol is primarily used to link master control stations with remote terminal units (RTUs) or the the next layer, Intelligent Electronic Devices (IEDs). DNP3 describes the data structures used to store and communicate information in the system and also defines a set of events that can be triggered. It provides more real-time transmission possibility than Modbus, with event-oriented data reporting. Only data that has changed status since the last report gets transmitted. There is also a mechanism to set different priorities and polling rates for data using the Class 1, Class 2, and Class 3 designations.

Name	Standard	Speed (Mbit/s)	Pairs Required	Cable	Max distance (m)	Typical usage
10BASE-T1S	802.3cg-2019	10	1	?	15	Automotive, IoT, M2M
10BASE-T1L	802.3cg-2019	10	1	?	1000	Automotive, IoT, M2M
10BASE-T (legacy)	802.3i-19949CL14)	10	2	Cat 3	100	LAN
100BASE-TX	802.3u-1995	100	2	Cat 5	100	LAN
1000BASE-T1	802.3bp-2016	1000	1	Cat 6A	40	Automotive, IoT, M2M
2.5/5/10GBASE-T	802.3bz-2016/802.3an-2006	2500/5000/10000	4	Cat 5e/6/6A	100	LAN

Table 4.1.2: Summary of Ethernet standards and their characteristics

IEC61850

IEC61850 is an object-oriented protocol with a highly structured, standardized nomenclature. It is used in substation automation, and is an international standard defining protocols for electrical substations [26]. IEC61850 defines both client-server communications as well as multicast capabilities, wherein a device on the network can broadcast an event to multiple listeners on the network. These Generic Object Oriented Substation Event (GOOSE) messages provide 3-20ms latency depending on the specific requirements. As IEC61850 is highly structured, and therefore not very flexible.

Additional Ethernet-based protocols

Ethernet sends information to and from devices in frames that range from 64 to 1518 bytes [1]. There are multiple Ethernet standards, that require different physical layer components. Table 4.1.2 summarizes a subset of the Ethernet standards most relevant to this project. Cable Category refers to the quality and structure of the cable used to transfer data. In general terms, the higher the cable number, the more expensive. The final determination for the cable standard for 10BASE-T1S and -T1L have not been published as of July 2020. The maximum distance refers to the maximum cable length between switches at which the stated speed can be maintained.

Figure 4.1.3 illustrates the different physical layers needed for the Ethernet protocols mentioned. Standard Ethernet in a building uses four twisted pairs to deliver maximum speed and bandwidth, but for industrial sensors, the volume of data communicated from a single sensor can be handled by the Single Twisted Pair architecture.

There are many protocols under the "Industrial Ethernet" umbrella. Beyond Modbus, DNP3, and IEC61850, which use the Ethernet physical layer, there are a

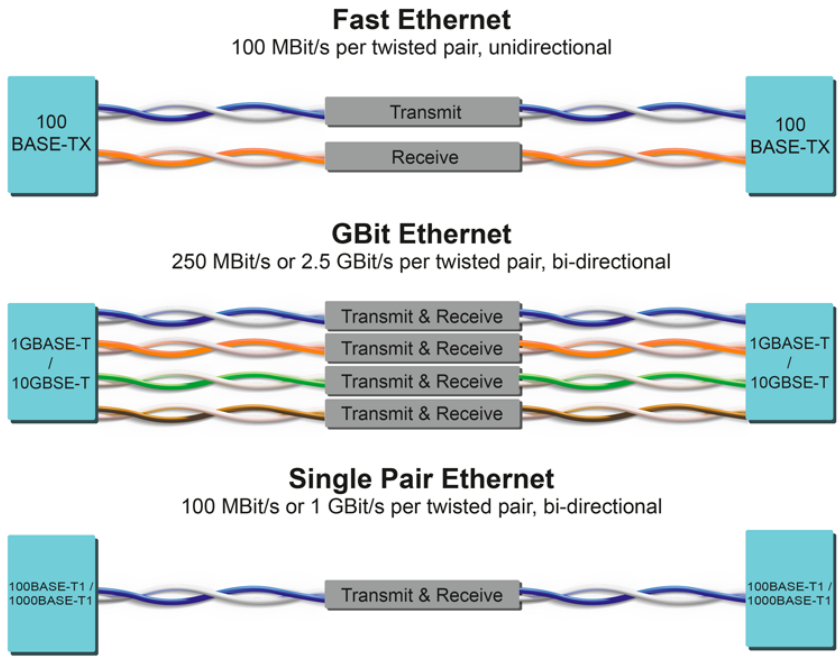

Figure 4.1.3: Single, two and four twisted pair Ethernet cable structures [15]

suite of industrial Ethernet protocols. These include:

- Profinet IO: Designed for collecting data from and controlling equipment in industrial systems, with a particular strength in delivering data under tight time constraints

- Ethernet/IP: classifies Ethernet nodes into predefined device types with specific behaviors. Enables modular approach, and can be less flexible. Requires a device definition.

- Ethernet Powerlink: Real-time industrial internet, developed to avoid unforeseen delays on regular Ethernet due to switching.

- MQTT: a lightweight protocol developed for connecting sensors. The architecture here is publish-subscribe. Sensors publish a set of datastreams, sending them to an MQTT broker. Clients can subscribe to some or all of those datastreams. The broker then intermediates the relationship. The protocol provides a framework for verifying whether packets are correctly delivered, but it is not required. The Digital Ventures team uses MQTT for the cloud-based asset management system currently under development, TESSA.

4.2 Considerations for Interface Moving Forward

Current sensor architectures, particularly for lower-cost and less complex sensors rely on two-wire, daisy chain communication interfaces, such as 4-20mA loops. As MR, and their customers seek to extract more data from existing equipment in order to better supervise, maintain, and operate them, there is a need to provide a cost-effective sensor architecture to enable more extensive data extraction than the analog system in place in many cases. We hypothesize that the adoption of a lightweight, secure, Ethernet-based interface would help MR both meet customers needs more effectively and generate a richer set of valuable data for use in the data-driven business models under development.

4.2.1 Customer expectations and requirements

In order to evaluate options for the possibility of a lower-cost Ethernet interface, first a Kano-model of the customer expectations and product functionality was generated, as shown in Figure 4.2.4.

Beyond customer requirements captured in the Kano model, internal requirements for data integrity and availability are considered as they also drive the types of interfaces that would be most useful to the business in the future. In order to evaluate different potential protocols and interfaces, the requirements were determined by consultation with subject matter experts within the company, and mapped out relative to the other parts of the sensor architecture under development. The qualities of each option were then evaluated against those criteria.

Table 4.2.3 shows a comparison of Ethernet-based application layer protocols that could be used with an Ethernet physical interface.

A summary of the findings is: Modbus is widely implemented and important for 3rd party compatibility, but does not have the possibility of streaming data, as it

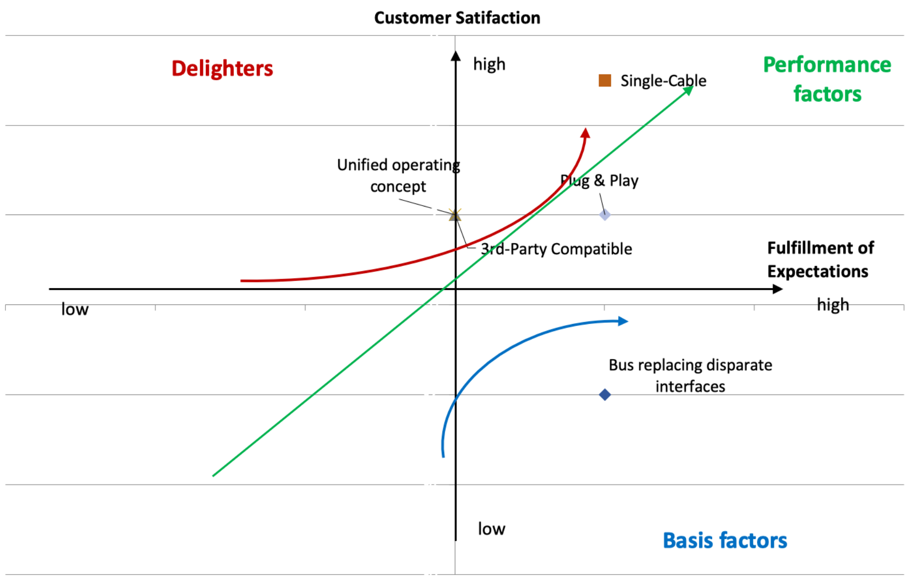

Figure 4.2.4: Kano-model of customer expectations and product functionality.

Protocol	IEC61850	DNP3	MODBUS TCP	MQTT
Transport Layer	TCP/IP	TCP/IP	TCP/IP	TCP/IP
Data Types Supported	Extensive	Extensive	Limited	Extensive
Device property auto-detection	Yes	Yes	No	No
Device address auto-detection	Through Ethernet: DHCP			
Reporting Type	Both event-based and request-based reporting supported	Both event-based and request-based reporting supported	Poll	publish/subscribe brokered by MQTT broker
Multicast capability	Yes, GOOSE		No	Yes
Latency	GOOSE: 3-20ms depending on configuration	12ms protection 90s monitoring	Limited by rate of data requests and network environment	Depends on implementation, should be low.
Error recognition	Yes	Yes	Yes	Yes, depends on Quality of Service
Heartbeat implemented in protocol	Yes, through GOOSE	No	No	Yes
Security	IEC 62351-6	Secure authentication features included in protocol	Limited	not through MQTT but possible at higher levels
Configuration update possible?	Yes	Yes	Yes	Yes
Real-time capability	Yes	Yes	Not prepared for real-time data	

Table 4.2.3: Comparison of application layer protocols using Ethernet at the physical layer

is a polling-based protocol and lacks heartbeat functionality. DNP3 also requires the implementation of heartbeat functionality in the application layer. However, it possible to report new data points without polling, by changing the device configuration. MQTT is best suited to streaming data, with a lightweight protocol. In the TESSA/ETOS interface, MR has implemented similar data labelling to IEC61850 for the MQTT topics. IEC61850 offers excellent interoperability with 3rd party systems, heartbeat functionality and ability to stream data. If real-time transmission is a requirement, it is possible to implement in IEC61850 through GOOSE messaging and also in the integration with Profinet IO, which is a real-time capable Industrial Ethernet Protocol, already implemented on the target hardware system.

4.2.2 Costs

An Ethernet-enabled interface is only cost-effective for the desired application if it can meet, or come close to meeting, the existing cost structure for communication interfaces. As the top-end intelligent sensors already have an Ethernet interface available, the devices affected by this investigation are the mid-tier sensors, which have existing simple serial or analog outputs. The inclusion of the Ethernet-enabled interface would replace the existing communication interface. As Ethernet capability is an add-on feature to the sensors but not currently a strict requirement from the customer perspective, it is necessary to be sensitive to costs. For this analysis, the goal was to specify an interface that could be considered comparable to the existing standard. In order to evaluate various possibilities, the estimated costs for each architecture were determined and compared to one another. In order to determine costs, the following process was used:

1. Build a bill of materials (BOM) for each option
    (a) Connectors, cabling, PHY, microcontroller are identified
    (b) A standard set of additional components are included based on prior company work to specify communication interfaces

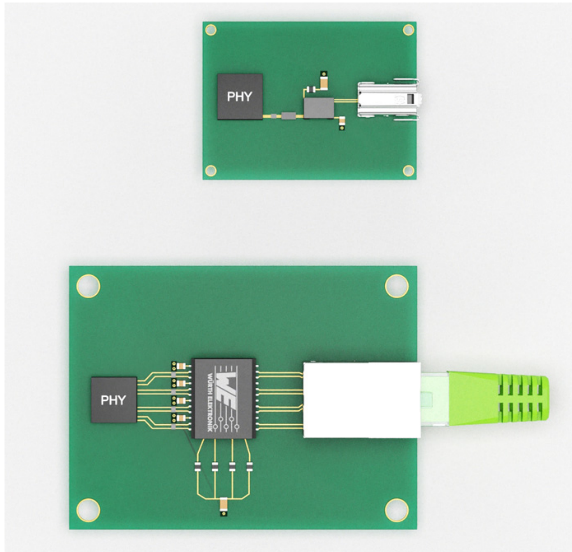

Figure 4.2.5: Relative size of Single Pair Ethernet and 4-Twisted Pair (1000Base-T, for example) Ethernet PCB footprints [15]

(c) Estimate size of PCB based on major component sizes, previous designs, and subject matter expert input

2. For components in BOM that have been previously quoted to MR from a supplier, use available cost

    (a) Cost per square cm for PCB: Single Pair Ethernet is expected to typically require 75% less PCB space than the standard RJ45 connector used for 2-and 4-Twisted Pair Ethernet standards[15].

    (b) Individual component costs

    (c) Cost of standard additional components estimated from previously quoted designs, three similar BOMs were identified and the average price of small components was used for all options

3. For components that did not have an internally available price, seek a quote from purchasing department

4. If quote was not available, estimate costs using a heuristic of 70% of public facing price list, based on consultation with subject matter experts

For each proposed interface, we generated expected component and cabling costs per connected sensor with one to five sensors included in the network. It was valuable to gain a perspective on the relative costs of connecting just one sensor compared to multiple sensors on a single asset. We find that based on the architecture of the interface, there can be significant per-sensor cost impacts as the number of sensors changes.

Cable costs represent a significant portion of overall system costs for industrial automation and monitoring networks. Single Pair Ethernet is appealing because the standard was developed with the aim of being able to re-use existing cabling, or at the very least, existing cable routing from 4-20ma loops, HART, or MODBUS, which all rely on a single twisted pair. This could reduce installation and retrofit costs significantly. For new installations, however, the advantage is that a single twisted pair cable uses 1/2 to 1/4 of the amount of copper as a two- or four-twisted-pair cable, significantly reducing raw material costs for the cable, and subsequently the per-meter cost of cable. With 1000s of meters of cable laid in larger sensor networks, these cost savings can be significant.

In Figure 4.2.6, we see that under the current conditions, Single Pair Ethernet, while promising from a cable cost perspective due to reduced cable requirements is, in 2020, still more expensive than the alternatives, particularly with only one or two sensors per interface. The cost is driven largely by the current price of Single-Pair-Ethernet compatible Ethernet switches. The technology is new to the market, with Single-Pair Ethernet compatible PHY and switches introduced during 2020. We expect that with time, the costs will reduce, particularly because the stated goal of the Single-Pair Ethernet standard is to provide Ethernet compatibility at a total system cost under 50% of the existing 1000 BASE-T1 Ethernet standard[20].

4.2.3 Risks

Any new interface must adequately balance risk and fulfillment of functional requirements. In tandem with the cost estimates, the options are evaluated with respect to the total risk profile, and the degree to which they meet the functional requirements.

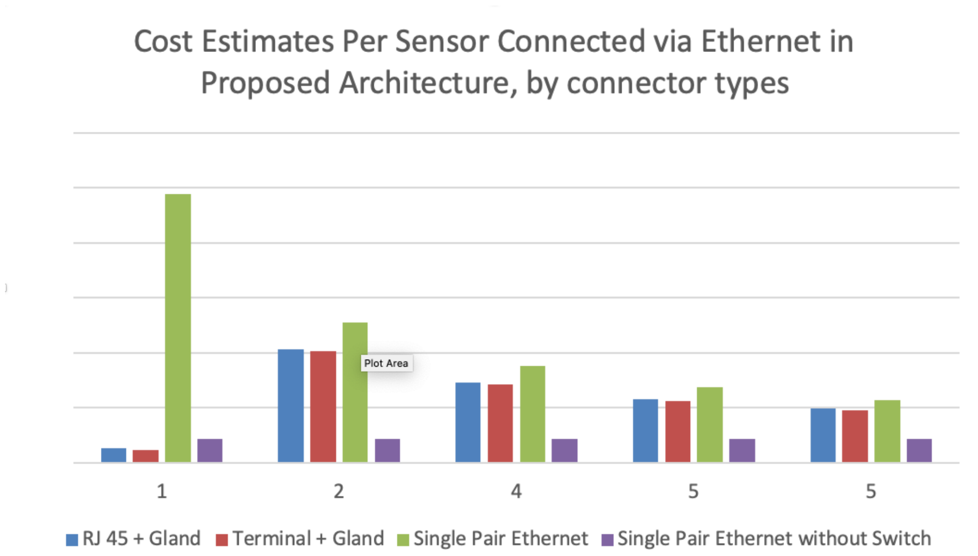

Figure 4.2.6: Estimate of relative cost of various connector systems

See Figure 4.2.7 for the risk vs functionality relationship, and Figure 4.2.8 for the assessment of complexity of Ethernet relative to the existing RS485 interface. All the options fall into acceptable portions of the diagram, however Single Pair Ethernet, while a promising technology is not yet well enough established to be a viable option. We do recommend that future work continues to evaluate the state of the technology. Once connected architectures are well standardized and integrated chips with SPE functionality are widely available this assessment will likely change dramatically.

4.3 Impact of Ethernet on data availability

For fulfillment of current and future needs, implementation of an Ethernet-based interface is important. Ethernet is capable of fulfilling the functionality of RS485, and additional functionality like Plug and Play, faster data rates, more flexibility in protocols used and more stringent security. In addition, as Ethernet becomes increasingly widely implemented within the energy industry, it is important for MR's sensors to also implement this interface. Single Pair Ethernet is a promising variant of Ethernet-based communication that would provide advantages in reducing cabling even further and providing power over data lines, but is not yet a mature standard.

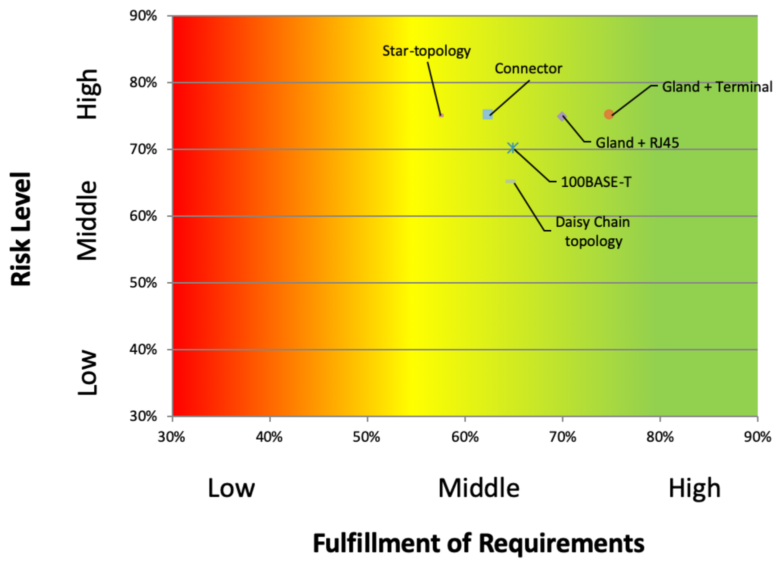

Figure 4.2.7: Total risk vs Degree of Functionality

	RS485	Ethernet
Installation	Mechanical Installation is simple, but communication requires configuration	Plug & Play allows less complex installation and confiuration/parametrization process.
Troubleshooting	Less self-reporting possible. Only Modbus rror codes available.	Ethernet-based protocols offer more error recognition and diagnostic functions for troubleshooting, automating some troubleshoting activity.
Plug&Play Functionality	Not possible to implement full plug & play functionality	Possible
Number of interfaces & cables	Can replace digital outputs & relays, reducing need for multiple interfaces and cables.	Extended functionality over Ethernet reduces need for addtional service interfaces, i.e. for configuration, firmware update, etc.
Number of mechanical parts	RS485 requires fewer components for daisy-chain implementation.	More components needed to enable Ethernet-based communication, particularly in daisy-chain topology

Figure 4.2.8: RS485 vs Ethernet Complexity

Chapter 5

Important Dimensions of Business Model Development Strategy

As discussed in Section 3.1, the following chapter provides a comparison of case studies and interviews across the dimensions in Section 3.2. The insights and conclusions drawn from these comparisons are discussed in Chapter 6. The case studies collected and interviews performed have many key points in common, but not every case or interview touches on every dimension the literature indicates is important to consider. Therefore, examples used in each section below vary based on where there is sufficient information available to discuss each dimension of the framework. After providing an overview of several case studies, the chapter is divided into a description of the cases and a discussion of the seven dimensions and common themes identified in 3.2.

5.1 Cases

The cases studied in this project were selected to provide perspectives from incumbent businesses that developed new digital and data-driven business models. The companies selected were intended to represent primarily industrial companies, manufacturing equipment, focused on B2B sales, that introduced new business models. Both successful and unsuccessful examples were sought. Below we provide an introduction to each of the case studies: the company background, a description of the data driven-business model developed, what is known about the development process internally, and the outcome to the extent information is available.

Kaeser Kompressoren SIGMA Air Utility

Kaeser Compressor is a German manufacturer of air compressors and vacuum products for industrial applications. Kaeser was founded in 1919 and has a worldwide network of branch offices and partners [58]. Kaeser is focused on innovation and has brought new product lines with innovative technology to market throughout its history. In 2001, Kaeser introduced the SIGMA AIR MANAGER [58], a computerized compressed air management system with high speed networking capability. The SIGMA AIR MANAGER provides full transparency into the operation of the compressed air station.

Through the following 17 years, Kaeser continued development of the SIGMA AIR MANAGER product, and increased the company's focus on developing Industry 4.0 solutions. In 2017, the SIGMA SMART AIR service package was launched at the Hannover Messe trade fair [27]. This package became the SIGMA SMART AIR business model: customers pay a fixed price for a contracted quantity of compressed air. When larger amounts are needed, additional air volume is billed at a fixed price. More broadly, the business model is: Kaeser analyzes the customer's compressed air needs and determines if they are an eligible candidate for the service. Kaeser designs, builds, and installs the compressed air system, and is responsible for ongoing monitoring, maintenance and service. For the customer, the value proposition is predictable costs, guaranteed uptime freeing personnel for other tasks, and a scalable system. Instead of paying for the equipment, customers pay for output. Kaeser conducted extensive analysis of data from the SIGMA AIR MANAGER products in use throughout the 2000's in order to determine an appropriate price point for the revenue model, and screens potential customers because the business model requires extended use of the hardware in order to be viable. The shift from an equipment purchase to a utility-like relationship is a significant change in the relationship to customers, and also required learning internally about how to sell the product and manage those ongoing relationships.

Rittal EPlan

Rittal is the world's leading system supplier for enclosures, power distribution solutions and IT infrastructure in mechanical and plant engineering as well as other industries. Rittal is owned by the Friedhelm Loh Group, and was founded in 1961 [48]. In 1984, Rittal founded EPLAN, a software and service provider for the electrical, automation, and mechatronic engineering fields. Initially distributed as a software package, EPLAN is now a platform solution providing design software solutions for machine and panel builders, that leverages digital twin models of the enclosures and machines to optimize panel design, layout and the engineering process. EPLAN alone is responsible for € 2.6 B in revenue in 2019. EPLAN was set up as a separate company under the Friedhelm Loh Group, and the software development was done in-house. This expertise has allowed EPLAN to continue to develop new features and capabilities over the decades, staying at the leading edge for the industry.

The EPLAN solutions are complementary to the core enclosure business, and facilitate design and implementation using Rittal's products [43]. In recent years, EPLAN has extended the platform capability to digital twin for in-service equipment, providing support and visibility into the equipment throughout the lifecycle [43]. A&E Engineering, a longtime Rittal customer that has begun using EPLAN in the last 5 years, says "what's changed within the past few years is the nature of our relationship. It has evolved from the tactical use of their products to a truly strategic partnership"[47]. EPLAN is considered a resounding success story, both due to the significant revenue it generates independently, and also because it increases the acquisition and retention of customers for Rittal and positions Rittal as a technological leader.

Airbus Skywise

Airbus is a European multinational aerospace company, that generated € 59 billion in revenue in 2017 [44]. Airbus products include a range of passenger aircraft, as well as helicopter, defense and space divisions. Airbus's commercial division designs and assembles aircraft, and also provides customer services such as training and maintenance. Airbus Commercial introduced the Skywise platform at the Paris Air Show in 2017 [44]. The platform enables carriers to analyse data for their in-service aircraft, in order to optimize fuel use, maintenance, and address operational issues and safety concerns.

The Skywise business model brings together data from a range of sources, both internally at Airbus, and from functional silos within which it exists at carriers. Customers (carriers) have access to their own data for analysis, and anonymized data from other fleets for benchmarking purposes. If airlines agree to share their anonymized data, they get access to the Skywise Core product free of charge. Beyond this core functionality, there are additional analytical products built by Airbus available for purchase. Skywise also leverages partners, who are subject matter experts that build specialized products on top of the Skywise architecture [51]. In 2018, Airbus extended the Skywise platform to include suppliers in order to address on-time delivery, quality, and reliability for components. One application of the platform for suppliers is to use in-service aircraft data in collaboration with Airbus in order to identify root causes for operational issues more rapidly[44].

In terms of resources and capabilities, Airbus relies on a partnership with Palantir to provide the backend for the Skywise platform [52]. Instead of finding a way to develop this expertise internally, Skywise looked outside to a provider that could provide secure and reliable infrastructure. We did not find documentation of the internal development process itself, so Skywise is used as an example of a successful implementation of a new, data-driven business model at an incumbent manufacturer selling large equipment. These dimensions are all relevant to MR's position. One key difference is that Airbus is the OEM, whereas MR is a supplier to OEMs in the industry.

LEGO Universe

LEGO Group is a privately held company, founded in 1932, based in Denmark. LEGO Group's flagship product is LEGO brand plastic bricks[59]. In October 2005, LEGO Group launched an initiative to develop a massively multiplayer online (MMO) game [63]. LEGO Group recognized they did not have the internal expertise to build an online video game, so they sought out a game developer as a partner, eventually working together with NetDevil, at the outset of the project a small, 9-person, game development company based in Boulder, CO [63]. LEGO Group's ambition for the project was to create the biggest MMO game in the world. The existing brand and the LEGO experience were very important to the company, and they wanted to ensure that the game experience lived up to the standards of the LEGO experience - high quality, safe for children, engaging, and aligned with other LEGO game and toy experiences. These standards led to stringent quality requirements, and conservative safety requirements to try protect children and remove any vulgar, offensive or dangerous content from an online platform geared at children [63]. The child safety aspect contributed to almost 30% of the cost and effort of development [63].

The project was the biggest project NetDevil had ever worked on. Throughout the project, the interface between LEGO Group and NetDevil was challenging, with LEGO simultaneously not having a wholly complete vision for the final product but also having very stringent quality requirements [63]. During development, NetDevil was bought by Gazillion, but late in the product development, due to delays, tensions with LEGO Group and other challenges, Gazillion decided to cancel development. LEGO then brought the team working on the game in-house to finalize the game development [63]. The tensions appear to have been the result of misaligned expectations around how game development works, LEGO Groups' product managers rigid expectations, and an unwillingness to adapt to new knowledge about the market [63].

LEGO Universe was launched as a subscription-based game, with a $15 per month subscription. In order to entice customers onto the game, a freemium model with two tiers was used. The tiers were: a free tier, with key limitations on gameplay, and the paid tier with full functionality [5]. Customers had to purchase the DVD in-store in order to access the game. This decision was the result of market research finding that customers really liked having a physical product.

The game launched in 2011, but 15 months later, by late January 2012, the game had been shut down. It had cost over $125 million, included over 450 stakeholders, and ran for less than two years. It represented one of LEGO Group's biggest investments in game development ever. Although LEGO Universe had over 2 million active accounts, it was not building enough revenue to justify continued operation [64] - a common pitfall of freemium models. On top of issues with the game itself, Minecraft entered the market in 2011 and playership there syrocketed. Minecraft had the MMO construction-concept segment of the market cornered and LEGO Universe recognized the writing on the wall[64]. The game elicited strong positive responses from test audiences and players, and the quality was high, but LEGO was not able to figure out a workable revenue and distribution model, to get the scale needed to make the game viable. Minecraft had lower quality graphics, but better gameplay and won out easily [5].

While LEGO Universe is considered a dramatic failure, LEGO Group did learn important lessons from the experience, and in the last decade has developed a licensing strategy for movies and video games that has become lucrative, particularly after the LEGO Movie in 2014. LEGO Group now generates revenue from licensing agreements, but leaves the game and movie development to other trusted parties.

Michelin Miles-as-a-Service

Michelin is a French multinational tire supplier. Michelin supplies the passenger car, motorcycle, bicycle, and truck and trailer markets (as well as other more specialized tires). In 2000, Michelin identified services as a key strategic initiative, and launched an effort to develop new data-enabled service-driven business models. In the trucking industry, large truck fleets negotiate tire prices with manufacturers directly, which tire dealers honor. In 2000, Michelin launched Michelin Fleet Solutions, a new business model wherein fleet customers buy comprehensive tire management from Michelin over a three to five year period[35]. The Fleet Solutions model represented a shift from selling individual tires and one-time services to providing a complete solution: customers pay for miles (or kilometers) driven, and Michelin handles tire maintenance, replacement and ongoing services.

Such a business model would be difficult to use without data. Michelin's ability to profitably provide this service depends on the ability to gather enough tire usage data to determine price levels. This is done through technology connecting the tires themselves, allowing Michelin insight into both usage and lifecycle costs, and characteristics of different fleets [19]. Challenges with the business model development came from difficulty selling a new type of contract and financial relationship to customers, and also from internal resistance to changes in the business model[36].The business model had a slow start, struggling particularly in the initial three-year period from 2000-2003 [35]. However, by 2019, it was generating revenue in the neighborhood of 400 million USD per year. Business model changes can require both internal and external adjustment and learning.

Michelin Maestro Digital Dealer Platform

In 2018, Michelin formed the global Sales and Services division to address business challenges and find solutions related to sustainable connected mobility. By 2019, the Sales and Services group had over 600 million USD in revenue globally and four business units. Tires-as-a-Service accounted for more than two thirds of this revenue. The rest was made up of Fleet Management, providing telematics for fleet tracking in real-time, Connected Mobility, which provided hardware technology used for fleet management, and the Digital Service Platform, intended to digitize existing services and introduce new services on the same platform [21].

Maestro, launched in August 2020, is a digital cloud-based platform connecting the company, commercial fleet operators, and service providers [50]. It falls into the Digital Service Platform business unit. Large fleet customers own and operate hundreds of trucks and trailers across the US. Mechanical repair and other services are performed by hundreds of different service providers across the country, and the industry still largely uses paper invoices. This results in significant administrative burden, inefficiency, errors, and payment delays [21]. The Maestro revenue model involves the cloud-based software subscription sold to the dealerships, with price based on number of locations and technicians per location. The goal is for Maestro to "be the leader and conductor of our customer's tire and vehicle service operations lines of business" according to Karen Schwart, director for the DSP for Michelin North America[39]. The value proposition to fleet owners is an opportunity to optimize their planned and scheduled maintenance to maximize vehicle uptime [39].

Development of this business model began in 2014, with the launch of Michelin Truck Care, targeted toward supporting light mechanical service. Despite promising early adoption rates, dealers quickly stopped using it because it was poorly architected, not scalable, and not user friendly. Michelin had outsourced all the development but the final product did not meet customer needs [21]. Later in 2014, Michelin launched the ONCall service for tire repairs. This service eventually managed 250,000 calls per year by 2019. During the scaling process, the Michelin team remarked that the paper-based transactions between service providers and fleets was a big pain point [21], and from that insight the idea to provide a digital solution emerged. As detailed above, Michelin dealt with early challenges around building products that meet customer needs adequately. Another challenge encountered during the Maestro business model development process is that the Michelin sales force, while highly experienced at selling tires, did not have experience selling software as a service. It is too early to tell how adoption will pan out for Maestro, but this case provides valuable insight into the pivots and setbacks encountered during data-driven business model development. The two Michelin cases taken together are also a good reminder that even if a company succeeds once, it is not necessarily an easy or straightforward road to do it again. Listening to and directly addressing customer needs is key.

Brock Group

Brock Group provides scaffolding, painting, insulation, shoring, lead and asbestos abatement, fireproofing, facilities maintenance and fabrication to a diverse set of industries including petrochemical, refining, offshore, and heavy manufacturing across the US and Canada [3]. Brock operates in industries where decisions are heavily cost-driven [6], but in order to provide additional value and position themselves as a leader in the space, Brock Group has pursued the development of digital and data-driven services. Brock's digital services are used as add-ons to the existing business model, that help Brock and their customers operate with more transparency and more efficiency [6]. For example, Brock has developed an attachment for tanks they rent to customers that provides information about the volume of material in the tank, allowing customers to have better control over their material usage and better control costs. This product was prototyped, tested and developed internally as a side project, and has seen success.

Brock is an example of a company pursuing digital and data-driven services as a way to improve their value proposition to customers, but in a context where generating additional revenue directly from those services is not possible given industry norms and structures. Instead, the services act as a differentiator for the company, leading to repeat customers, more work from existing customers, and more internal efficiency [6].

CRDigital

CR (formerly CQMS Razer) is a global IP, engineering, software and manufacturing company serving mining operations worldwide. CR's product range includes hydraulic excavator lip systems, dragline buckets, ground engaging tools, dragline rigging, conveyor systems and load haul optimization software systems [13]. CR Digital is the business providing mining technology software and services. The product range includes: tooth-loss detection systems, drill optimization, load haul optimization, data analysis and terrain mapping [13]. CR's digital services have developed over the last 5 years, with a range of initiatives identified based on customer needs. The products were developed through extensive conversation with customers about their pain points, needs, and by identifying relevant technologies that could be applied to the mining space[4]. In 2019, leadership determined that the pilots and initial development of the business models had shown enough promise to set up a separate CR Digital business unit. This structure helped to define boundaries around responsibilities, and marked a shift toward scaling the revenue-generating potential of the products as opposed to proving viability [4].

CR Digital spends a significant amount of time convincing customers to try their products. Successful avenues have revolved around clearly identifying pain points and then demonstrating, through case studies, pilots, and other smaller scale projects, quantitative evidence that the solutions work, and generate cost savings and efficiency gains. The data analysis platform is sold as a subscription, as are the optimization tools[4]. One major challenge for CR Digital was training the sales force and bringing in new resources who had experience selling software and solutions rather than hardware products, as the sales processes are different, customer concerns and hesitations are different, and the new business model represented a significant change in the sales process [4].

Thyssen Krupp IoT

Thyssen Krupp AG is a German multinational conglomerate with €28B in revenue in FY19/20. ThyssenKrupp has activities in Automotive Technology, Industrial Components, Elevator Technology, Plant Technology, Marine Systems, Materials Services, and Steel. The Materials Services division is responsible for €11.3B in sales over the same period [60]. The case study for this project is the development of the Thyssen Krupp IoT GmbH [25] within the Materials Services division between 2015 and 2020. The Materials Services business is a global materials distributor supplying steel, other metals, pipes, plastics and other raw materials. Materials Services also includes services activities: processing, warehouse and logistics, supply chain management, and trading. As part of a push to add more digital capabilities, Thyssen Krupp IoT GmbH was developed. Initially, the concept developed as an additional service provided by IT, with three coders, working on new solutions for production for existing customers [34]. The initial work was very customer specific, with a consultative approach. Around 2017, the business model was adjusted to shift to a subscription software license model, with defined products and use cases [34]. Another key dimension of this business model is that in order to facilitate adoption, the introductory products are priced relatively low and bigger systems become progressively more expensive. Thyssen Krupp IoT is targeting customers early in their digitalization process, for example steel mills exploring their first Industrial IoT implementation [34].

Key aspects of the business model include: an initial focus on existing Thyssen Krupp customers, as their needs were well understood, they were easy to access, and the needs matched Thyssen Krupp IoT's skills and capabilities. Thyssen Krupp IoT developed the software platform and the products or modules that run on it, while the hardware used on-site is supplied by Intel [41]. We consider this example a successful example to date.

Thyssen Krupp IoT is not the only data-driven business model developed at Thyssen Krupp. There is also TKGarage, an internal incubator that hosts employee-generated innovation ideas. The Garage provides mentorship, skills and support to develop these ideas. Thyssen Krupp IoT did not develop through this pathway. Instead, it was an internal effort within Materials, that was set up as its own business model once the market demand for an Industrial IoT solution from Thyssen Krupp was validated through the initial consultative projects. Lang cites management support through the middle stage of development as a key differentiator between the success of the IoT business and other innovation ideas that did not get off the ground, he mentions that the garage provides a great environment for early development, but without a bridge from the first pilot implementation through to a fully ready-to-scale state, business models or initiatives tend to die off once they are re-integrated into the rest of the company [34].

5.2 Strategic intent

In interviews, subjects consistently emphasized the importance of generating and maintaining clarity about the strategic intent of new data-driven business model development. Understanding how the new business model relates to the existing

Company	Description	Value Proposition	Revenue Model	Resources & Capabilities	Partners & Ecosystem	Culture	Process	Governance	Metrics
Kaeser SIGMA Air Utility	Kaeser is a manufacturer of air compressors for industrial applications. The company introduced a new business model where customers pay per meter cubed of air used.	+	+	+			+		
Rittal EPlan	Rittal makes control cabinets for industrial applications. EPlan is a design software that integrates CAD models of the cabinets with component information and information about equipment controlled through the cabinets to streamline the design and specification processes. The software is now a standalone product that also supports the core business.	+	+	+	+				
Airbus Skywise	Skywise is a cloud-based service providing analysis of aircraft fleet data. Airbus uses a freemium model, with base functionality available for free if the customers allow their anonymized data to be shared with other members on the platform. More specialized analysis is provided as an add on, and there is an ecosystem of partners.	+	+	+	+				
LEGO Universe	LEGO group attempted to develop a web-based video game, but slow development due to desire for control from HQ, mismatch of project requirements and revenue model from customer needs, and missing new products in the marketplace led to failure of the effort.	+	+	+	+	+	+	+	
Michelin Miles as a Service	Michelin launched a miles-as-a-service business model in the early 2000s, encountered slow progress and internal resistance to the new business model. The model eventually gained traction but it was a difficult process.	+	+	+		+	+		+
Michelin Digital Dealer Platform	Michelin launches a digital platform for interacting with dealers around tire service. The launch took extensive experimentation and ongoing communication with users to understand their real needs and find a workable revenue model.	+	+	+	+		+		+
Brock Group	Mid-size construction services firm that has developed data-driven digital services to enhance their value proposition to clients. Interview.	+	+	+		+	+	+	+
CR	Interview about process of developing CR Mining offerings - CR Digital is a digital technology business specializing in the development of mining technology software and services. CR makes components and accessories for surface and underground mining.	+		+		+	+	+	+
Thyssen Krupp IoT GmbH	IoT platform targeted at manufacturers early in their digitalization journey, a business model developed by Thyssen Krupp. Interview about process of developing business model inside a large incumbent.	+	+	+	+	+	+	+	+

Table 5.1.1: Summary of case studies and relevant dimensions

business strategy, and how it fits with the future business strategy is important for determining how to best structure interaction between the existing business models and management, and the new business model.

Data-driven business models can either supplement the existing product offering, by extending new services, capabilities and sources of value creation to the customer, or they can substitute the existing business model. The latter happens when a data-driven business model does the same "job" for a customer, but with a different revenue model, service arrangement, etc. Establishing clear expectations early on in the business model development process about whether the business model under consideration will complement or substitute the core business is important, as it has significant impacts on how to best pursue the new business model [42].

The business models MR is currently pursuing are complementary to the core business. As discussed in 2.1.3 and 2.4.1 the types of business models available to MR are most likely complementary to rather than substitutes for hardware sales. The business models currently under development are aimed at providing customers insight and decision support for managing their assets: this value proposition does not replace having hardware installed in the field, and in fact in most cases requires it. Similarly, LEGO's development of a video game was intended to be an extension of the existing business model. CQMR Razer and Brock Technologies both also would describe their data-driven business model development as an extension of the core product rather than a replacement. In contrast, Michelin's pay-by-the-mile tire program substitutes revenue that would be earned through tire sales, and Kaeser Kompressoren's SIGMA Air Utility compressed air as a service offering replaces revenue from equipment sales.

5.3 Value proposition

The precise value proposition of each business investigated is not particularly useful information, as they are specific to the industry and customers they serve, however we can draw out common themes. The Skywise, Kaeser, and Brock cases demonstrate a new value proposition for the existing customer base, adding additional value and deepening the customer relationship. Skywise is an add-on Airbus' customers can choose to engage with to better manage their aircraft fleets. Kaeser's SIGMA Air Utility business model provides additional flexibility to their customers, and relies again on a long-term relationship.

All interviewees emphasized that the value proposition they eventually developed was the result of extensive listening to customers, iteration, and understanding of the specific market they are competing in. In one example, Michelin's launch of the Digital Service Platform was the result of years of work to develop ideas, get feedback from their dealers, investigating why adoption for previous offerings were stalling, learning more about their specific needs, hangups, and fears, re-configuring the product to address those, and finally hitting on a good fit of the product to the market[21]. Pichette and Anderson both emphasize that across the range of startups they have worked with, figuring out product-market fit takes experimentation and is almost never correct on the first try[42]. The process of developing the Thyssen Krupp IoT value proposition was the result of extensive interviews and interaction with individuals throughout Thyssen Krupp's plants, from operators through plant managers, in order to understand their needs, challenges, and fears. Based on the learning from those interactions, the focus of the product was tweaked in order to best serve the apparent needs [34]. While it is tempting to attempt to copy successful formulas from other entities [40], they should be taken only as starting points, not strict templates - fitting the value proposition to the market and customers at hand is critical. This is only possible through a deep understanding of their needs, and testing the assumptions and ideas out with the relevant parties.

5.4 Revenue Model

The type of revenue model a firm can pursue is tightly linked to the type of value proposition they provide. In reviewing the cases and literature, there were four primary dimensions of the revenue model: the payment type, relationship of data-driven business model revenue to hardware revenue, pricing model, and customer.

- Payment type: we break this category into three options. One-time payments, subscription payments (fixed, recurring fee) and usage based (fee based on output or utilization). In deciding which of these to employ, it is important to understand customer price sensitivity and whether customer organizations are willing and able to change over to a recurring payment model. Kaeser's SIGMA Air Utility business model had to spend extensive time communicating with customers and iterating on contract types in order to find a payment model that worked both for Kaeser and their customers. The other critical consideration when determining a payment model is how well customer's usage patterns can be understood and tracked. Usage-based models are only possible if utilization or output can be precisely determined, and a subscription-based model needs to have a clear understanding of expected usage patterns in order to price well.

- Hardware - Data relationship: the cases covered exhibit three kinds of relationships. An integrated hardware + data product, the data value proposition as an add-on to hardware sales, and finally a data-driven business model that provides a fully standalone product. Rittal's EPlan is an example of a stand-alone product - it is related to the core business but is purchased separately and generates revenue independently. LEGO's attempted web-based game would also have been a standalone revenue model. In contrast, Airbus' Skywise is an add-on: a carrier wouldn't purchase Skywise without owning Airbus aircraft, and Kaeser's SIGMA Air Utility is an integrated hardware and data product. Key considerations in this dimension are the standalone value of the hardware to the customers, the incremental value over that hardware of the data or software to the customers, and the overlap between potential hardware only and software-only customers, if relevant.

- Pricing model: some examples of pricing models are freemium, tiered services, flat rate, and the "razor and blades" model where non-consumables are priced at or around cost, but consumables generate a high margin for the manufacturer. Key considerations along the pricing dimension are how willing customers are to pay for the incremental value of the product, how evident the value is to the consumer, and whether the data is more valuable to the customer or the company. Brock Technologies has developed digital offerings, but many of them are used to enhance the value of the service to the customer without charging additional fees, as the industry is highly competitive on cost, and Brock perceives an opportunity to differentiate themselves using the digital services and win repeat business, but cannot add cost for risk of losing jobs. Another example is Skywise's freemium model: fleet owners get access to the core functionality free of cost if they agree to share their (anonymized) data with the rest of the platform. The increased value to Skywise of access to that data is worth providing the core functionality free of charge, and this pricing structure incentivizes customers to share their data and make the platform more valuable for all parties involved.

- Customer type: Decisions around the revenue model also depend on who the customers are and how they relate to the end-user of the equipment or service being enhanced or supported by the value proposition. Some considerations along this dimension are who can get the most value of the information the data can provide? What are the advantages and challenges of serving the end-user directly as opposed to a potential intermediary, for example selling to service providers instead of the end user or asset owner? If the primary beneficiary of the data is the manufacturer, the manufacturer may need to forgo deriving revenue directly from the data and instead incentivize customers to share their data. Skywise provides an example here: when air carriers are willing to anonymously share their fleet data with the platform, they receive free access to key functionality. Skywise then charges for additional functionality beyond the core suite.

5.5 Resources: architecture and technical platform selection

Key decisions for companies developing new business models involve the choice of what resources to bring internal as opposed to buying or partnering with outside parties. The question is particularly salient when the company does not currently have the types of resources needed to enable a new business model. Some, like Thyssen Krupp IoT choose to focus solely on the software aspect, using off-the-shelf hardware from Intel in order to enable the product[41]. Thyssen Krupp IoT developed the software for their IoT platform, and runs their Industrial IoT platform on top of of-the-shelf hardware from Intel. This decision allows them to focus on adding value specifically through the application, rather than needing to have capabilities throughout the entire stack. Intel is a trusted, reliable supplier, and the partnership is successful. See section 5.6 for a more detailed discussion on partnerships.

Similarly, when Airbus developed Skywise, they partnered with Palantir, in order to leverage Palantir's expertise in platform development and data management. Airbus has access to the key resource - aircraft data, and has the internal knowledge and capability to do useful analysis of the data, but did not invest in the internal capability to build and maintain the backend of the platform. The management of the infrastructure and the platform on which these analysis run is left to the expertise of Palantir.

In contrast, we see an unsuccessful example in LEGO's attempt to develop a video game - LEGO bought a video game company and brought the development team inside the existing organization in order to try and speed up development[12]. LEGO wanted to have control and ownerhsip of every stage of the development process, and thought it was cirtical to bring the capabilities in-house. Unfortunately, LEGO's management did not have experience with software developement, and the effort ran into frequent delays and challenges due to mismatches in process between the existing business structure and the game development team. This did not work well and the video game was never a commercial success[31].

These examples reinforce the view of Collins and Montgomery, discussed in Section 2.2, that resources are a key source of sustainable competitive advantage. As with all strategic decisions, it is necessary to make tradeoffs and choices, in order to focus on the most beneficial resources. MR, as a component and sensor manufacturer is in a different starting position to the examples above, with in-house expertise in the hardware side of the business, and expertise in the best ways to utilize the data, so MR pursues a strategy of integrating the hardware and software under their own brand. MR has deep knowledge of the needs of the end-user (the customers of the OEMs) due to MR's current business model of specifying tap changers with the final user, and also due to the deep internal knowledge of power grid phenomena and systems.

5.6 Partnerships and Ecosystem

The discussion of resources and partnerships is closely linked. If resources do not exist internally, then partners are a key to gaining access to resources such as data or critical capabilities like platform development, infrastructure development machine learning expertise. In order to focus on the resources and capabilities that a company has privileged access to, strong expertise in, and can serve as a source of lasting advantage, it is often necessary to forgo expertise in other dimensions. This can be the source of mutually beneficial partnerships, such as that between Intel and Thyssen Krupp IoT described above.

Skywise is another case with a strong ecosystem around the product thanks to partnerships. Firstly, Skywise was developed with Palantir, which is a more efficient path to a functional platform than Airbus gaining the capability to build a secure, highly functional platform from the ground up. Secondly, Skywise partners with a range of consultants and analytics experts to provide a suite of advanced and tailored analyses for their customers [52]. The partners are able to use the platform to deliver value to the customers, and also to charge customers an add-on fee for those services. This makes the platform more valuable for fleet owners, and Skywise is able to keep their customers inside their ecosystem instead of having them export data in order to get their advanced analytics needs met.

Taking an ecosystem view of value can also increase the utility of the value proposition for customers, and result in better outcomes for the company. Rittal's development of EPlan is an example of a successful ecosystem development. Rittal could have built software that incorporated only their own hardware, but instead EPlan provides an environment in which Rittal's potential customers can design and optimize their control cabinet configurations, using up-to-date CAD files not only for Rittal's hardware, but also all the other hardware the cabinets would interface with [47]. Rittal created a product that generates value for all the participants in the industry, and in doing so improved their position and reputation [48].

5.7 Venture Structure and Process

In addition to the business models and their dimensions previously discussed, there are also critical dimensions related to the process an incumbent uses in building and launching the new business model. The way the venture, or business model, is structured, and the manner in which it operates and is governed within the existing company also have an impact on the success of the initiative. Interviewees consistently mentioned the importance of carefully considering the processes put in place during business model development, and the relationship of the new business model to the existing business.

Pichette advocates for thinking about the structure based on how the proposed business model relates to the existing core business. If the proposed business model will substitute the core business, and involves more risk for the organization, it is often better structured independently from the core business. On the other hand, if it is an extension of the existing business model, or relies on leveraging the existing customer relationships, it is better off being developed within the existing business [42]. These are not hard and fast rules, rather a starting guideline.

5.7.1 Pivots and path to current model

Some companies appear to have a linear path between the decision to engage in data-driven business model development and a successful outcome, whereas others have many more twists and turns in the story. It is easier to draw a straight line in retrospect than it is to predict the future. Michelin's development of the mileage program had a rocky start, with initial growth far below projections[36]. The project eventually became a success after adjustments to the relationships with dealers and better communication of the value proposition. Kaeser went through extensive conversations and adjustments with clients during the launch of the SIGMA Air Utility program. CR-Digital updates the roadmap for their digital products based on feedback from customers, new insights, and learnings. Interviewees were asked what the key element of success for developing their business models has been, and all mentioned being willing to listen and make adjustments based on what was learned. They all described a process of learning and refining the model based on feedback, insights and roadblocks that are uncovered.

5.7.2 Culture

Support from top management is uniformly cited as a critical component to venture success. As developing new business models breaks the mold of "how things are usually done", having top management support is key to incentivizing other parts of the business to enable and cooperate with the new business model rather than shutting it down [34].

Lang cites three dimensions of culture that differ between the legacy business and the nascent business model. First, the new business model necessarily has significantly less hierarchy than the core business, second, employees are more accountable for decisions. Third, with a developing business model, the focus must be entirely on the customer and their needs, developing solutions for them not for what you think they want [34].

When culture is not aligned or compatible, challenges emerge. LEGO is a cautionary tale of an organization that wanted to apply the same exacting high standards and rigid controls from its core product line's processes to a new digital product. The stringent requirements and strict degree of control slowed down development, and resulted in a game experience that while technically superior, did not match customer preferences or needs [31].

Diemer claims visible support from top management for innovation teams is critical to helping remove barriers and negotiate the existing processes. When the rest of the organization perceives a team trying to bend the rules to fit their needs has the support of top management, they are more likely to try work with them to find solutions, but if there is no visible support, progress tends to stall out [16]. Diemer also emphasizes that keeping expectations realistic is important; recognizing world-changing, breakthrough successes such as the iPhone are exceedingly rare events. A better goal is to develop products adjacent to the existing business that expand the value proposition [16].

5.7.3 Governance from parent company

Lang cites autonomy as one of the most critical ways in which the parent company supports the internal venture. The IoT business had to carefully carve out space within the parent company to operate with autonomy. In order to gain autonomy, they work on being transparent with upper management about the risks and their decision-making, and also invest significant time in educating members of management who may be familiar with the core business of steel but unfamiliar with the world of IoT. Previous attempts to develop disruptive business models had support until their first market success, but then were expected to integrate into the rest of the business too early, and did not reach their potential. With the IoT business, a different approach was taken, where the venture had a longer period of autonomy and support as a developing business model, which allowed the venture to flourish [34].

One strategy used by a payment services provider is to clearly delineate a plan to navigate existing internal gatekeepers, and the acceptable level of risk for any particular initiative [16]. For each new product under development, the team would negotiate with all the stakeholders internally (e.g. the legal team, the regulatory team, the marketing team) in order to set out a clear set of expectations for how all the groups would interact. Developing a new business model involves different processes and different levels of risk from the established business, but the processes in place to govern the business are there for a reason. Therefore, generating clarity for all parties involved about which rules can be bent, and which processes must still be strictly followed enables better interactions between the core functions such as legal, and the new business model [16]. Additionally, Diemer mentions it was helpful to have a single person in each core function be responsible for managing the relationship with the innovation team, as it provided a clear point of contact and clearer decisions.

Anderson goes further and describes the critical decision for digital business model development as the decision of whether to pursue the new business model within the existing business, or outside it. From his perspective, the two primary considerations are whether the culture in the incumbent company can accommodate and help a new venture thrive. Changing an existing organization's culture is difficult (see 2.4.3), but not impossible if the right characteristics can be leveraged.

Chapter 6

Implication for MR

The examples described in Chapter 5 do not converge on a single formula for successful data-driven business model development. They do however point toward a useful framework for thinking about this problem, particularly in respect to process, culture and governance, some best practices. This chapter explores those findings, and the implications for MR.

6.1 Types of value propositions to consider

The primary insight from the various types of value propositions discussed in Section 5.3 is there exists a wide variety of opportunities to add value. For manufacturers in B2B contexts, often the primary pathways are providing deeper insight into the primary product's performance and status (e.g. Skywise), enabling a different financial arrangement and ongoing customer relationship (Kaeser, Michelin), or as an enhancement to the customer experience that is not a separate value proposition (Brock). Interviews indicate that in practice, landing on a successful combination of market and value proposition is a matter of experimentation, learning, and is fundamentally driven by deep, detailed understanding how user needs are changing and the applications of data and digital technology intersect with those needs.

For a company like MR serving multiple types of customers, from transformer OEMs to grid operators, to asset managers, one path to success is to consider tailoring value propositions to each customer segment, by providing a range of solutions and capabilities. It is unlikely that a one-size-fits all solution works well given the variety of customer types and needs, so recognizing and adapting to the specific needs of each group is a key component to success. The cases and interviews indicate that the best way to achieve this is through rapid, targeted experimentation that is focused on validating (or invalidating) the key assumptions for the value proposition, and through intentional interaction with customers to quantify and react to their needs. In order to support this approach from a hardware resources perspective, a flexible modular approach to integrating data-communication capabilities and more advanced analysis to the existing hardware is a promising path forward. As there will inevitably be a range of use cases and customer types, it would be advantageous to have a hardware platform that can support the full range of customer types and needs through a simple, easy to integrate interface. A one-size fits all approach is not appropriate, and not flexible enough to deliver tailored value propositions for each type of customer. In order to identify customers needs and address them with relevant value propositions, it is critical that MR continues to seek input and insight from customers themselves.

6.2 Considerations for revenue models

In order to capture value effectively, the revenue model selected for a new business model must fit with the value proposition. In addition, the revenue model must be acceptable to customers - sometimes companies are limited by the willingness of their customers to adapt to or consider different financial transactions. For example, switching from one-off purchases of hardware to long term contracts for output or services can be a difficult selling process, that takes extensive time and customer education in order to overcome. MR should carefully consider the capabilities of the sales teams and plan to train or augment those capabilities based on the revenue models that are needed for new business models.

The revenue model structure is also affected by whether the value proposition complements the existing product range, or is a substitute for current offerings. In the former case, it is more likely to succeed as an add-on purchase, and an important decision to make early on is whether the value the data-driven offering provides should be charged to customers, or whether it gets integrated into the existing product to make the existing product more valuable. In the latter case, the revenue model for the new business model must be able to stand alone. It is also important to take into consideration how the different options interact with the sales force's incentive structure. There is a danger that the sales force has misaligned incentives and inadvertently slows down development of the new business model if this is not addressed.

Finally, the value added by the data-driven business model must be sufficient to justify using it as a revenue stream. If there is more value to the company from gathering the data than there is to the customer, a model where the data-driven value is provided to the customer for free in exchange for access to data may be the most beneficial. Skywise is an example of this in that customers that agree to share their data (anonymously) across the platform have access to more free functionality than those who do not. This incentivizes information sharing, which increases the value of the platform for all parties involved and strengthens Airbus' position.

When revenue models are significantly different from the core business, it is also important to ensure that the salespeople involved have the knowledge and skills to sell the new type of product and manage the financial transaction appropriately, or for the new business model to have its own dedicated sales force.

For Maschinenfabrik Reinhausen, this part of the framework indicates that a clear understanding of the value proposition for the customer is the first step in determining which kind of revenue model is best. The second step is to determine the magnitude of the value to the customer, and whether they are willing to change the way they purchase the product.

6.3 Partners and Ecosystem opportunities

Successful business models investigated focus on key areas where they add value, rather than trying to do everything themselves. For example, ThyssenKrupp IoT focuses on the application of IoT technology to materials manufacturing, but leaves the device hardware engineering to a trusted partner and supplier, Intel. This allows ThyssenKrupp IoT to focus their effort on the part of the value chain where they add the most value without adding additional strain of bringing entirely new capabilities in-house. On the other hand, Michelin's first iteration of their dealer interface, was entirely outsourced, leading to problems with the user interface that reduced adoption and scalability. The challenges encountered in the interface's launch illustrate the danger of delegating the key component of the process, the interaction with the customer. Companies can also swing too far the other way. LEGO Group's attempt to develop a video game entirely in-house did not succeed because the skills and capabilities required were too different from their core competencies and decision-making was bogged down with too many layers of hierarchy.

These examples indicate incumbents should carefully evaluate which resources and capabilities are critical - core IP, unique resource the company already controls, or wants to control, strategically important future capabilities, and be open to forming relationships with partners in order to accelerate development of solutions.

The potential to generate ecosystems presents a large opportunity for incumbents. When other parties can constructively add value to the product, in areas of different specialty than the primary company, there is an opportunity to generate value for all parties involved. A more open ecosystem, where multiple parties can generate value for the customer is more likely to create lock-in as the customer does not have to leave in order to have additional needs met. Skywise, which controls access to valuable aircraft data, allows other parties to build applications and provide services through the Skywise platform, which increases the value of the platform to users without burdening Skywise with the more specialized types of analyses those providers perform.

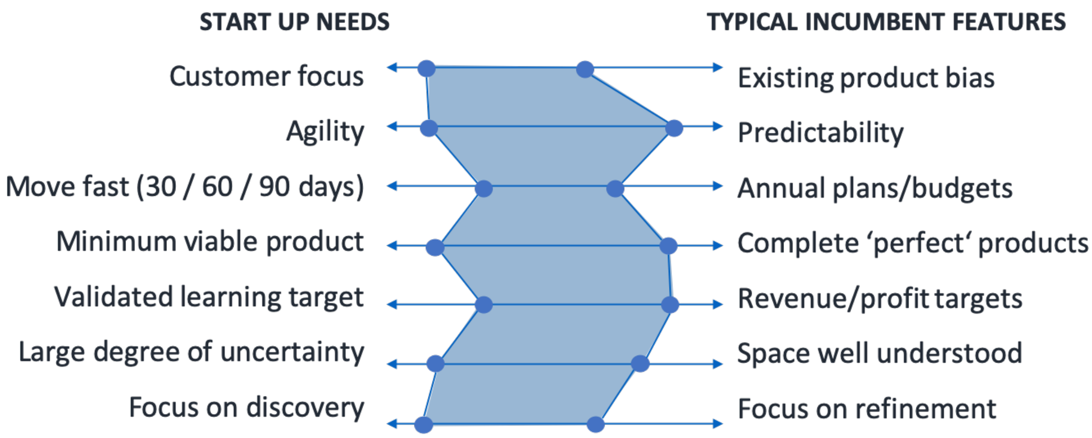

Figure 6.4.1: Dimensions of environment for business model development

6.4 Venture structure and process

While there is no clear prescription for the business model structure itself, the cases and interviews conducted do point to a consensus on best-practices for the development of data-driven business models within an incumbent company. While the path to success often looks linear in hindsight, the process of business model development is iterative, driven by learning and re-evaluating the model, and a high degree of uncertainty throughout. In order to succeed in this paradigm, business model development appears to work best when the existing business can carve out an environment for business model development defined by two key characteristics.

First, a focus on rapid, disciplined learning. the imperative to be iterative and agile is not an imperative to be random and haphazard, rather to move rapidly through articulating, testing and validating or rejecting key hypotheses and assumptions about how the business model could work. Second, recognizing a nascent business model requires a different type of governance than the established business. The environment in which data-driven business models are developed is an aspect fully within the control of the organization. Focusing on the process and approach rather than on the exact recipe for the best data-driven business model increases the likelihood of successful implementation. The key insights from this project are to preserve the autonomy and agility of the new business model until the product-market fit is proven and ready to scale, adjusting existing processes in order to maintain the momentum of the new business model, and focusing on the culture and process around the business model as tools to enable better, faster decision making and development. The visualization in Figure 6.4, is put forth as an illustration of the gap between typical startup needs and incumbent features of culture. In order to navigate the difference between the two, it is critical to have the ability to have clear discussions around where compromise is possible, how the new business model can be enabled to develop as effectively as possible, and how the needs of the business model under development can be protected. While we often desire the best of both worlds, i.e. strong agility and a very clear commitment to a set of expected results 6-12 months in the future, full commitment to both ends of the spectrum is not possible. One has to make a compromise about where on the line the organization is willing to sit, for every one of the dimensions.

At MR, the tension between the two sides of Figure 6.4 can be seen (as they would be in any incumbent) in the differences in process between the Digital Ventures group and other parts of the Automation division. As part of the work for Chapter 4, work was performed within the Product Architecture Development framework. This workflow, like most workflows at MR, is clearly laid out, runs step by step, with a clear set of requirements, resources, checkpoints, and a structured decision-making process. The process, or project structure, is linear, planned out months in advance and has clear endpoints and outcomes. All the hardware development processes at MR run using similarly structured workflows. This presents a challenge for effective collaboration and integration with the ongoing business model development work, as it is less linear, more agile and more responsive to changing conditions. This contrast in styles and working cultures highlights the gap between the existing, well understood and clearly defined processes within the incumbent with the more fluid and fast-moving needs of the nascent business model. Literature and interviews indicate new business models should not be fully integrated into existing business processes until the models are well-proven and accepted in the market. Until that point, the need for flexibility is significantly higher than the existing processes can provide.

The cases and interviews conducted uniformly emphasize the importance of culture to the success of data driven business model - creating an environment where learning is prioritized over the avoidance of failure, ideas can be openly exchanged and debated, and customer needs are at the forefront. The challenges of forming and maintaining these cultural dimensions inside an organization that is more rigid, outcome-oriented and technology driven are not unique to MR. Lessons drawn from elsewhere indicate careful and consistent effort is needed to shift culture. Changing expectations and consequences around failure and learning are critical to becoming capable of rapid and effective experimentation and learning. In order to do so, the expected outcomes should be defined in terms of learnings, or questions answered rather than metrics such as revenue, number of customers, etc, particularly in the early stages of development.

As a supplier to OEMs and trusted partner to transformer end-users, MR is well positioned to create an ecosystem of value-added services for the industry by exploring opportunities for a platform or ecosystem perspective of data-driven business models.

Chapter 7

Summary and Conclusions

The cases and interviews available indicate there is no single "recipe" for a successful data-driven business model, rather the exact business models that will be successful in each context depend heavily on the specifics of the industry and company. The key factors to consider are the fit of the value proposition with customer needs, matching revenue model to the value proposition, and identifying which resources and capabilities are critical to keep inside the company and which can be sourced outside through partners in order to accelerate development and generate an ecosystem to create more value.

While there are not *prescriptions* for the business model structure indicated by the findings in this work, there is evidence the *environment* in which data-driven business models are created has an impact on their degree of success. While the conditions surrounding the business can be rapidly changing and uncertain, the environment, process, culture and governance of new business model development inside the company is within the control of the company. Focusing on creating an environment that encourages rapid learning, a clear understanding of what assumptions must be proven true to prove out the business model, a culture of learning, experimentation and innovation, and sufficient autonomy to adapt quickly without being stuck in the slower processes of a mature business are key to success. In order to do so, the developing business model must retain enough autonomy to adapt rapidly, bypass internal processes that are not helpful or relevant to the work being done, and take risks to the degree acceptable to the organization.

Technology is a resource and tool available to deliver a value proposition to customers. In order to make more data available and actionable for both MR and their customers, this author concludes pursuing the development of a low-cost Ethernet interface in order to extend data availability is a promising proposition.

7.1 Recommendations for Future Work

The work in this document has focused externally on the learning available from other companies and how they apply to MR. This framework provides a way to think through potential business models, and how to best develop them in an incumbent B2B manufacturer.

Partnerships and Ecosystem

Moving forward, it will be valuable to map out the potential partnerships and ecosystem relationships available, and evaluate the possibilities for a platform-based business model in this context. Such a project might attempt to map customer needs, as currently understood, against the capabilities of MR and potential partners. The analysis should take into consideration the kinds of resources and capabilities MR would like to control and those the company is willing to source externally.

In this vein, an analysis of which capabilities and resources would provide MR with long-lasting advantages, and which can either comfortably, or out of necessity, be left to other parties would be a valuable addition. These analyses could potentially result in a general make/buy/ally framework to use in future decisions related to data-driven business model development at MR.

Ownership of Data

The use of data, generated by various parties, in business models inevitably brings up questions of data ownership. In order to use data that would be competitively or commercially useful to a company, the company must have access and the legal right to use the data in that manner. Take, for example, data generated by smart cars: sensors, components, and software running in the car all generate and transmit data that provide information about the physical status of components in the system, traffic, car performance, and driver behaviour. These data are useful and valuable, but because so many different players interact, and there is not a clear framework in the law, it is still unclear who exactly owns the data [7]. For data about assets in the field, there could also be questions around legal ownership of the data.

Both Banterle et al. (2018) and Bird & Bird (2017) conclude the current European legal framework is "not satisfactory"[7]. Firms currently solve ambiguity surrounding data ownership by relying on contracts. While contracts can provide greater flexibility, there are limits with regard to arrangements with third parties, and with the increasingly interconnected data economy, Bird & Bird also recognize the limits of the current legal structure [61]. This document did not delve further into the intersection of property law, data rights, and data-driven business models. However, the ownership of data, and the uncertainty around them, is a critical consideration in developing data driven business models in industrial contexts moving forward. Further research into the field would be important in the continuing development of a data-driven business model strategy at MR.

Value Propositions

Continued exploration of customer needs and how the set of available data can meet them is an ongoing effort, and future work in this area would be beneficial in order to respond to changes in available data, identify gaps in available data, and potential new sources of value. These needs include but are not limited to ways to improve the in-service use of MR's products. There are likely valuable opportunities in the sales, design and implementation phases that are worth more detailed exploration.

Appendix A

Interview Questions

1. What have been the key elements of success for developing your digital business model?

2. What's the key way the company supports this venture?

3. What has been the biggest challenge to setting up this digital business?

   How have you dealt with it?

4. What do you think are the critical aspects of culture to have for success here?

5. How does the digital business relate to the existing business? Is it an add on, expanded services, or does it compete with core business?

   Has this changed over time?

6. How does the digital business interact with the existing business?

   Where is the team located?

   How tightly integrated with the core business processes?

7. What revenue model, or models are you using?

8. Has the business model shifted over time?

   If so, how did you recognize it needed to change, and how did you implement change?

9. If you feel comfortable answering, how fast is the digital part of the business growing?

10. What's been the trajectory in terms of revenue/adoption/success of this initiative, was it linear, was there a big inflection point?

    How long did it take to get traction?

    What was the most important factor to get traction?

11. Could you describe the demographics of the team? Age, background?

    Where do you recruit - inside or outside the existing organization?

    How do you ensure the team has the right skillset?

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