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Ensuring Availability of Electronics Supply with Obsolescence Management

A Case Study of How an Organization Can Establish Sustainable Procurement of Electronics

Master's thesis in Quality and Operations Management

DANIEL OLSSON

OSKAR WAHLUND

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SUPPLY AND OPERATIONS MANAGEMENT

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Supervisor: Ala Arvidsson, Department of Technology Management and Economics
Examiner: Ala Arvidsson, Department of Technology Management and Economics

Report No. E2021:067
Department of Technology Management and Economics
Division of Supply and Operations Management
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone +46 (0)31-772 1000

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OSKAR WAHLUND
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Abstract

The increased use of electrical and electronic (E&E) components implies that companies need to have processes of managing obsolete components. The purpose of this thesis is to provide knowledge on how to manage obsolescence issues to ensure availability of E&E components included in products with long manufacturing and support life cycles. Furthermore, the thesis aims to assess how an organization could act to mitigate issues of E&E component obsolescence and what actions could be implemented. The theory of Product Life Cycle Management (PLM) and Obsolescence Management (OM) serves as a basis for the research. The thesis has its outset in Alpha, a company that has expressed issues related to the obsolescence of E&E components and a need for expanding their knowledge and improving their processes within the area of PLM and OM. A case study in two phases was created to research the topic of managing obsolescence. The first phase focuses on Alpha and explores the issues and current conduct of managing obsolescence within the organization. The second phase focuses on external companies and explores how different organizations are managing obsolescence in order to understand how an organization such as Alpha can improve the management of obsolescence of E&E components.

This thesis concludes that Alpha, along with the majority of the benchmark companies, currently are acting on obsolescence through a mainly unintentional reactive approach case-by-case with few or no consistent proactive or strategic measures. These findings show a discrepancy with what previous research proposes, accentuating the inclusion of a comprehensive OM to effectively mitigate related issues with lower cost, lead times, and operational disturbance, in addition to a better understanding of the product portfolio life cycle status. The aspects of *Design for Obsolescence*, *Cross-Functional Collaboration and Organizational Awareness*, *Supplier Management*, *Focusing Resources*, *Supplier Relationships* and *Implementation of Intentional Reactive Obsolescence Management* are identified as key areas to develop. Each area is addressing mitigation efforts in the different phases of the product life cycle and the different areas of OM, from design conception to discontinuance. To sufficiently succeed in ensuring available supply of E&E components, an OM conduct integrating reactive, proactive, and strategic aspects is emphasized.

Keywords: Obsolescence, Obsolescence Management, Electronics Obsolescence, Obsolescence Mitigation, Product Life Cycle Management, Life Cycle Mismatch

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Daniel Olsson & Oskar Wahlund, Gothenburg, June 2021

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List of Abbreviations

BOM Bill of Material. xv, III, 3, 22, 23, 39, 40, 42–45, 48, 57, 59, 60, 62, 63, 66, 69–71, 73, 75, 80, 81, 83, 85, 87

E&E Electrical & Electronics. v, xiii, xv, III–V, 1–4, 7, 9–12, 15, 16, 18–20, 26, 28–30, 32, 34–36, 38–64, 66–74, 77–88

LTB Last Time Buy. 19, 21, 45–47, 51–59, 63, 71, 72, 74, 84

NPD New Product Development. 69, 70, 79

OBM Original Brand Manufacturer. 3, 4, 32, 74, 85, 86

OM Obsolescence Management. v, 5, 16, 17, 21, 22, 25–27, 29, 35, 39, 40, 42–45, 47, 49, 57, 59, 60, 65–67, 70, 71, 78, 80, 82, 83, 86–89

PCN Part Change Notice. 25, 44, 45, 61, 71

PDN Part Discontinuance Notice. 12, 19, 21, 25, 44–46, 52–54, 56, 61, 71

PLM Product Life Cycle Management. v, 5, 7, 9, 26, 34, 39–44, 47, 57, 70, 71, 80, 81

POM Proactive Obsolescence Management. xv, IV, 21–23, 26–28, 39, 47, 49, 57–64, 74, 81–84, 86–88

ROM Reactive Obsolescence Management. v, xv, IV, 17, 20–22, 24, 26–28, 39, 47, 49–57, 74, 83, 84, 86, 88

SOM Strategic Obsolescence Management. V, 23, 24, 27, 28, 39, 47, 49, 64, 65, 75, 79, 86

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1

Introduction

This introductory chapter describes the motives for this thesis by presenting a contextual background, the purpose, the research questions that will be addressed, the delimitations and scope, as well as a brief description of how the thesis is structured.

1.1 Background

Technological shifts have long been a challenge for individual businesses to manage and is one key factor why companies must adapt to stay relevant in ever-changing industry climates. In modern times, the industries have transformed rapidly and the new market preconditions as a result of new technology have been an opportunity for businesses to strengthen their positions, whereas businesses lagging behind the development have seen their operative competitiveness decline. As a consequence of this rapid pace of development, perhaps best depicted in Moore's Law[1], the technological life cycle of high-tech components grows ever shorter while its complexity continues to increase (Bartels et al., 2012; Coffman et al., 2009).

A leading example of technology development is the electronics industry, which according to Huang et al. (2019) is one of the most dynamic business sectors in the world economy. To get a comprehension of its nature, the sector grew three times faster than the overall economy in the United States in the 1990s and is now one of the biggest industry segments in the world. Electrical and electronics components, henceforth abbreviated as E&E components, are being more and more integrated into products. In this thesis, E&E components refer to the basic devices included in an electronic system, e.g. active and passive components. A part is referring to a portion of a whole product that is sold by a company, e.g. an electronic system consisting of several E&E and mechanical components that together with other parts form a product. The E&E component diversity is also increasing as a consequence of product differentiation. The fast technological advance has led to shorter technological relevance and higher grade of unavailability of E&E components, i.e. short procurement lifetime, while the same components tend to have critical functions in products with long manufacturing and support life cycles, leading to growing obsolescence complications. As Huang et al. (2019) and Rojo et al. (2009) present,

[1] The empirically observed phenomena that entail that the computing power in terms of the number of transistors in the integrated circuits doubles every two years.

this mismatch between the life cycles of individual components and products with long manufacturing and support life cycles is currently growing globally in present-day industries. This mismatch creates major difficulties for manufacturers of these products to ensure aftermarket and maintenance services as the E&E components become obsolete and outdated in their supply chain. In face of this, the management of obsolescence for E&E components becomes increasingly important, not least as environmental legislation in the form of substance regulations[2] advances and further limits the life cycle of used components whereas corporate knowledge and mitigation strategies fall behind (Cao & Folan, 2012).

To manage the life cycle mismatch, Singh and Sandborn (2006) imply that there is an essential need in present and future manufacturing organizations to work more proactively, and less reactively as is commonly conducted today. The authors further suggest that there are benefits to be gained from more proactive and strategic approaches as it may generate shorter and more reliable lead times, lower overall costs and better product quality. Moreover, a more sophisticated product and service offering may increase customers willingness to pay for business offerings, leading to competitive advantage and a justification for high prices and margins.

The context in which this thesis is being performed highly stresses the importance of ensuring available supply of E&E components and managing component obsolescence. Lynn (2018) presents that there is currently a global supply shortage of E&E components overlapping many industries. The problems emerge as consequences of shorter component life cycles, obsolescence of E&E components as well as more complex systems hastened by new innovative trends in the areas of transport electrification, 5G and Internet of Things (Coffman et al., 2009). According to Knight (2021), the supply complications have only gone worse with escalating trade wars between producers such as the US and China, as well as supply and demand disruptions on the global market due to the covid-19 pandemic. As the global supply of critical E&E components decreases and the demand is experiencing exponential growth, a high level of competition and uncertainty are induced in the product portfolios as well as increased lead times in the supply chain.

1.1.1 Industry and Company Background

The Automotive and Heavy Equipment Industry is one that in the recent decade has been facing technological shifts in the form of electrification, connectivity, and autonomous mobility. Threats of new market entrants and preconditions have led companies to begin their transformation from business centered around internal combustion engine technology to platforms centered around connected and electrified powertrains, largely enabled by the inclusion of E&E components (Coffman et al., 2009). The organizations within this changing industry are at a greater extent facing the challenge of managing the life cycles of E&E components in their products, which puts increasing pressure on the obsolescence management of E&E components.

[2]Such as the Restriction of Hazardous Substances (RoHS) and Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) directives (European Commission, 2011)

This thesis has its outset in an Original Brand Manufacturer (OBM) providing Industrial Applications and Power Solutions within the Automotive and Heavy Equipment Industry. The OBM, henceforth referred to as Alpha in this thesis, are facing the growing challenges of obsolescence in the life cycles of their products. Alpha is selling complete product systems and aftermarket spare parts, in the context of business-to-business. Currently, the product life of Alpha's products is up to 30 years with an aftermarket responsibility of approximately 15 years. In Alpha's product portfolio, there exist many products that contain E&E components. Moreover, the E&E components dependence and product complexity are only expected to grow further as the product electrification and connectivity will continue. The increasing complexity due to an increasing number of E&E components in the products induces a challenge for the supply chain as the value chain gets more complicated. This may constitute future problems for downstream stakeholders to declare the Bill of Material (BOM) and substance content in conformance to the advancing environmental regulations (Rojo et al., 2009). Furthermore, complications can also be induced by discrepancies of interest between an OBM and suppliers as the supplier may have few incentives to allocate resources producing obsolete E&E components for an OBM with low bargain power generated by low order volumes.

These shifting technological and market preconditions put pressure on companies to be able to understand when E&E components included in their product portfolio will be obsolete to work proactively to mitigate rising complications. Issues related to E&E components in the shed of this new business environment could be bridged by better organizational understanding and actions within the management of obsolescence.

1.2 Purpose

The purpose of this thesis is to provide knowledge of obsolescence management of E&E components so that OBMs can ensure availability of E&E components in products with long manufacturing and support life cycles. Furthermore, the thesis aims to assess how an OBM could act when facing issues of E&E component obsolescence and what actions could be implemented to mitigate the consequential impact.

1.3 Research Questions

To ensure fulfillment of the purpose of this thesis, the following main research question (RQ) and two supporting sub-research questions (SQ) will be addressed.

RQ: *How can an OBM ensure available supply of E&E components with short procurement lifetime in products with long manufacturing and support life cycles?*

A short procurement lifetime for E&E components in products with long manufacturing and support life cycles will eventually result in the components being non-procurable, i.e. no longer obtainable from the original manufacturer or supplier.

The situation where an E&E component is included in a product but no longer is manufactured or possible to procure makes the component obsolete. By addressing the obsolescence of E&E components, which is elaborated in the two SQs below, the main RQ of how available supply of E&E components can be ensured is answered.

SQ1: *What common obsolescence issues does an OBM face in the procurement of the components mentioned in the RQ and what measures are being made today?*

SQ2: *How can an OBM develop strategies to improve current and future procurement to mitigate obsolescence issues related to the components mentioned in the RQ?*

1.4 Delimitations of Scope

The scope of this thesis is limited within certain areas to focus the study and to ensure that outcome will be aligned with the research questions. The areas which are being considered are the applicability of the thesis findings and recommendation, the relevance of industries, the context of validity, and the time frame.

The thesis scope is limited to only include findings from companies in relevant industries with similar outset as Alpha to make the findings contextually appropriate; the outset being the issues of life cycle mismatch between E&E components and products. As of this, the qualitative data collection based on interviews is limited to nine companies within similar industries.

Furthermore, it is possible that the outcome can be generalized outside the scope of the thesis, but further research is then needed. The recommendations of this thesis are made based on the available information and knowledge possessed during the given time of reference. Thus the findings and insights may be obsolete and in need of revision sometime after this thesis has been published. Therefore, this thesis should be regarded as a foundation for continued strategic work and should not be regarded as an unquestionable truth. Moreover, not all stakeholders in the organizational process have been accounted for, hence there might be gaps in the applicability of the thesis recommendation in a broader corporate context. All results presented in the outcome are acquired in the context of Alpha and can therefore not be assumed to be generally applicable, even though several aspects surely will be beneficial for other companies and industries to contemplate.

1.5 Disposition

This section serves the purpose of supporting the reader in the navigation through the thesis with a holistic view of the thesis disposition and content of the different chapters.

Chapter 1 - Introduction

This chapter introduces the background to the topics of this thesis as well as a description of the industry and context in which Alpha operates. Moreover, the purpose of the thesis is presented in addition to the research questions that it aims to answer. Lastly, the scope and delimitations of the thesis are presented.

Chapter 2 - Theoretical Framework

This chapter aims to provide the reader with the necessary knowledge basis of the research topic to better understand the context and analysis presented further on. The chapter consists of an introduction to Product Life Cycle Management, Obsolescence, Obsolescence Management and is concluded with a summary of the theory.

Chapter 3 - Methodology

The methodology chapters introduce the reader to the research strategy, research design, data collection, analysis of data as well as reliability and validity considerations in the conduct of the thesis.

Chapter 4 - Empirical Findings

This chapter presents the findings and insights from the conducted case study. It consists of three sections, one for each phase conducted, and a concluding summary. The first section aims to answer SQ1 by presenting the outcome and insight from the internal interviews within Alpha's purchasing and R&D departments, as well as within the tier 1 supplier base. The second section concerns SQ2 and consists of the outcome and insights from the interviews with representatives from others companies in order to establish a best practices in the management of obsolescence.

Chapter 5 - Discussion

The discussion chapter presents the findings and insight from the empirical findings and provides an analysis them in the context of the theoretical framework to answer the research questions and fulfill the purpose of the thesis.

Chapter 6 - Conclusion

This final chapter wraps up the thesis with a conclusion of the conduct and gained insights that answer the research questions and fulfills the purpose. Moreover, recommendations to Alpha are presented in addition to suggestions for further research.

2

Theoretical Framework

The following chapter presents the theoretical framework which is the foundation for the analysis and the conclusion of the thesis. Moreover, the chapter aims to give insight into key concepts needed to get a comprehensive understanding of the frame of analysis. The first section (2.1) introduces Product Life Cycle Management in general and then focuses on implications for the life cycles of E&E components, i.e. Electronic Part Life Cycle. The next section (2.2) presents the causes of obsolescence and electronic component obsolescence. The third section (2.3) introduces the reactive, proactive, and strategic approaches of obsolescence management, thus, how a company could act to mitigate the complications of E&E component obsolescence. The chapter is concluded with a summary of theory, summarizing the key concepts for the analysis.

2.1 Product Life Cycle Management

Product Life Cycle Management (PLM) is a term that has changed considerably during the latter half of the 21st century. When researching and discussing PLM, one has to bear in mind that the term can mean different things to different actors depending on the context (Cao & Folan, 2012). The term was at first connected to the 1950s' frameworks related to the different market characteristics of a product, its needs, and conceptions. This model mainly focuses on the economic aspects of the four product phases of *Market Development, Growth, Maturity* and *Decline*, in relation to time on market and sales volume, depicted in Figure 2.1.

Cao and Folan (2012) further present that in the conception of PLM, its purpose was to produce a coherent framework that could relate to a product's relative success or failure on the market. This involves how to adapt the strategies of e.g. pricing, manufacturing, marketing investments, and eventual discontinuance to the respective phase the product endures. The different phases are explained further in Table 2.1.

Bartels et al. (2012) and Cao and Folan (2012) describe that an extension of the product life cycle can be prolonged by continued promotion and market development into new customer groups, as well as refurbishment and functional upgrading of the design. By doing this, the company would benefit from an existing product

Table 2.1: The Different Phases in the Product Life Cycle

Type of Phase	**Description**	**Characteristics**
Market Development	The introductory phase is when a product is launched to the market. The focus of this phase is to gain market share, acceptance and make potential customers aware of its existence and benefits for the user.	High costs due to market promotion investments. Low competition, sales growth, sales volumes, and profit margin.
Growth	This phase is where the sales growth is increasing substantially due to an increased market acceptance. As the market awareness and size increase, so does the competition. A larger product supply decreases prices	Reduced costs per unit sold and significant growth in sales volume leads to higher profit margin.
Maturity	The maturity phase is signified by stagnating sales growth and focus has shifted from market penetration and development to profit optimization. Cost-cutting is prominent. Competition has begun to shrink as the market sales initiate its volume decline.	Higher profit margins, stagnant growth in sales volume. Low overall costs, the low need for promotion, and fewer competitors.
Decline	This is the phase where there is clear negative growth in sales volume. The prices decreases due to obsolete products and lower volume lead to a cost increase. To be successful in this phase efficiency in production and distribution is key. However, an extension of a product lifetime is possible due to product re-development, meaning that the product can be relevant on the market for a longer period.	Decreasing sales volume and profit. Rising overall cost.

Note. Adapted from Cao and Folan (2012).

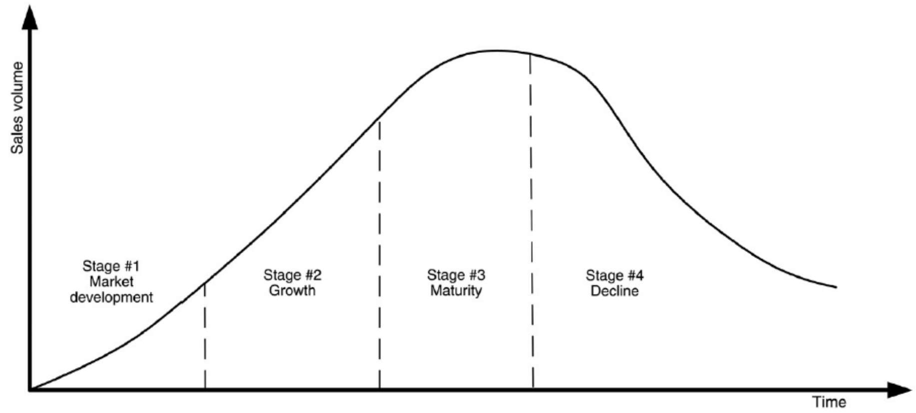

Figure 2.1: Life Cycle Curve and Phases of a Typical Product. Source: Cao and Folan (2012)

platform, meeting customer value expectations with relatively low development costs compared to launching new product designs. However, one has to consider that this is not applicable for all situations where products are being phased out (Bartels et al., 2012; Cao & Folan, 2012).

A more recent form of PLM theory emerged when the need of managing the product life became increasingly important as the product systems got ever more complex (Cao & Folan, 2012). This PLM theory was first developed and implemented by the US Department of Defence to increase the effectiveness in the procurement process. Cao and Folan (2012) argue that it was essential to include the whole life cycle cost of the product system and not only the initial purchasing costs, such as uptime support and decommissioning. Moreover, the different life faces such as Beginning of Life, Middle of Life, and End of Life was coined. The monitoring of the life cycles was enabled by innovations in information technology that created crucial enterprise infrastructures. As of today, PLM software is very much integrated into business central infrastructure along with Customer Relations Management, Supply Chain Management, Enterprise Resource Management, and Product Data Management. From being a tool of managing marketing effectively, PLM has evolved during the decades to be a fully integrated product and business management system to optimize the full broadness of a company's operations, from procurement and product conception to product decommission. (Bartels et al., 2012; Cao & Folan, 2012).

In summary, PLM was initially developed in a macro perspective and aimed to visualize the strategical nature of the product's business life cycle. The theory is applicable when forecasting and managing market supply. Later on, it was introduced by companies to handle the life cycle on a detailed level to manage the growing product complexity. This aspect of PLM focuses on how to manage individual product life cycles by proactively monitoring their lifetime from development to phase out and thereby mitigating complications on a holistic level. The following section will introduce Electronic Part Life Cycle, which describes the lifetime mismatch problems in products including E&E components.

2.1.1 Electronic Part Life Cycle

The electronics industry is currently one of the most dynamic industries in the global economy. According to Bartels et al. (2012), the massive growth, investments and competition among the manufacturers have been spurred by increasing demand from new innovative technologies dependent on electronic hardware. New E&E components are being introduced to the market ever more rapidly with the demand of reduced size, differentiation, customization and with increased functionality, leading to growing complexity. As a consequence, the functional relevance period of E&E components is shrinking as more upgraded components become available.

Furthermore, Bartels et al. (2012) present growing issues that are becoming a concern for product manufacturers using E&E components. The author explains that in companies handling products of long life cycles, the included E&E components have a significantly shorter life cycle than that of the product. This life cycle discrepancy is the root of the E&E components obsolescence discussed in the following sections.

Bartels et al. (2012) illustrates the problem of obsolescence with an example. The automotive sector in the present global market is dependent on the same components and suppliers as the higher volume consumer electronics market. The component life cycle is normally around two to three years while the procurement life and supply availability needs to be much longer. As the automotive manufacturers are not relatively huge buyers of the components, the electronics manufacturers tend to refocus their production and consolidate capacity for new technology components demanded from the high volume customers, i.e. the consumer electronics market. This creates supply challenges for the automotive sector. When the original component supply from electronics OEMs disappear, the component turns obsolete as its procurement availability diminishes. A component aftermarket will emerge and the components will typically remain purchasable for usage for a longer period. However, it will entail high cost due to lower economy of scale, requalification and eventual function loss over time, rendering it relatively expensive over time (Bartels et al., 2012).

Bartels et al. (2012) explain that E&E component selection in the designing of new products needs more attention as they are the root cause of obsolescence, and one critical component can make a whole product obsolete in the worst case. To give an apprehension of how common obsolescence of E&E components are, Bartels et al. (2012) and Singh and Sandborn (2006) express an eloquent example where up to 70 % of the commercial of the shelf (COTS) components are obsolete before the product is launched to the market, illustrating the lifetime mismatch of when the use of standard components are not customized for the purpose.

In the research of Electronic Part Life Cycle, Huang et al. (2019) present a further developed model of the life cycle curve and phases presented earlier by Cao and Folan (2012) (see Figure 2.1). This modified curve, illustrated in Figure 2.2, is a generalization of the life cycle that E&E components are expected to follow. The phases that are of certain interest to answer the research questions in this thesis are the three last ones: *Decline, Phase-out* and *Obsolescence.* These are the phases where complications typically arise due to the life cycle mismatch (Huang et al., 2019). Note that the units shipped per time, which equate to production volume, on the y-axis is maximized in the maturity phase. Similarly, the inverse units shipped/time curve is valid for the production cost per unit and is a contributing factor for the original manufacturers of E&E components to phase-out production to readjust for new high volume components (Bartels et al., 2012; Huang et al., 2019; Sandborn, 2013; Solomon et al., 2000). Relating to the findings of Cao and Folan (2012), the authors previously mentioned demonstrates a model of the Electronic Part Life Cycle presented in Figure 2.2. The theory of Electronic Part Life Cycle proposes how to effectively managing life cycle concerns in different phases. These actions will be described later in the next following sections.

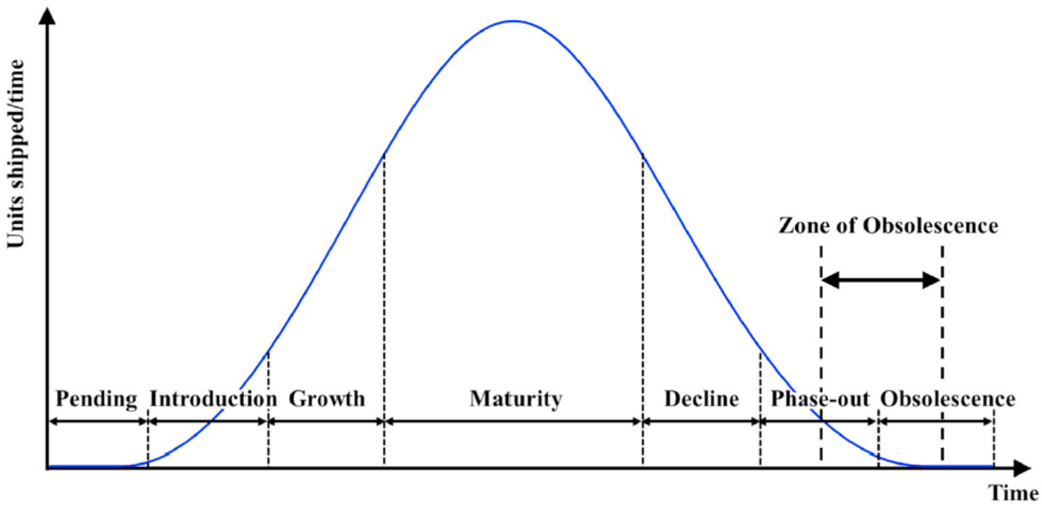

Figure 2.2: Curve of the Life Cycle of a Typical E&E Component. Source: Huang et al. (2019)

According to Huang et al. (2019), the occurrence of obsolescence begins in the phase-out when the original manufacturer of E&E components decides to end component production. Table 2.2 gives a more explicit description of the typical characteristics that define the last phases in Figure 2.2. Huang et al. (2019) and Bartels et al. (2012) agree that during these last phases, companies dependent on the components facing obsolescence need to plan and monitor how to handle and mitigate eventual complications that might affect their products. This could be done by proactively monitoring the company product portfolios and the including product's life cycles to secure the supply of E&E components throughout the product life.

Table 2.2: Final Phases in the E&E Component Life Cycle

Phase	Description
Decline	This phase is defined by lowering profit margin for the components as the loss of production volume causes an increase in cost per unit sold, this trend continues until the product is fully obsolete. As a consequence, the number of original component manufacturers decreases, creating a more limited supply on the market need.
Phase-Out	In this phase, the last manufacturers end production and shift production to other components more aligned to the future market demand. Thereby, a Part Discontinuance Notice (PDN) is sent out downstream to offer last time buy and suggesting alternative substitute components for the aftermarket. Components are usually still available on the market the supply tend to shift to secondary sources such as stockpiling component brokers and Electronics Manufacturing Services (EMS).
Obsolescence	In this phase no more components are produced to supply the demand from customers downstream and for aftermarket services. The obsolescence zone of the components is a fact either when the manufacturing has stopped or when reliability concerns make the component unusable for new products. Note that the obsolescence happens on a component level whereas the discontinuance of a product occurs at the individual manufacturer.

Note. Adapted from Huang et al. (2019).

2.2 Obsolescence

Obsolescence refers to the situation where materials, components, parts, devices, services, and processes are no longer obtainable, i.e. non-procurable, from their original manufacturer or supplier (Bartels et al., 2012). Obsolescence in a product system is further described as the result of a situation where a specific component is required for production or maintenance, but that specific component is no longer manufactured or possible to procure. This situation leads to the loss of manufacturers or suppliers of that specific component, which makes the component obsolete. When obsolescence occurs, it leads to a supply shortfall where the demand of customers and users cannot be satisfied (Bartels et al., 2012). Obsolescence caused by the unavailability of components or technologies required for manufacturing and support of a product system is also referred to as Diminishing Manufacturing Sources and Material Shortages (DMSMS) (Bartels et al., 2012; Sandborn, 2013). DMSMS is the result of the situation where components needed to support the product system become unavailable before the end of demand for manufacturing and support of the product system (Sandborn, 2013). Based on the definitions of obsolescence and DMSMS, the terms are deemed interchangeable in this thesis and will henceforth be described as obsolescence.

There exist different types of obsolescence, and the classification of types into different categories illustrates the breadth and variety of the term (see Table 2.3).

Table 2.3: Types of Obsolescence

Type of Obsolescence	Definition
Logistical Obsolescence	Occurs when the ability to procure components, services, and processes, etc. needed for the manufacturing and support of a product is lost.
Functional Obsolescence	Occurs when the specific requirements of a product have changed and result in an obsolete function, performance, or reliability despite having the components, services, and processes, etc. needed for manufacturing and support.
Technological Obsolescence	Occurs when the supply of older components needed for manufacturing and support of a product no longer is available due to the replacement of newer and more technologically advanced components.

Note. Adapted from Bartels et al. (2012).

Obsolescence can also be categorized based on why it occurs (see Table 2.4). Bartels et al. (2012) argue that it is essential to understand both the different types of obsolescence and why obsolescence happens to develop strategies for managing obsolescence. Obsolescence becomes an issue for an organization when the causes lead to involuntary effects in terms of change in products manufactured, maintained, and supported by the organization (Sandborn et al., 2011).

Table 2.4: Causes of Obsolescence

Cause of Obsolescence	**Definition**
Technological Evolution	A new generation of technology replaces an older one which results in the obsolescence of the old technology. In general, the newer generation of technology has an improved function and performance at a lower cost.
Technological Revolutions	A completely new technology makes its predecessor obsolete. Technological revolutions are strongly linked to technological shifts and innovation.
Market Forces	A fall in market demand for technology or component leads to a manufacturing discontinuance of production due to a lack of economic viability for the manufacturer.
Environmental Policies and Restrictions	Governmental legislation and restrictions on material usage, waste, and substances of concern can cause obsolescence in products and components.
Allocation	Long product or component lead times can result in temporary unavailability of products or components. This temporary unavailability is a type of temporary obsolescence often associated with short-term supply chain disruption. Allocation obsolescence can be caused by different reasons, e.g. market disruptions, economic recession, and natural disasters.
Planned Obsolescence	A method where obsolescence is consciously designed into a product to stimulate customer demand and repetitive consumption. It limits the durability of the product and is also referred to as built-in obsolescence.

Note. Adapted from Bartels et al. (2012).

2.2.1 Electronic Component Obsolescence

The growth and development of the electronics industry has lead to obsolescence of E&E components, which can be illustrated by the situation where the procurement life cycles of E&E components are significantly shorter than the manufacturing and support life cycle of the product they support (Bartels et al., 2012; Solomon et al., 2000). Sandborn (2013) suggests that E&E components are heavily affected by obsolescence issues since the procurement life of E&E components can in some cases be less than one year. Bartels et al. (2012) share the opinion that the short procurement life cycles of E&E components is a major cause of obsolescence and adds that the effect of obsolescence on supportability and readiness is more evident for E&E components.

In the theory of E&E component obsolescence, sustainment-dominated systems is frequently occurring in research (Rojo et al., 2009; Sandborn, 2013; Singh & Sandborn, 2006; Solomon et al., 2000). Sustainment-dominated systems are product systems where the cost of support and maintenance in the life cycle exceeds the costs of manufacturing and procurement (e.g. avionics and military systems) (Sandborn, 2013; Singh & Sandborn, 2006). These product systems are characterized by being low volume and long-term, with requirements of being manufactured and supported for long periods (Rojo et al., 2009; Sandborn, 2013). The aspect of these product systems being long-term makes them sensitive for obsolescence issues where obsolete components have a high impact (Rojo et al., 2009). The obsolescence of E&E components is a major cost driver in long-term product systems where the requirements of sustainment (i.e. support and maintenance) lead to high life cycle costs (Singh & Sandborn, 2006; Solomon et al., 2000). The low production volumes of sustainment-dominated systems and long field life products result in low control over the supply chain for E&E components which add to the sensitivity of obsolescence (Sandborn et al., 2011; Sandborn, 2013).

E&E components and products are exposed to all of the different types of obsolescence (see Table 2.3). Furthermore, E&E component and product obsolescence can be exemplified in the context of the different causes of obsolescence (see Table 2.4). The technical evolution of a new generation of electronic components and products render old ones obsolete (e.g. faster microprocessors), opposite to technical revolutions where a completely new technology replaces an old one (e.g. DVD replacing VHS) (Bartels et al., 2012).

Conditions in the market environment affect the obsolescence of E&E components and products. Obsolescence due to market forces and changes in market demand is an increasing problem for low-volume markets since convincing suppliers to maintain production or keep stock of low-volume components is rarely economically justifiable for the supplier (Bartels et al., 2012). Furthermore, obsolescence due to allocation occurs for E&E components and can be illustrated by how the earthquake in Japan 2011 resulted in longer lead times and shortages of E&E components in the market due to the impact on electronic component manufacturer's facilities, employees, infrastructure, etc. (Bartels et al., 2012).

There exist several environmental policies, restrictions, and regulations that affect electronic components and products, such as the *Waste Electrical and Electronic Equipment* (WEEE), the *Restriction on Hazardous Substances* (RoHS), and the *Registration, Evaluation, Authorization, and Restriction of Chemicals* (REACH) (Bartels et al., 2012; Huang et al., 2019; Rojo et al., 2009). New policies, restrictions, and regulations on environmental aspects often generate obsolescence in materials and manufacturing processes (Rojo et al., 2009). RoHS concerns the majority of electronic components and products, and one example of the RoHS directive is how it limits the usage of lead (Pb), which has been common in E&E components (Bartels et al., 2012).

2.3 Obsolescence Management

Obsolescence Management (OM) is the process of mitigating or avoiding the shortfall in the supply of components in the life cycle of a product (Bartels et al., 2012). Managing obsolescence is a continuous process with focus on quality improvement, where the process of OM can be structured based on the Plan-Do-Check-Act (PDCA) cycle according to Bartels et al. (2012) (see Figure 2.3). OM according to the PDCA cycle highlights the importance of having a plan for obsolescence, with the different steps of *planning* for obsolescence, *designing (do)* for obsolescence, *checking* for obsolescence, and *acting* according to the plan.

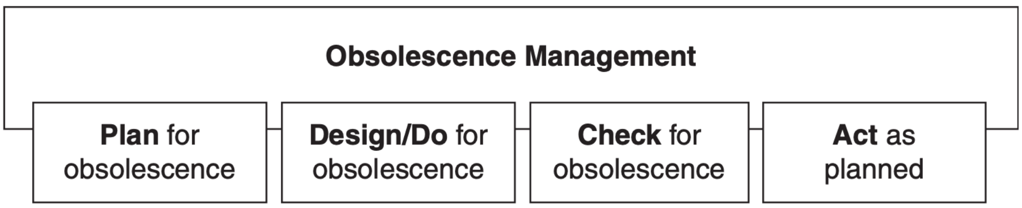

Figure 2.3: Process Steps of Obsolescence Management. Source: Bartels et al. (2012)

Management of obsolescence requires three different areas of management: reactive, proactive, and strategic management (Bartels et al., 2012; Sandborn, 2008, 2013). In general, OM in companies and organizations are dominated by and focused on reactive activities and measures (Rojo et al., 2009; Sandborn et al., 2011; Sandborn, 2013), managing obsolescence issues after they have occurred (Sandborn et al., 2011; Singh & Sandborn, 2006). While the reactive part of OM is important, avoiding costs related to mitigating obsolescence and sustaining product systems can be attained to a higher degree with an OM strategy including proactive and strategic approaches (Sandborn et al., 2011; Singh & Sandborn, 2006). Sandborn (2008) argues that the best way of maximizing cost avoidance is by utilizing an OM including all three management areas.

The three different areas of OM including their relations and outputs are illustrated in Figure 2.4. Beyond the reactive management, i.e. managing issues of obsolescence by applying methods of mitigation when they have occurred, proactive and strategic management are important parts of OM (Bartels et al., 2012; Sandborn et al., 2011; Sandborn, 2008; Singh & Sandborn, 2006). The proactive area of OM deals with the identification and management of critical components that have a risk of becoming obsolete before the actual obsolescence occurs (Bartels et al., 2012; Sandborn et al., 2011). The criticality of these components is related to risk and the problems that will occur if obsolescence happens, which implies managing the components and risks before they become obsolete (Bartels et al., 2012; Sandborn, 2008). The proactive management can be seen as an evaluation of the status of the system, a measurement of the *health* of the system, where obsolescence forecasting is key (Sandborn, 2008). The strategic area of OM is executed in combination with the reactive and proactive areas. The strategic area of OM aims to create a good combination of reactive mitigation approaches and design refreshes of the products to optimize the life cycles, minimizing cost while still meeting set requirements (Bartels et al., 2012; Sandborn et al., 2011; Sandborn, 2008). The three different areas of OM will be further elaborated upon in the following sections.

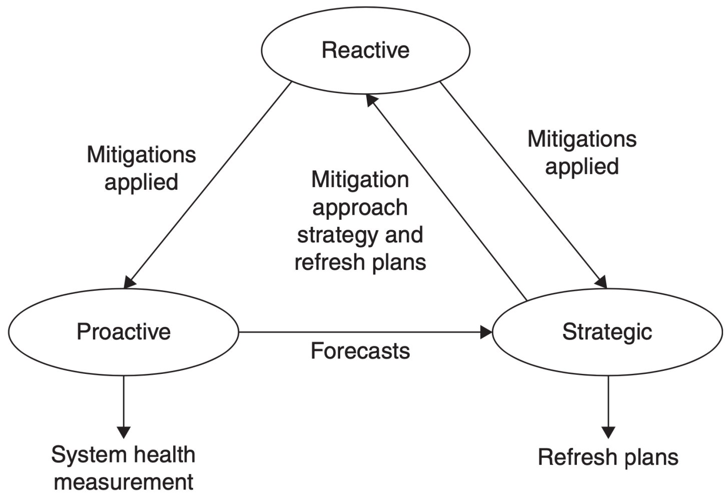

Figure 2.4: The Three Obsolescence Management Areas and Their Outputs. Source: Bartels et al. (2012) and Sandborn (2008, 2013)

2.3.1 Reactive Obsolescence Management

Reactive Obsolescence Management (ROM) is an approach to in the short-term manage and mitigate the occurrence of obsolescence of components by securing component supply until redesign employment or support commitments have been fulfilled (Bartels et al., 2012). Depending on the specific circumstances and pre-condition; such as remaining support life, volume, and complexity, there are several different tools that an organization facing obsolescence could use, described in the following sections. According to Rojo et al. (2009), the ROM must be applied immediately to address the problem to minimize supply shortage or operational disturbance within the organisation. Rojo et al. (2009), Sandborn (2013) and Bartels et al. (2012) all agree that ROM ought to consist of determining an appropriate tool for the component that is already unavailable or will be in the near future, followed by execution of the preferred measure and documentation to map the actions taken for retrospective assessment. Even though the authors emphasize that proactive approaches and strategies to mitigate E&E components obsolescence is preferable, organizations need prepared processes to be in place when the problems occur.

Same Component

This section explains different reactive tools that can be applied when facing ongoing or approaching obsolescence of E&E components, presented in Table 2.5. The approaches are measures feasible when the original component becomes obsolete and an equal is to be used in its place.

Table 2.5: ROM Approaches Regarding Same Component

ROM Approach	**Description**
Negotiation with Manufacturer	Once the E&E component manufacturers decide to phase-out and discontinue it is rarely delayed. However, if the obsolete component is important enough for the customer, there might be possible to negotiate a deal to produce exclusively at a higher price if production volumes can be guaranteed. Another outcome could be that the manufacturer suggests a substitute component or an aftermarket supplier to supply the remaining needs. (Bartels et al., 2012)
Existing Stock	This is a first step reactive approach that should be explored as it is relatively inexpensive to other alternatives. The approach proceeds from quickly securing the stock of the obsolete component still available in one's supply chain to satisfy the demand at least in the short term until a new action is established (Rojo et al., 2009).

Last Time Buy	Last Time Buy (LTB) is a reactive action in which the company acting on obsolescence procures sufficient supply to meet the remaining commitments for the obsolete E&E component. If the remaining commitment is regarding the entire lifetime of the product, the action is also called Life Time Buy. According to Bartels et al. (2012) and Rojo et al. (2009), this is one of the simplest options of mitigating obsolescence considering that re-engineering and eventually accompanied validity tests can be avoided. LTB is typically offered by the supplier as a consequence of a PDN so that customer can bridge their demand until a permanent solution has been established, i.e. a bridge buy. Nonetheless, the LTB measure is also associated with certain risks. The first being dependent on an accurate basis for the decision, it might very difficult to estimate demand far into the future and how much capital one is willing to lock in inventory. It might also be physical limitations on the product that might limit the usage of LTB as the components may have an expiring date or service needs during storage that lack tenability for the customer. There are also cases where the producer or suppliers cannot meet the LTB volumes or sent the information too late to be an attractive alternative.
Aftermarket Sources	If the LTB is not feasible from the original supplier, a company could choose to source the remaining lifetime supply from secondary sources. Those could either be authorized and approved of the said original supplier, or they could be external so-called brokers on the spot market. The first should be prioritized first hand as there are considerable risks of counterfeit and quality concerns when procuring from the spot market. Advantages of using aftermarket sources are the expertise, obsolescence consultation, and available comprehensive services. Such services could be controlled long-term storage of components, risk- and lifetime assessments as well as knowledge building for organizations. (Bartels et al., 2012; Rojo et al., 2009)
Reclamation and Cannibalization	This approach is set in reusing components already available in the current product systems. Reclamation refers to salvage E&E components from unserviceable systems for usage in other in order so short-term meet the demand of components. Similarly, cannibalization refers to cancel of laying of the production or service of another product to meet the commitments on another higher prioritized product. These measures are usually used in the last phase as the last measure, however, they have accompanied risks that the salvaged components might be just as prone to failure as those they are meant to replace.

Component Substitution and Form-Fit-Function Replacement

This section explains different reactive tools that can be applied when facing ongoing or approaching obsolescence of E&E components by replacing the original component with one with the same functions, explained in Table 2.6.

Table 2.6: ROM Approach Regarding Substitution of Components

ROM Approach	Description
Equivalent	A substitute component, which according to Rojo et al. (2009), is functionally, parametrically, and technically interchangeable replacement with the original component without any need of re-qualification. Therefore, the main benefit is the lower cost compared to options such as redesigning and further testing. The main disadvantage is that substituting with an equivalent component is difficult due to the Form-Fit-Function criteria, i.e. that the equivalent component need to have the same form, fit, and function as the original component. It is especially complicated for active semiconductor devices, where the embedded software could be affected by replacements. Passive components are more usual to substitute with equivalents due to lower complexity.
Alternate	Is a substitute component that lacks the same performance as the original components in terms of functionality or quality. Thus testing is often required, which increases costs.
Uprating	Is when a component is chosen for assessment to meet the set requirement even though the manufacturer specification is lower. In other words, a component is being used that by origin is not meant for certain usage. For electronics, the temperature is a common functionality specification that is assessed to fit the new needs

Emulation

According to Bartels et al. (2012), this approach is primarily applicable to electronic components. Emulation components are not aftermarket components but are rather a substitute based on old obsolete components that are being remade and upgraded for a new function. The data for creating or remaking components to this new application is usually based on data such as data sheets or test reports to replicate the functionality of the original components. Rojo et al. (2009) refer to that an emulation also applies to software, where a software interface may allow legacy software to be used. In physical products, an adapter is usually used to bridge legacy COTS components.

Redesign

Redesign is an approach in ROM which involves development or revision of a component to terminate the use or dependency of a component facing obsolescence (Bartels et al., 2012; Huang et al., 2019; Rojo et al., 2009; Sandborn, 2013). The main objective is to improve the components' performance, reliability, maintainability, or design robustness, partly by enabling newer and maybe most important: a greater offering of components. According to Huang et al. (2019) and Rojo et al. (2009), this could be achieved by applying modularized design, thereby enabling standard components to a greater extent. However, the authors all agree that this option is the most expensive and should be considered as a last resort if functionality upgrades are necessary. Redesign is the most long-term of the described ROM approaches. Furthermore, redesign could be technically and economically viable when utilized as a life cycle extension to prolong the market relevance, increasing lifetime profits. According to Bartels et al. (2012), products requiring redesign are inevitable for long-life product systems, and some long-life systems are usually under constant redesigns throughout their remaining life as a consequence of the lifetime mismatch and service requirements of individual components. Therefore, companies providing these types of products must have a clear redesign strategy how to efficiently and cost-effectively manage the needs of a redesign.

Factors to Consider when Choosing a Reactive Approach

When considering choosing to go with a reactive obsolescence problem strategy, Bartels et al. (2012) present different factors to contemplate. One of those might be if the PDN issuance from the supplier in the sense how foresighted the supplier has been to communicate the discontinuance. Thus the time until component unavailability, affecting the preconditions of the reactive approach used. Another factor to consider is the lifetime mismatch, and if the approach is economically justified and technically feasible in the remaining time frame. This choice is also affected future market forecasts and probable product support. Other concerns are volume requirements, the number of products using the obsolete component, and the number of obsolete components remaining in the system, affecting the choices whether to redesign or proceeding with LTB is the most effective measure (Bartels et al., 2012).

2.3.2 Proactive Obsolescence Management

Proactive Obsolescence Management (POM) is the area within OM where information of non-obsolete components is proactively being tracked and managed before the problems related to obsolescence occur (Bartels et al., 2012; Sandborn et al., 2011; Sandborn, 2008). The aim of POM is to proactively mitigate obsolescence risks that could lead to unavailability of components, production stops, and expensive redesigns, etc. Monitoring and tracking of component life cycle information is a part of obsolescence forecasting, which is a main activity within POM (Sandborn et al., 2011; Sandborn, 2008). Besides the forecasting of obsolescence, POM also needs to include processes for reviewing and updating obsolescence status (Sandborn, 2008).

Rojo et al. (2009) argue that several authors within the research of OM advocate for the shift from reactive to more proactive measures in managing obsolescence. While this may be true, Rojo et al. (2009) also highlight the importance of understanding that different parts, components, and products require different levels of proactiveness. The level of proactiveness needed should be evaluated based on an initial risk assessment evaluating the probability of obsolescence and the cost impact of occurring obsolescence. If the impact on cost is low (e.g. due to form-fit-function replacement), it may be advisable to manage the obsolescence strictly reactive. If the impact on cost is high, the need for proactiveness is higher to avoid costs. When a part, component, or product has both a high impact on cost and a high probability of obsolescence, it can be categorized as *critical* and proactive measures should be emphasized (Rojo et al., 2009).

In addition to the different needs for proactiveness described by Rojo et al. (2009), a key limiting factor in POM and obsolescence forecasting is the resources of a company or an organization (Bartels et al., 2012). Since an organization will not have the resources to proactively manage all components and products, there is a need for identifying and prioritizing critical components (Bartels et al., 2012). According to Bartels et al. (2012) and Sandborn (2008), the criticality of a component is based on the risk of going obsolete, the availability after obsolescence, and how problematic it will be when they become obsolete.

In order to focus resources and decide the level of proactiveness needed, set responsibilities and a process for POM is needed. Meyer et al. (2004) argue that within OM, there is a lack of participation in obsolescence teams and project structures for managing planning, monitoring, and controlling obsolescence. Bartels et al. (2012) recommend participation in an obsolescence management board from different functions and departments in the POM process to provide expert knowledge in different areas. The obsolescence management board is equivalent to the obsolescence teams mentioned by Meyer et al. (2004). For the responsible obsolescence team in an organization, Bartels et al. (2012) are proposing key steps for a POM process:

1. Product Selection
2. Risk Analysis
3. Prioritization
4. Selection
5. Availability Monitoring
6. ROM Initiation
7. Reprioritization

The first step of selecting products of focus is a strategic decision relating to the limiting factor of scarce resources. When the initial component or product selection is done, an obsolescence risk analysis is done on the whole BOM. Based on the data from the initial risk analysis, a prioritization of components in need for POM should be established. The components in need for POM should then be selected and monitored on their availability. The initiation of ROM refers to the reactive measures launched when the components not chosen for proactive measures become obsolete and need resolution. The last step of reprioritization highlights the need for a continuous update of selection and prioritization of components, products, and parts in need for obsolescence monitoring and ROM (Bartels et al., 2012).

Obsolescence Forecasting

Obsolescence forecasting aims to inform on the future availability, possible alternatives, and critical single-sourcing of the components in the BOM of the selected components or products. The risk analysis provides information on BOM data such as the forecast on availability and obsolescence, identification of risks, and gives an overall health status of the system (Bartels et al., 2012). While the obsolescence risk analysis and forecasting of obsolescence are important during the whole life cycle of a product, an initial analysis is vital to avoid the inclusion of obsolete or soon-to-be-obsolete components in the final design (Bartels et al., 2012; Rojo et al., 2009). Bartels et al. (2012) argue that the POM and analysis of obsolescence risks needs to start early in the design stage before the process of qualification has begun to avoid unnecessary cost related to requalification.

When forecasting obsolescence, the most common way of working for organizations is by utilizing the product BOMs to avoid the selection of obsolete components with the imminent risk of obsolescence (Sandborn, 2013). The management of BOMs can be done in several ways, but common approaches are the use of commercial tools and databases (Bartels et al., 2012; Rojo et al., 2009). Rojo et al. (2009) describe that many organizations that proactively manage obsolescence are implementing commercial tools which allow for the monitoring of all components in a BOM. Furthermore, online databases can be utilized similarly by uploading BOM lists and receiving relevant obsolescence information (Bartels et al., 2012).

The results of the obsolescence risk analysis should be summarized and compiled into a material risk index (MRI), which is often provided by the tool or database (Bartels et al., 2012; Singh & Sandborn, 2006). The MRI is a score describing the level of obsolescence risk for each component in the BOM. In general, the classification of the MRI categorizes a component as red if it is obsolete or recommended for redesign, orange if future availability does not meet requirements or is single-sourced, blue if no information is available, and green if no risk is identified (Bartels et al., 2012).

To achieve effective POM, the information from the forecast and risk analysis need to be up to date to achieve accurate component MRI (Bartels et al., 2012). Conducting the risk analysis and forecasts regularly is equivalent to monitoring component availability. The frequency of tracking the component availability is dependent on the need for monitoring. If a product or part includes critical components, risk analysis, and obsolescence forecasting need to be done on a more frequent basis. If a product or part does not include critical components, risk analysis, and obsolescence forecasting can be executed less often (Bartels et al., 2012).

2.3.3 Strategic Obsolescence Management

Strategic Obsolescence Management (SOM) is used in addition to reactive and proactive management and involves planning and optimization of the use of different obsolescence mitigation approaches to minimize the life cycle cost while at the same time meeting set functional requirements (Sandborn et al., 2011; Sandborn, 2008). According to Bartels et al. (2012), SOM constitutes of using available technology and obsolescence forecast data as well as supply chain input to enable strategic planning and optimization of the life cycle. The author further explains that a prerequisite to succeed in obsolescence mitigation is to develop plans and processes to be followed throughout the life cycle in design, production, and aftermarket support.

As described earlier, ROM is an important tool to handle an unplanned obsolescence situation and is a must in an organization. However, the reactive approaches may be very costly over the lifetime of a product, in addition to the risk of not being able to handle component unavailability throughout the life cycle. Thus, SOM is needed to avoid obsolescence from conception, but could also be applied throughout the life cycle with the PDCA improvement, as presented by 2.3. The most effective way to mitigate obsolescence is to design for obsolescence in the early design phase and thereby prohibit root cause effect later on in the life cycle. Furthermore, emphasis is to accommodate rapid component changes to streamline design and production processes in all product levels to efficiently mitigate obsolescence and associating costs. (Bartels et al., 2012).

The strategic approach revolves around building an obsolescence business case where project management is applied to facilitate a mitigation process. The following SOM concept process presented by (Bartels et al., 2012) is structured and formulated in the following four stages:

1. *Initiation Stage:* Is established to determine the problem definition and analysis of the current situation. The stage involves the building of an obsolescence knowledge base by auditing conditions within the organization, in addition to raising awareness.

2. *Planning and Design Stage:* Involves the assessment and decisions to identifying weaknesses, risks, and causes related to obsolescence. These inputs are used to develop an obsolescence plan as a part of the SOM. This phase emphasizes making product developers acknowledge the importance of design products to avoid obsolescence as well as process analysis to enhance the product quality and supportability of the life cycle (Bartels et al., 2012). Technical roadmapping is also input on how to manage and screen new and phased-out technologies (Rojo et al., 2009).

3. *Execution Stage:* This stage revolves around the execution of obsolescence actions, strategical operations and leads of the obsolescence management. One approach is to conduct forecasting of the product life cycle, relating to planning, and continuously assessing requirement fulfillment and supportability from the conception and throughout the remaining service life. This constitutes of performing a component risk assessment to avoid obsolescence and receive early warnings of imminent obsolescence. A parallel action to apply is forecasting of the market trends to include external influences on the products. Design refresh planning is applicable to effectively handle the design adjust-

ments and to minimize the needed resources and testing, of which both induce high costs. Furthermore, the most common approach is to perform design refreshes. Singh and Sandborn (2006) present a plan in Figure 2.5 where design refresh planning is combined with other obsolescence mitigation actions. Another action to strategically mitigate the occurrence of obsolescence is to implement a rigid component selection process in the design stage, e.g. a preferred component list, to clarify what components are applicable for usage. This way, the selection is optimized to ensure long-term usage. However, such a process demands sophisticated collaboration with the suppliers to provide availability and supply. Bartels et al. (2012) additionally suggest that a well-functioning supplier management is a critical aspect to effectively manage to mitigate obsolescence. The key is to ensure that the relevant Part Change Notice (PCN)s and Part Discontinuance Notice (PDN)s reach the organization on time to be acted upon accordingly. Contractual language is needed to ensure effective communication and clarify agreed responsibilities between supplier and customer. Besides confirming flow of PCN and PDN information, Bartels et al. (2012) suggest that the contractual policies could mitigate obsolescence by making the suppliers share the responsibility of solving problems, including sharing cost and resources. Lastly, suppliers may ensure component availability, securing of inventory as well as maintenance support for the customer. Rojo et al. (2009) further address that partnering agreements are advisable for ensuring continuous support and provision of components. Both Bartels et al. (2012) and Rojo et al. (2009) suggest that usage of standardized components and modularization of the product system architecture, if viable, is an excellent tool to minimize the system redesign impact. Having a design for obsolescence strategy may therefore be favorable.

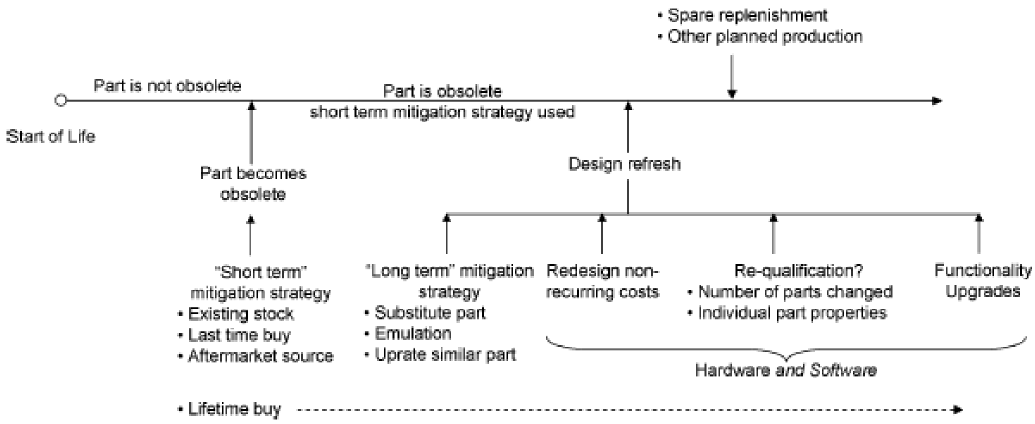

Figure 2.5: Design Refresh Planning Analysis Timeline. Source: Singh and Sandborn (2006)

4. *Monitoring and Controlling Stage:* This stage is intended to define, analyze and evaluate the cost of OM. The approach is assessing their cost-effectiveness, i.e. how much net benefit could be achieved by determining the output value of benefits relative to the input value of costs.

2.4 Summary of Theory

In this chapter, the theoretical framework is summarized to present a comprehensive portrayal of the theory presented. The theoretical framework begins with an introduction to the general concepts of Product Life Cycle Management, where the characteristics of the four product phases of *Market Development, Growth, Maturity* and *Decline* is introduced along with its purpose of managing product complexity throughout the life cycle. Moreover, the more focused perspective of the Electronic Part Life Cycle is introduced where the additional phases of *Phase-out* and *Obsolescence* are presented. Here, the complications of the life cycle mismatch between products and E&E components are described. E&E components invoke challenges of ensuring supply for companies as the components increasingly become more utilized in products, while at the same time having a short procurement lifetime in relation to the product life cycle, illustrated in Figure 2.6. This life cycle mismatch is further escalated by the shrinking life cycle of E&E components. The lifetime mismatch produces the problem that components, parts, materials, services, and processes may no longer be obtainable, i.e. non-procurable from the original manufacturer. This results in E&E component obsolescence, which is described as a major cost driver in long-life product systems. To manage these obsolescence issues, the theory of Obsolescence Management is presented. The theory of OM and its including areas are connected to the empirical findings and create a foundation for the discussion and conclusion of this master thesis.

Obsolescence Management (OM) is described as the process of mitigating or avoiding the shortfall in supply of components and material in the life cycle of a product (Bartels et al., 2012). According to Bartels et al. (2012) and Sandborn (2008, 2013), OM requires three different areas of management: reactive, proactive, and strategic management, see Table 2.7. In general, OM in companies and organizations are dominated by and focused on reactive activities and measures (Rojo et al., 2009; Sandborn et al., 2011; Sandborn, 2013), managing obsolescence issues after they have occurred (Sandborn et al., 2011; Singh & Sandborn, 2006). While the reactive part of OM is important, avoiding costs related to mitigating obsolescence and sustaining product systems can be attained to a higher degree with an OM strategy including proactive and strategic approaches (Sandborn et al., 2011; Singh & Sandborn, 2006).

The three areas of OM have different functions in the management of obsolescence. The areas of OM can be linked to the different phases in the life cycle curve, see Figure 2.6. ROM can be linked to the final phases in the life cycle curve, i.e *Decline*, *Phase-out*, and *Obsolescence*. ROM approaches are to be utilized in the proximity of the *Zone of Obsolescence*, i.e. when E&E components are, or soon-to-be, obsolete which occurs at the end of the life cycle. POM is foremost linked to the early and mid phases of the life cycle, i.e. *Pending*, *Introduction*, *Growth*, and *Maturity*. The POM processes cover tracking and managing information of components before the problems related to obsolescence occur, i.e. before the component has reached the *Zone of Obsolescence*, to mitigate the occurrence of obsolescence already in the

Table 2.7: Summary of the Three Obsolescence Management Areas

Obsolescence Management Area	**Description**	**Key Activities**
Reactive Obsolescence Management (ROM)	Reactive and short-term management and mitigation of components that are, or soon-to-be, obsolete by securing component supply. Rojo et al. (2009), Sandborn (2013) and Bartels et al. (2012) all agree that ROM ought to consist of determining an appropriate tool for the component that is already unavailable or will be in the near future, followed by execution of the preferred measure and documentation to map the actions taken for retrospective assessment.	Key ROM approaches: • Same Component • component Substitution and FFF Replacement • Emulation • Redesign
Proactive Obsolescence Management (POM)	The process of proactively tracking and managing information of components before the problems related to obsolescence occur (Bartels et al., 2012; Sandborn et al., 2011; Sandborn, 2008). Includes processes of forecasting obsolescence, reviewing, and updating obsolescence status of components.	Key steps in a POM process: 1. Product Selection 2. Risk Analysis 3. Prioritization 4. Selection 5. Availability Monitoring 6. ROM Initiation 7. Reprioritization
Strategic Obsolescence Management (SOM)	Used in addition to ROM and POM and involves planning and optimizing the use of different obsolescence mitigation approaches to minimize the life cycle cost while meeting set system requirements (Sandborn et al., 2011; Sandborn, 2008). SOM constitutes in using available technology and obsolescence forecast data as well as supply chain input to enable strategic planning and optimization of the life cycle (Bartels et al., 2012).	Key steps in a SOM process: 1. Initiation Stage 2. Planning and Design Stage 3. Execution Stage 4. Monitoring and Controlling Stage

early life cycle phases. POM also covers the phases of *Decline* and *Phase-out* in some aspects, since the the transition to and initiation of ROM occurs in the *Zone of Obsolescence*. The information of obsolete E&E components is also utilized in the reprioritization of critical components in future projects. SOM can be linked to the entire life cycle curve and covers all of the including life cycle phases. SOM constitutes in using available technology and obsolescence forecast data as well as supply chain input to enable strategic planning and optimization of the entire life cycle. There is a need to develop plans and processes to be followed throughout the life cycle in design, series production, and aftermarket support and services.

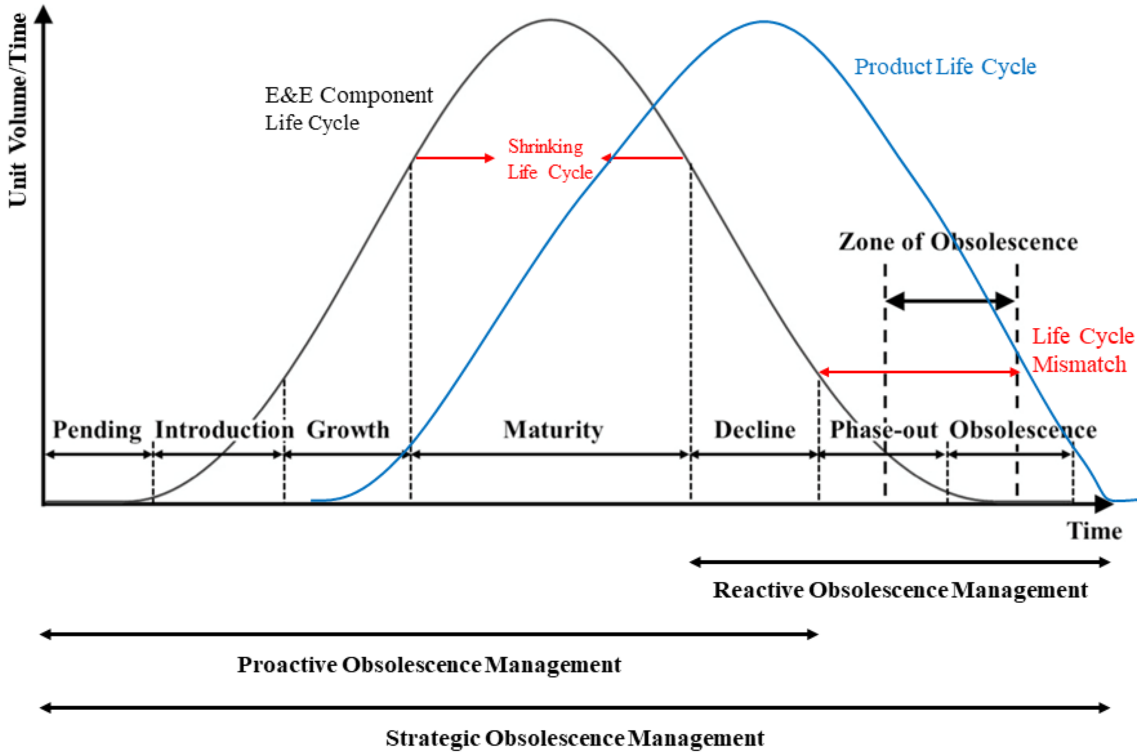

Figure 2.6: The Mismatch Between Component and Product Life Cycles and the Position of the Three Obsolescence Management Areas. Adapted from Huang et al. (2019)

3

Methodology

This chapter presents the methodology of this thesis, consisting of research strategy, research design, research methods, methods for data collection, analysis of data, reliability and validity and other courses of action conducted in this research. The decisions made are presented with support from complementary theory.

3.1 Research Strategy

This research aims to provide learnings and insights to expand on the current research within the subject of obsolescence and OM. These new learnings and insights are to be regarded as theory generated by the outcome of the conducted research. The nature of this research is therefore to be regarded as primarily inductive since it will generate new theory based on the observations and findings in the research (Bryman & Bell, 2015).

The approach of induction in the research is linked with the defined purpose and intended outcome of the research. The aim of providing knowledge of obsolescence management of E&E components and guidance on how to act when facing issues of E&E component obsolescence implies a lack of knowledge in the existing literature of these research areas. There exists literature in the obsolescence management of E&E components, but by addressing these subjects and their related issues in a specific context, an expansion of theory can be attained. By providing new learnings and knowledge in the outcome of this thesis, new theory is created in an inductive manner (Bryman & Bell, 2015; Patel & Davidson, 2019).

The construction of the research strategy applied in this research builds upon certain epistemological and ontological considerations. Epistemology and ontology are two philosophical branches concerning knowledge and existence, and they describe what can be regarded as acceptable knowledge about the social world and if that reality is regarded as something external to social actors or if the reality is a construction based on social actors (Bryman & Bell, 2015). The position in these philosophical considerations will reflect the assumptions of research and how the research is carried out. The epistemological position in this research is of an interpretivist perspective, which means that reality is something subjective and it takes interpretations of reality into consideration (Bryman & Bell, 2015). This position is favourable in this research since the focus lies within the subjective and internal issues and strategies within organisations derived from E&E components. The ontological position in this research is of a constructionist perspective, which means that reality and social phenomena is something dependent on social actors and currently shifting (Bryman & Bell, 2015). This position is motivated by the fact that the research conducted only presents a specific version of reality in a certain context, and therefore not can be regarded as definitive, independent of social actors, and true for all settings.

A qualitative research strategy was decided to be the most appropriate based on the nature of the research. The inductive approach in combination with the epistemological and ontological considerations of interpretivism and constructionism is linked to the qualitative approach according to Bryman and Bell (2015). The difference between quantitative and qualitative research is described as two clusters based on the relation between theory and research, epistemological considerations, and ontological considerations. A qualitative research strategy emphasizes words instead of quantification and is in general inductive, interpretivist, and constructionist in its orientation (Bryman & Bell, 2015).

This thesis follows a research structure with inspiration from the research process described by Saunders et al. (2019) and the main steps of qualitative research described by Bryman and Bell (2015). The main process steps are illustrated in Figure 3.1, and follows the stages of clarifying the topic, reviewing literature, designing the research, collecting data, analysing data, and writing up the research as described by Saunders et al. (2019). As the figure illustrates, even though the process seems to be straightforward and chronological, it is an iterative process where several stages will overlap and be subject to constant reflection and revision. The solid arrows in the figure show both the direction of the research process but also includes the need for planning ahead as emphasized by Saunders et al. (2019). The dashed arrows represent the process of reflection and revision between the stages as a visualization of the iterative process. Beyond the including elements in the research process, Saunders et al. (2019) also highlight the importance of considering ethical issues during research, which will be further elaborated in the next section.

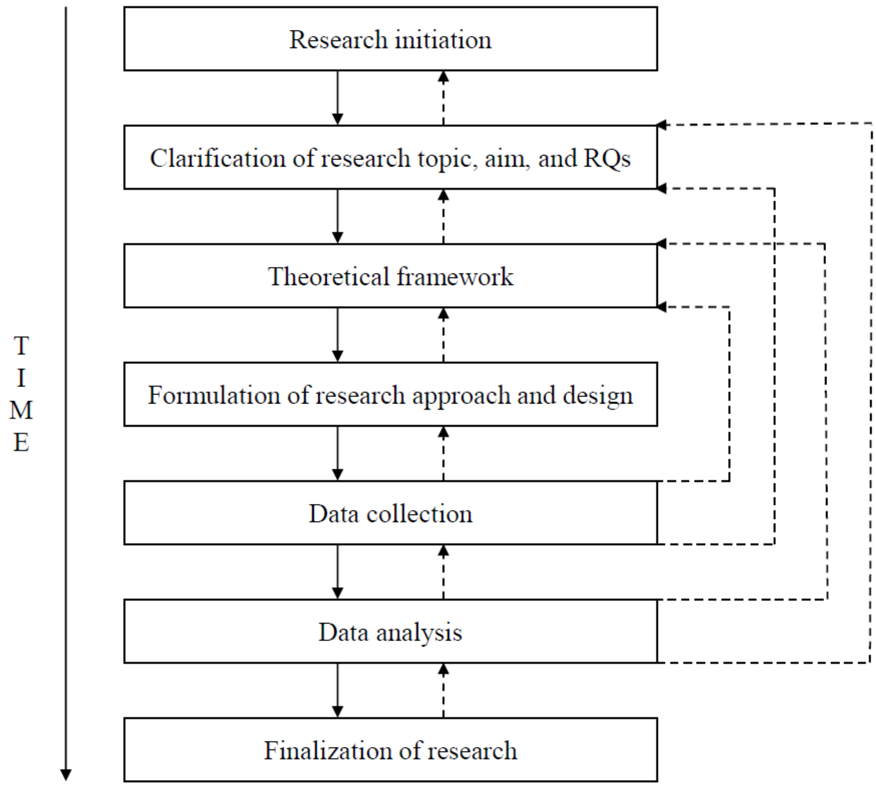

Figure 3.1: The Research Process

3.1.1 Ethical Considerations

Bryman and Bell (2015) emphasize considering ethical principles when conducting research and suggest four main areas to contemplate. First off whether there is harm to participants. As the empirical data in this thesis is based on qualitative interviews, there are multiple occasions where participants are involved in the conduct. However, no situation might entail any harm. The contribution to the interviews is voluntarily and no confidential information is asked of the interviewees that might harm them. Anonymity for all participants ensures the confidentiality of information. Since the approach of this thesis is subjective regarding the interpretation and understanding of the data, careful consideration of how the qualitative data is processed with minimal skewness from the interviewee's intent needs to be addressed. Further, whether there is a lack of consent from the participants in the qualitative interviews. As the interviews were voluntarily and were explicitly informed of the questions and structure before they took place, the consent is considered adequate. As all topics of discussion were non-confidential information and mostly generalized, no invasion of privacy is deemed to have occurred. Lastly is whether there was deception involved in the data collection. When inviting the interviewees to participate, as previously mentioned the setting, topic and questions were given beforehand so that the choice of declining participation was optional.

3.2 Research Design

To provide a framework for the collection and analysis of data, a research design was decided upon. To investigate how OBMs can ensure available supply of E&E components, the research design of a case study was deemed as the most appropriate. A case study is described as a detailed and intensive study of a single unit to generalize to a larger set of units (Bryman & Bell, 2015; Gerring, 2004). The unit is what is regarded as the case and can be constructed based on several different constructs, e.g. a single organization or location. A case study focuses on a bounded system, where an examination of the setting, purpose, and different parts of the system is emphasized (Bryman & Bell, 2015). As this research aims to provide knowledge of obsolescence management of E&E components, an in-depth exploration in terms of a case study serves that purpose.

3.2.1 Case Study

The selection of a case should focus on where the opportunity to learn about the research topic exists (Stake, 1995). To answer the sub-research questions regarding common obsolescence issues OBMs face in the procurement of E&E components and how OBMs can develop strategies to improve current and future procurement to mitigate issues related to the obsolescence of E&E components, the research case has its outset in Alpha but also investigates the subject in the context of other companies.

The case study in this thesis is constructed in two phases, illustrated in Figure 3.2. The first phase focuses on SQ1 and Alpha. This phase aims to understand common obsolescence issues an OBM face in the procurement of E&E components with short procurement life cycles included in products with longer manufacturing and support life cycles. The first phase is initiated with the problem defined in the thesis background with a divergence stage to discover insights into the problem. This is executed through data collection within the domain of Alpha, further described in the next section on data collection. The phase continues with a convergence stage and the definition of which areas within the research subject to focus on in the second phase. The second phase of the case focuses on SQ2, and to broaden the perspective of the research subject outside Alpha. This phase aims to understand what can be done to improve current and future procurement of the E&E components described to mitigate obsolescence issues. The second phase starts with the output from the first phase, i.e. areas within the research subject to focus on, and is initiated by a second divergence stage exploring insights on how to work with identified issues. This is executed through data collection outside the domain of Alpha, further described in the next section on data collection. The phase continues with a convergence stage to develop potential solutions as the final research output.

It is important to notice that even though the case process in Figure 3.2 is described as a linear process, the different steps in the process is not executed in a strict chronological order due to many aspects of the research being done in parallel. As exemplified in the research process (see Figure 3.1), the nature of reflection, revision, and iteration in the process result in overlap between different research tasks.

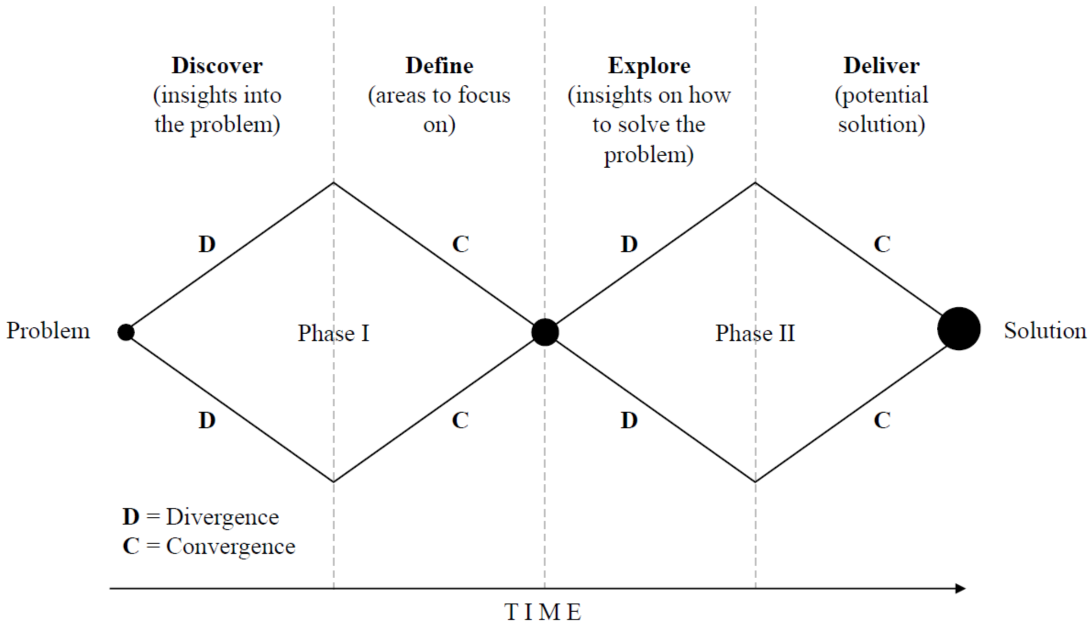

Figure 3.2: The Case Study Process

3.3 Data Collection

This section presents the data collection of the thesis. The data gathered in the empirical findings is primary data originating from a qualitative interview study.

3.3.1 Interview Design

This section presents the qualitative interview study conducted in this thesis. In line with the structure of the case study, the data collection was divided into two phases (I and II), where each aimed to answer the sub-research questions SQ1 and SQ2 respectively. All interviews were conducted with a semi-structured approach, which according to Bryman and Bell (2015) is characterized by setting a main topic of discussion but also encouraging open and spontaneous discussion based on the interviewee input. This structure was deemed suitable as it was precarious to accurately extract information without the exceptional insight of the topic. All the interviews were done online with digital video conferencing software. The questions prepared and asked during the interviews were both of open and closed nature. Saunders et al. (2019) describe open questions to be suitable when wanting the interviewee to answer extensively and when the aim is to understand a person's opinions or attitudes. Furthermore, closed questions are suitable to ask when wanting to introduce new topics within the interview (Saunders et al., 2019).

The two phases had different focuses. Phase I focused on gathering information within Alpha. It consisted of exploring the problem definition and current complications from different inputs from internal stakeholders as well as assessing what knowledge already exists in the present day. Phase II was characterized by additional exploration outside Alpha, conducting qualitative interviews with external organizations affected similarly to obsolescence as Alpha. Interviews with key stakeholders within Alpha were also conducted to understand Alpha in more detail. The qualitative interviews from the second phase were intended to collect outside perspectives and benchmark of the problem formulation and to observe best practices that can be applied by companies such as Alpha.

3.3.2 Phase I

This phase aimed to provide data to be used to answer SQ1 by exploring the current situation at Alpha and what input internal stakeholders could add to the problem formulation. As presented earlier, the interviews in this phase were conducted with a semi-structured approach. Moreover, the questions were open to stimulate further discussion and to give the interviewee chance to explicitly introduce their views and insights of the matter. Emphasis was put to make the interviewee explain their function in the organisation, their relation PLM, E&E component obsolescence and understanding its related issues. The interview participants originates from Alpha's *Purchasing Department, Research & Development Department* and E&E components *Suppliers*, and were categorised according to the business functions, see Table 3.1. In aggregate, 60 interviews were conducted with 50 participants, some of which were conducted with reoccurring interviewees to elaborate on earlier interesting discussion content. Each interview lasted 30-60 minutes. The questions used to steer the topic of discussion is presented by the interview guide in Appendix A.

Table 3.1: Compilation of Interviews Conducted in Phase I

Business Function	**No. of Interviews**	**No. of Interviewees**	**Roles & Competences (#)**
Purchasing	30	22	Buyers (10), Project Management (2), Obsolescence Leader (1), Directors (3), Supplier Risk Management (1), Procurement Support (2), Supplier Quality Management (1), Business Development (2)
Research & Development	17	17	PLM Manager (2), Developers (4), Directors (1), Managers (2), Product Management (3), Project Management (1), Aftermarket (3), Product Testing (1)
Suppliers	13	11	Account Manager (1), Senior Sales Manager (1), Business Development (2), Supply Chain Manager (5), Group Manager (1), IT Management (1)

The focus in Phase I was on the exploration of the issue and to achieve a comprehensive picture of the problem, rather than determining each interviewee's specific opinion. Therefore, the interviews were treated as clusters of data related to the three different business functions, see Table 3.1, and further analyzed to detect general patterns in the data.

3.3.3 Phase II

The goal of the second phase of the data collection was to collect data to answer SQ2. To collect the relevant data, the sample for the interviews was decided to consist of people from external organizations and people within Alpha with in-depth knowledge within obsolescence and OM. The sampling of the organizations was done based on their prospect of adding valuable information and inputs on obsolescence. The chosen organizations are all having products including E&E components and are facing similar challenges related to obsolescence as Alpha. This was ensured when initiating contact with the organizations, as all of them acknowledged the challenges and issues related to the obsolescence of E&E components when introduced to the research. In total, nine different organizations were a part of Phase II in the interview study.

In total, twelve interviews were held in Phase II, see Table 3.2. The sampling of the interviewees was done based on the person's responsibility and knowledge of managing obsolescence in their respective organization; either as a set responsibility, a part of their daily work, or experience gained when working with obsolescence issues. The management of obsolescence seems rarely to be assigned to a single and specific role within an organization, which is illustrated by the vast role descriptions of the interviewees in Phase II. Beyond the role description, Table 3.2 also states if an interview is internal or external, which relates to if the interviewee is from Alpha or an external organization.

All the interviews conducted in Phase II were of a semi-structured approach. In preparation for the interviews, an interview guide with questions was constructed, see Appendix B. In comparison with the interview guide and the interviews held in Phase I, the questions in the interview guide for Phase II was more elaborated to allow for relevant data collection based on input from Phase I and the literature review. All the interviewees were contacted via email where the research topic and interview as a part of the data collection was described. The questions were sent out beforehand to let the interviewees prepare for the interview. The prepared interview time was set to 1 hour and the interviews spanned between 49 and 70 minutes. All interviews were held in Swedish, except for Company C interview where the interview was held in English.

In Phase II, the focus was to collect and determine the opinions and inputs of specific interviewees as an extension of their respective organization. The interviews were treated individually, see Table 3.2, as opposed to Phase I where the interviewees were clustered. The differences in the data collection approach between Phase I and II is characterized by the number of interviews (larger amount in Phase I and fewer in Phase II) in combination with the aim (general opinions in Phase I and specific opinions in Phase II).

Table 3.2: Compilation of Interviews Conducted in Phase II

#	Company ID	Internal/ External	Position	Date & Duration	Language
1	Alpha	Internal	Global Commodity and Project Buyer for E&E	2021-03-24 55 min 32s	Swedish
2	Alpha	Internal	Segment Manager for E&E	2021-03-24 51 min 11s	Swedish
3	Alpha	Internal	Global Product Manager	2021-03-25 53 min 47s	English
4	Alpha	Internal	Regulatory Affairs Manager - Environment and Substance Compliance	2021-04-12 52 min 45s	Swedish
5	B	Internal	Senior Buyer - Global Life Cycle Management	2021-04-12 57 min 19s	Swedish
6	C	Internal	Project Manager Purchasing	2021-04-29 59 min 32s	English
7	D	External	Global Category Manager & Strategic Category Lead	2021-04-13 57 min 48s	Swedish
8	E	External	Lead Buyer & R&D Engineer	2021-04-14 61 min 23s	Swedish
9	F	External	Strategic Sourcing Manager	2021-04-15 69 min 47s	Swedish
10	G	External	COO & R&D Manager	2021-04-20 48 min 53s	Swedish
11	H	External	Head of Strategic Sourcing	2021-04-23 64 min 17s	Swedish
12	I	External	Category Account Manager	2021-04-19 58 min 34s	Swedish

Note. Companies B & C are sister companies to Alpha within same corporate group, and are therefore seen as internal interviewees.

3.4 Analysis of Data

This section will present how the data from the data collection was analyzed to develop valid insights and knowledge. Qualitative data usually consist of non-numerical data values that represent the characteristics of a feature of something rather than quantity. Therefore, qualitative data is more open to subjective interpretation (Bryman & Bell, 2015). Unlike quantitative data, qualitative data is to a greater extent influences by the circumstances and earlier experiences of the collector. As an inductive approach was used when conducting this thesis, it was important to assess if the data applies to the research process used (Saunders et al., 2019). Bryman and Bell (2015) explain that qualitative data is not straightforward, but rather complicated to analyze as it puts demand on the analyst to interpret subjective data with minimal bias.

In both Phase I and II, the data analysis process consisted of an initial analysis simultaneous to the execution of the interview. At this time, notes of key statements and emerging analyses were documented for further assessment after the interview had been conducted to enable interconnection between the data samples in a structured way. The questions in the interviews in Phase II were proactively grouped in the four categories *Benchmark Context, Reactive, Proactive* and *Strategic* to simplify the thematic analysis of accurately comparing data samples from different interviews, see Appendix B. At the end of the interviews, the documentation was summed up and presented to the interviewees to confirm and ensure the validity of the data and initial analysis. The insights presented together with the main findings in the empirical findings are a further analysis of the categorized findings conducted by the authors to provide a nuanced summary of the findings. The final stage of the analysis consisted of evaluating the structured data in the context of the theoretical framework to facilitate more sophisticated insights that would help to answer the research questions.

3.5 Reliability & Validity

In establishing and assessing the quality of research, reliability and validity are two important criteria to evaluate (Bryman & Bell, 2015). Bryman and Bell (2015) develop the criteria further and makes an adaption for qualitative research by dividing the criteria into *external reliability*, *internal reliability*, *internal validity*, and *external validity*.

Bryman and Bell (2015) describe external reliability as to what degree a study can be replicated, i.e the consistency of measures made. Furthermore, the authors proclaim that this is a difficult criterion to fulfil since the setting and circumstance in which the qualitative interviews are conducted are unrealistic to replicate. Thus, replicated results may be difficult to obtain. However, increased robustness in the data collection could be achieved by triangulation, meaning to compare data of the same topic from different sources. In this case study, the same interview questions and data structuring were applied for the same data source (interviewee), hence increasing the external reliability of the case study conduct.

Internal reliability is referred to by Bryman and Bell (2015) when indicators are consistent in the research conduct, meaning that the same measures and settings were made for different qualitative data extractions. Additionally, its means whether there was more than one observer to mitigate subjective interpretation of data. During this thesis, the interviews were held under similar conditions, with the same questions and structuring. Additionally, the interviews were held by two observers who checked to answers with the interviewee before finishing the interviews.

Internal validity is concerning the quality in the relationship between observations and findings (Bryman & Bell, 2015). It relates to the trustworthiness in the claims of what can be said about cause-and-effect relationships. Saunders et al. (2019) argue that the theoretical relationships in qualitative research often is well-grounded in a rich collection of data and that the in-depth nature of qualitative research supports internal validity. To guarantee internal validity in this thesis, respondent validation was utilized by checking the accuracy of collected data and interpretations with participants.

External validity refers to the degree of generalization of results (Bryman & Bell, 2015). Within qualitative research, the question of generalization is of interest since research often is limited to small samples and one or few cases (Bartels et al., 2012; Saunders et al., 2019). In this thesis, the question of generalization arises since the research design is a case study with a relatively small sample for data collection. However, since the data collection was conducted with interviewees from several different business functions and several different organizations, many different perspectives and aspects of the issue were collected to represent general perceptions and opinions. Even though the issues and problems underpinning this thesis were introduced by Alpha, the issue is not company or content-specific per se. The issues related to the obsolescence of E&E components are a general issue for many organizations and many industries. The aim of this thesis is not to produce results that can be generalized outside the context of this thesis, but many of the findings can probably be of interest to other stakeholders with further research.

4

Empirical Findings

This chapter presents the empirical findings gathered in Phase I (4.1) and II (4.2). The chapter consists of qualitative data gathered through semi-structured interviews both from the internal perspective of Alpha as well as the external perspectives of companies with similar characteristics and challenges with E&E obsolescence. The first section is presenting a compilation of the main findings and insights from the case study context at Alpha, focusing on SQ1. The second section aims to establish a benchmark and exploring best practices of how an organization like Alpha could act when dealing with E&E components obsolescence through obsolescence management, focusing on SQ2. The content of these findings and insights is presented systematically, categorized in each OM approach; Reactive Obsolescence Management (ROM), Proactive Obsolescence Management (POM) and Strategic Obsolescence Management (SOM). The final section (4.3) presents a summary of the gained findings in Figure 4.1, which illustrates the how the respective finding and insight is related to the specific research question, and thereby purpose of this thesis.

4.1 Case Study Context at Alpha

This section presents the context of the case study made on Alpha as well as acquired findings based on interviews with internal employees at Alpha and its suppliers as a part of Phase I of the case study, aiming to accomplish a basis of answering SQ1. The findings presented on a consolidated level are the perspectives of *Purchasing*, *R&D* and *Suppliers* are categorized in different key areas. The main findings of the analysis of the interviews are presented in Tables 4.1-4.5, where findings, examples from data and insights of the different perspectives are structure. Note that each of the *Findings* is an perspective that aims to answer SQ1.

4.1.1 Design Ownership and BOM Control

Insights: Since Alpha is outsourcing product design of E&E, less organizational know-how of E&E development and knowledge of the BOM's components and respective life cycle status is achieved. These preconditions complicate Alpha's ability to assess the life cycle status within the product portfolio, as well as in the PLM conduct and communication of the suppliers.

Table 4.1: Summary of Context at Alpha: Design Ownership and BOM Control

Findings	Examples From Data
Design Ownership and BOM Control	• Product design work of E&E is outsourced to tier 1 suppliers, resulting in limited internal BOM control **(Purchasing/R&D)** • Suppliers are trusted to manage the outsourced E&E part and component life cycles **(Purchasing/R&D)** • Purchasing is seldom involved in formulating supplier requirements concerning PLM and OM **(Purchasing)**

In the development of subsystems in their products, Alpha currently practices outsourcing of the E&E product design, according to internal purchasers and developers, leaving the BOM ownership to the tier 1 suppliers. Outsourcing of design is preferable as electronics design is not a core competence within Alpha, which challenges the development with complex product systems containing E&E components. A risk described is that a lot of know-how may be lost when outsourcing. These designs are regulated by *Technical Requirements* documents from R&D, containing i.e. functional and legal requirements on the design. However, little to no functional requirements are made on component detail level at present. This is a conscious decision from Alpha, as the supplier is trusted to have adequate knowledge of what components are applicable if the other requirements from Alpha are fulfilled. Purchasing is seldom involved in formulating supplier requirements concerning PLM and OM.

4.1.2 Design for Obsolescence

Insights: It appears from the internal interviews that there are challenges in the design conduct related to the unavailability of E&E components caused by life cycle mismatch and emerging obsolescence. Increasing legislation of substances is one of many such factors why, which is problematic since it disrupts the planned usage of the E&E components, driving additional unforeseen costs through securing stock, replacements or redesign. Due to the functional complexity and uniqueness, finding compatible E&E components to replace obsolete ones are difficult, particularly semiconductors, and forces Alpha to unwanted single sourcing which lowers robustness to risk and bargaining power towards the suppliers. To the extent possible, Alpha seeks to increase modularity and standardization in the designs to gain volume and avoidance of losing supply options. Several of the challenges described are strongly related to the lack of insight into the BOM and outsourcing of E&E design.

From interviews within the organization, employees representing both purchasing and R&D are emphasizing the increasing challenge of fulfilling environmental requirements set within Alpha to meet automotive standards and institutional legislation. Alpha is affected and aims to comply with environmental regulations such as REACH, RoHS and SCIP. The declaration of substances is, because of the outsourc-

Table 4.2: Summary of Context at Alpha: Design for Obsolescence

Findings	Examples From Data
Design for Obsolescence	• Discrepancy between product life cycle and E&E component life cycle complicates availability of supporting E&E components to aftermarket **(Purchasing/R&D)** • Increasing legislation of substances within E&E disrupts the planned usage of E&E components **(Purchasing/R&D)** • Complicated to find compatible E&E components to replace obsolete ones, especially semiconductors **(R&D/Suppliers)** • High competition in securing E&E component supply, both within automotive and consumer electronics **(Purchasing/Suppliers)** • Usage of overqualified components in hardware development to mitigate risk of component obsolescence **(R&D)** • Usage of modular design and standardized components are desirable **(R&D)**

ing of design of the E&E, mainly left to the suppliers through Material Data Sheets and declaration to the International Material Data System. Internally, Substances of Concern are tracked on a half years basis, as well as components that are evaluated as precarious for future usage in products. In general, work with the inclusion of PLM and end of life perspectives has a minor priority in the design stage by R&D as most focus is put on functional requirements.

One of the biggest challenges in the E&E components aftermarket is to find compatible components to replace obsolete ones without any need for redesign or requalification, especially when a supplier is no longer active. Critical E&E components are referred to components with an imperative function in the product, and which has few alternative options of usage. Changing these components typically is very resource consuming as they affect many other functions in the product. Processors, memories and other semiconductors are often put in this category as they are very critical due to their function and embedded software that is usually optimized after the application.

Alpha is to some degree utilizing standardization and modularization by using shared components by its sister companies, creating synergies and bargain power. Emphasis is put by developers to use standard components if feasible as this may avoid component-specific problems in the future as well as enabling bigger procurement volumes. Another common approach to avoid obsolescence is to “take height” in the hardware and adapt software for specific usage. In long term, this is expected to reduce risk and cost while in the short term entail higher unit costs.

4.1.3 Cross-Functional Collaboration and Organizational Awareness

Insights: In the internal interviews with the different stakeholders, it is apparent that awareness and a better understanding of how to deal with emerging obsolescence of E&E is improved by better internal communication and collaboration between functions and tier 1 suppliers. According to the interviewees, the awareness of supporting the full life cycle of products containing E&E components is most important to achieve. The current internal communication is considered adequate in other aspects, but also need to include aspect of obsolescence mitigation. The suggested formal obsolescence lead could be the facilitator of a unified work towards working with PLM and OM since no formal role is appointed within Alpha today.

Table 4.3: Summary of Context at Alpha: Cross-Functional Collaboration and Organizational Awareness

Findings	Example From Data
Cross-Functional Collaboration and Organizational Awareness	• There are requests within Alpha from various functions for extended cross-functional collaboration, along with initiation of obsolescence leads responsible for creating a common practice on how to deal with emerging obsolescence **(Purchasing/R&D)** • Supplier management and internal collaboration are important when assessing BOM to identify critical components of concern is identified as an enabler for better OM conduct **(Purchasing/Suppliers)**

It is suggested by employees that an essential part of the current management of obsolescence is common understanding and awareness. Currently, this is not always the case and prioritization and resource allocation are complex. Today, simple traffic light lists are used to help developers account for the components PLM status applicability in design. Forecasting of obsolescence is mainly conducted together with suppliers. However, one must be aware the forecasting may not be valid for long and requires continuous refreshing.

At present, there is described to be uncertainties regarding how the responsibility of obsolescence and PLM is to be distributed between different functions, resulting in that purchasing must deal with emerging obsolescence scenarios that originates earlier in the life cycle. There are initiatives taking place today to create a more cross-functional and systematic way to handle obsolescence in the sister companies. This is also proposed and welcomed by employees at Alpha as it lacks a common structure of working with obsolescence. The creation of a company-wide obsolescence management strategy to become more proactive towards future obsolescence situations through cross-functional collaboration is sought. Moreover, a formal lead is yet to be announced in Alpha to embrace how to implement OM practices.

4.1.4 Procurement and Supplier Management

Insights: It is conveyed from the interviews that one of the main causes for complications of managing obsolescence of E&E in the supply chain is that Alpha is conforming to high industry standards, which put high requirements on the suppliers, while at the same time having low order volumes as a consequence of having a wide component variety in their product portfolio. This results in low bargain power in the supply chain. To supply those low volumes in the aftermarket pose a challenge as it might not be in the interest of the original component manufacturers or suppliers to continue the supply of the whole product life cycle. Since the supplier has ownership over the BOM, Alpha is dependent on their expertise to solve eventual shortages of E&E components. This emphasize the need for supply chain transparency between Alpha and their suppliers. But, since the responsibility of performing sufficient PLM and OM is generally undefined between the parties, this work could go neglected by the suppliers. Consequently, the obsolescence mitigation time frame decreases and renders approaches of managing obsolescence impossible due to the short time to act. Alpha is currently working actively with establishing back-up suppliers (multi-sourcing) and risk management, however, this is not enough to long-term handle emerging obsolescence effectively in its current form.

Table 4.4: Summary of Context at Alpha: Procurement and Supplier Management

Findings	Examples From Data
Procurement and Supplier Management	• Conforming to automotive standards with low purchasing volumes creates low bargain power towards suppliers **(Purchasing/R&D)** • A broad product diversity and supplier base induces low volumes and low mutual interest from both parties **(Purchasing/R&D)** • Alpha is working actively with supplier risk management to mitigate supply shortage, however OM is not fully integrated **(Purchasing/R&D)** • Currently undefined responsibility split of PLM and obsolescence mitigation of E&E between Alpha and tier 1 suppliers **(Purchasing/Suppliers)** • There is a wide range in level of maturity in PLM and OM within the supplier base **(Purchasing/R&D)** • Insufficient communication with suppliers about discontinuance worsens the obsolescence mitigation time frame **(Purchasing/Suppliers)** • There is a need for supplier back-ups and supplier development to prevent E&E component unavailability **(Purchasing)**

Regarding E&E component obsolescence, there is a considerable difference in the maturity of how well suppliers work with obsolescence management, based on statements both within the organization and in discussions with tier 1 suppliers. For those suppliers who work actively with monitoring the life cycle of E&E components in the BOM of their product portfolio, a PLM software system is usually in place to regularly track information of components and BOMs. Some of the BOM analysing services are offered to Alpha from the suppliers, but may drive additional costs. Roadmapping and standardized processes including PLM and phase-out of critical components are also present. Typically, the tier 1 suppliers receive a notice from their sub-suppliers if including E&E components from the original manufacturer becomes obsolete. The priority is then to find replacements, sometimes with the help of the sub-supplier, before sending out notifications to Alpha in terms of PCNs, PDNs or affecting design changes.

At present, Alpha is working actively with supplier risk management, which means that OM implicitly is partly processed within the organization. It is stated that obsolescence is mainly handled with reactive processes and case-by-case when it occurs and that obsolescence complications are often managed mutually with suppliers. One proactive measure established is contracts that enable the transfer of business to other suppliers when obsolescence disrupts the supply.

In the interviews with R&D and purchasing, it is mentioned that Alpha has challenging preconditions in following automotive standards as it does not have the typical high automotive production volume. Therefore, it is difficult to assemble bargain power to negotiate aftermarket support volumes to meet the demands from Alpha's customers. Consequently, the cost per unit increases as well as complicating ensuring the supply of E&E components for aftermarket services during a longer timeframe. Employees from the purchasing function argue that the supplier base is comprehensive with many suppliers, where most have small order volumes creating mutual low interest in keeping active communication between Alpha and suppliers. A more focused supplier base with deeper collaboration is strived for to create synergies and efficiencies according to purchasing representatives. Moreover, from an aftermarket perspective, legislation is a growing problem for ensuring the availability of E&E components as they risk becoming obsolete and non-usable before product phase-out.

Suppliers state that preconditions change fast with E&E components and that what is relevant now may be irrelevant in half a year. One issue described is the ordering of old products in low volumes in an inconsistent ordering pattern. A growing challenge is that lot of competitors, especially in the consumer electronics industry, are buying to stock which complicates procurement as the electronics manufacturing base is getting ever more consolidated, decreasing supply options. At the same time, the automotive industry is increasing production. This amplifies the demand with a short notice from customers leading to market disruptions and E&E component shortages.

One of the issues presented that complicates the mitigation of obsolescence is that one could be stuck in old processes that are hard to alter from. This is especially troublesome when it comes to long-time suppliers where old requirement specifications make it difficult to change requirements in the agreement with the supplier. One recurring area of concern is insufficient communication with suppliers about PDN and PCN, which consumes time and limits the choices of acting on obsolescence issues, in addition to mutual low transparency. There is a mutual understanding that collaboration between Alpha and suppliers are needed to ensure the availability of components in the BOM, especially to identify and focus on critical components. From Alpha's perspective, it is important not to lock in with suppliers too early in the new business development, and to thoroughly assess the long-term applicability of a new supplier, especially when it comes to single sourcing of critical components.

4.1.5 Acting on E&E Obsolescence

Insights: Alpha is currently handling occurrences of obsolescence case-by-case and mainly with reactive approaches such as LTB and redesigns. The interviewees convey that this obsolescence mitigation is done unintentionally and in absence of any additional complementary approach such as formal integrated proactive and strategic obsolescence management. This structure is unfavourable, as the solely reactive approach could be disadvantageous long-term as it brings costs and allocates resources that could have been used elsewhere in the organization. Based on Alphas preconditions of not owning the design or BOM of the outsourced E&E parts, having low supply chain transparency and low bargain power, there are viable ways to develop a more comprehensive OM process through embracing the proactive and strategic approaches, further explained in Chapter 5.

Table 4.5: Summary of Context at Alpha: Acting on E&E Obsolescence

Findings	**Examples From Data**
Acting on E&E Obsolescence	• Adopts a mainly reactive approach to obsolescence mitigation **(Purchasing/R&D)** • LTB and component substitution are preferred over redesign due to cost and resource allocation **(Purchasing/R&D)** • The purchasing function is the first instance of handling occurrences of obsolescence **(Purchasing/R&D)** • LTB and component substitution are usual practices to handle obsolescence at present **(Purchasing/R&D)** • Alpha is affected by increased environmental legislation which limits the use of E&E components **(Purchasing/R&D)**

This section presents the current measures used by Alpha to manage the cases of obsolescence of E&E components. A reactive case-by-case approach is the most common approach to handle E&E obsolescence at Alpha when obsolescence occurs. The earlier the emerging obsolescence is detected and notified, the better preconditions one has of managing the problem in a planned way, e.g. effectively compiling several PDN notifications into one redesign and set of tests. From a developer perspective, LTBs are preferable over redesign if viable depending on if the time frame of the PDN allows it. The reason is presented as the opportunity costs and resources required to perform verification, validation, and certification of the designs, in addition to fulfilling new legislative requirements added after the initial product launch. However, an LTB is not always an ideal long-term solution as some E&E components have a functional expiration date.

An LTB is occasionally also preferred in combination with a redesign, where a common practice is to bridge the need of E&E components until either a substitute has been found or a redesign and validation has been achieved, i.e. a bridge buy. If no spare parts could be procured for the aftermarket support, the customers are offered to upgrade their current product to a reduced price while Alpha gets the opportunity to design for phase-outs and ease of replacement. Currently, a process of managing an obsolescence issue at Alpha can look like this:

1. *Receive notification from supplier (PDN/PCN):* Understand why the situation has occurred.

2. *Secure supply and investigate:* Assessment of available safety stock and eventual bridge buy.

3. *Discussion with supplier and R&D:* Evaluation if it is possible to replace components with substitutes, to conduct an LTB or if redesign is the only option depending on the severeness and remaining product lifetime.

The purchasing function is responsible to ensure the availability of E&E components; however even though their role in obsolescence management is not formally outspoken, they are most often the first instance to handle occurrences of obsolescence as they are responsible for the supply of the outsourced E&E parts. Since no explicit obsolescence responsible function is organized, Alpha are lacking official processes and checklists for handling obsolescence. Purchasing has specific requirements for every supplier regarding e.g. quality, lead-times, payments, costs, and delivery precision, but also on the ability to supply during the series production in addition to 15 years of aftermarket. However, these terms are not followed up in detail as they occur far ahead in time.

Today, LTB is the most frequent approach to secure supply for future use, yet it might not always be the most viable or cost-effective way to handle emerging E&E obsolescence. If substitutes such as replacement of E&E components with equivalents are feasible then it is preferable if the remaining market lifetime allows it. A redesign is usually used as a last resort if no other measure is applicable and could only be tenable if the remaining sales volume is high enough since the cost of resources, test and certifications quickly accumulates. Currently, employees from purchasing and R&D states explicitly that no mapping of life cycles and obsolescence information is made by Alpha, but is expected to be done by the suppliers with varying results.

4.2 Findings & Insights from Benchmark Companies

This section presents the findings gained from the twelve interviews of Phase II with aim of acquiring in-depth information answering SQ2. The focus of this phase is on the external perspectives of how a company could utilize OM to mitigate the occurrences and consequences of E&E components obsolescence within the organization. Table 4.6 presents a compilation of the current OM conduct status and examples within the interviewed companies. The table illustrates that all nine companies are utilizing reactive measures in managing obsolescence. Furthermore, only a few companies are utilizing proactive and strategic measures in their management of obsolescence. The following sections will handle the OM areas of ROM, POM and SOM more thoroughly as well as present key findings that contribute to an analyzed representation of the benchmark.

Table 4.6: Compilation of the Current Conduct of Integrating Obsolescence Management

Company	Reactive	Proactive	Strategic
Alpha	✓	X	X
B	✓(LTB, redesign, spot market)	P (supplier collaboration)	P (obsolescence leads)
C	✓(component substitution, LTB)	X	P (supplier management)
D	✓(component substitution, bridge buy, redesign)	✓(statistical model, reverse analysis)	✓(explicit strategy, design refresh planning)
E	✓(LTB, redesign)	P (proactive monitoring systems)	P (strategic inclusion, forums)
F	✓(LTB, bridge buy, redesign)	X	X
G	✓(component substitution, spot market)	X	X
H	✓(bridge buy, LTB, spot market)	X	X
I	✓(component substitution, LTB, redesign, spot market)	✓(component monitoring, PLM software)	✓(explicit strategy, obsolescence leads)
Summary	**9 ✓, 0 P, 0 X**	**2 ✓, 2 P, 5 X**	**2 ✓, 3 P, 4 X**

Note. ✓= Yes, P = Partly, X = No

4.2.1 Benchmark Context

A consistent finding in the conduct of the interviews with the external companies is the strong accord of the portraying of life cycle mismatch between product and E&E components in the BOM. All the interviewees agree upon that this is a complex issue to comprehend and manage as it has rapidly increased over the last decade as a consequence of continuous integration of E&E in the product portfolios. Among the interviewees, there seems to be an awareness of the current issues of ensuring availability of E&E components, and what consequences lacking mitigation conduct might inflict on the organization and supply chain. The majority of the company interviews indicates that technological development and conformance to environmental regulation are two significant drivers to the emerging E&E obsolescence within the companies.

As in the internal interviews within Alpha, there is a consensus in the benchmark that the complex E&E supply chain, as well as low volumes over longer time frames, complicates the procurement of E&E supply over the full product life cycle. The companies' low production volumes in combination with a consolidation of the electronics original manufacturers have lowered their bargain power within the own supply chain. According to Company G, the size of the company in combination with low volumes creates a situation with low bargaining power and a low ability to impact their suppliers' decision on their procurement of E&E components. Furthermore, Company G highlights that their limited resources pose a risk for obsolescence since it is challenging to spare and assign resources for obsolescence management. All of the companies interviewed state that they heavily depend on close collaboration and transparency towards their tier 1 supplier base, and the suppliers' viability to ensure available E&E supply. However, there are expressed concerns that the communication and contracts can be insufficient as full life cycle supply obligations are not always committed to, especially after series production has ended.

In the interviews, the challenge of accurately estimating the remaining life cycle of a product's components, as new orders and market preconditions changes throughout the life cycle, is mentioned. This means that, as one interviewee puts it, "*either you buy too much or too little*", inducing either supply shortage or capital costs. This issue is especially true for the aftermarket as volume is low and unpredictable, meaning that keeping products alive is uncertain. Company D further highlights two main challenges: communication and forecasting. Communication relates to getting the right information at the right time. When information of obsolescence reach Company D from their suppliers, it can often be too late and the choices of managing obsolescence issues are limited by the aspect of time. One of the interviewees at Company D argues that "*communication is key since the more time you have, the more options you have to handle the problems*". According to the interviewee at Company F, the biggest challenge regarding obsolescence of E&E components is that "*You never know when obsolescence will occur*". When obsolescence occurs, Company F describes that it is time-consuming and costly to find alternative components that can replace the obsolete ones.

Company D, among others, describes the main consequence of obsolescence being the allocation of resources. One of the interviewees explains that when obsolescence of E&E occurs, "*resources that can be utilized in developing new products needs to be allocated to manage existing products instead*". Company B states that if the delivery and support experience towards the customers is affected negatively, then it may influence the brand reputation in full, resulting in less business in the future.

4.2.2 Reactive Obsolescence Management

This section presents the findings from the interviews in Phase II within the conduct of Reactive Obsolescence Management within the various companies. As visualized in Table 4.6, all of the companies interviewed currently uses reactive practices to mitigate obsolescence, however, only a few utilizes intentional ROM as a mitigating approach. The remaining companies unintentionally use reactive practices when the eventual problem occurs. In the sections below, the main findings are elaborated upon.

ROM as a Main or Complementary Obsolescence Process

Insights: Reactive Obsolescence Management does not have a single definition or represent a generic process equal for all organizations. The meaning of ROM differ, and how a reactive way of working expresses itself is unique for all companies based on specific company context and prerequisites. The major difference between companies is whether they utilize ROM as a main or complementary process in their OM. When ROM is used as a complementary process to the POM and SOM, the reactive approaches of managing obsolescence is a deliberate choice resulting from strategic decisions, i.e. intentional ROM. When ROM is used as a main process with the lack of POM and SOM, the reactive approaches of managing obsolescence is an undeliberate choice and the result of a lack of strategic decisions, i.e. unintentional ROM. The major difference is that for intentional ROM, you allow for obsolescence to occur and to manage it reactively since you have processes set to handle and control it. In unintentional ROM, you let obsolescence occur and the reactive approaches is your only way of managing the issues with a lot of challenges and high risks.

Even though all companies interviewed state that they conduct reactive measures as a part of their OM, there still exist differences between how the different companies relate to ROM. One major difference is if reactive measures of managing obsolescence are seen as the main OM processes, i.e. only solving problems when they occur, or if reactive measures are seen as complementary to the POM processes, i.e. making a deliberate choice of which E&E components to monitor and manage proactively and which components to manage reactively. The different views in ROM is presented in Table 4.7. Company B, C, E, F, G, and H state that their way of managing obsolescence issues is mainly or solely reactive in nature and that they rely on ROM approaches. Company D and I describe that their ROM are to be seen in relation to their POM. The reactive approaches at Company D are described as being utilized when obsolescence of E&E components has not been identified by the proactive measures. Company I have a similar perspective, where the need for reactive approaches is initiated when the proactive measures have been insufficient to prohibit E&E component obsolescence.

Table 4.7: ROM as a Main or Complementary Obsolescence Process

Findings	Examples from Data
Reactive Obsolescence Management as Main Obsolescence Process	• "The main approach of managing obsolescence is done by reactive processes" **(Company F)** • Solely reactive processes when trying to mitigate consequences of obsolescence **(Company B & E)** • Mainly reactive processes of managing obsolescence **(Company G & I)** • "We are only reacting to obsolescence, we are not proactive" **(Company C)**
Reactive Obsolescence Management as Complementary Obsolescence Process	• "The reactive processes of managing obsolescence is to be seen as complementary to the proactive processes" **(Company D)** • "The reactive processes is only needed when the proactive processes have been insufficient to prohibit obsolescence issues" **(Company I)**

Solving Obsolescence Issues Case-by-Case

Insights: Managing obsolescence reactively is challenging due to the high complexity and uniqueness of every issue that occurs. This results in the general approach of solving obsolescence issues case-by-case, which inevitably results in high consumption of resources and high costs. A more generic process of solving obsolescence issues would be advantageous in terms of lower resource consumption and costs.

Reactive approaches are common for managing obsolescence, either ROM as a main or complementary process. The processes of reactively managing obsolescence are described by several companies to be based on a case-by-case approach, see Table 4.8. Company B, C, E, and H are explicitly stating that there are no formal processes on how to address obsolescence issues, rather that every situation is unique and managed case-by-case.

Table 4.8: Solving Obsolescence Issues Case-by-Case

Finding	Examples from Data
Solving Obsolescence Issues Case-by-Case	• "The current and normal procedure is to solely to solve obsolescence issues case-by-case" **(Company B)** • "There is no formal processes set on how to deal with obsolescence issues" **(Company E)** • No generic process for solving obsolescence issues is outlined. Instead, the problems are solved "case-by-case" **(Company H)** • There is no formal process for solving obsolescence issues. The solutions are based on implicit know-how **(Company C)**

Reactive Obsolescence Management Approaches

Insights: When addressing issues of obsolescence in a reactive way, the utilization Component Substitution, Last Time Buy & Bridge Buy, and Redesign are the most common approaches. These approaches appear to be aligned in a linear order of preference. Component Substitution is preferred as the primary approach since it can ensure long term supply at a relatively low cost if it is possible to carry out. The disadvantage for Component Substitution is that it requires time in a situation where time is often a limitation. If time is limited, then an LTB or a bridge buy is often the solution to ensure supply while either substitute components are looked for or if a redesign is decided to be carried out. For LTBs and bridge buys, the uncertainties lie within making the accurate prognoses for the future, which is a challenging feat with increasing time perspectives. Redesigns are often seen as something to avoid due to the high costs and resource consumption. While the Spot Market is seen as a last resort, it is a highly risky approach and rarely recommended as an obsolescence solution. There exist several factors that affect the choice of the different ROM approaches, and these will be further elaborated in the following section.

Among the companies interviewed, four different ROM approaches are mainly prevalent: *Component Substitution*, *Last Time Buy & Bridge Buy*, *Redesign*, and *Spot Market for E&E Components*, see Table 4.9. The use of different approaches and the order that they are implemented are both similar and different between several companies.

Table 4.9: Reactive Obsolescence Management Approaches

Findings	**Examples from Data**
ROM Approach: Component Substitution	• "A common approach is to look for alternative components that can replace soon-to-be obsolete components" **(Company D)** • "The suppliers' abilities to find substitute or equivalent components is a important approach in solving obsolescence issues" **(Company G)** • "As a first step in managing obsolescence, the possibilities of using substitute or equivalent components is investigated by component engineers and purchasers" **(Company I)** • "When solving obsolescence issues in series production, reverse engineering and finding alternative components is a solution" **(Company C)**
ROM Approach: Last Time Buy & Bridge Buy	• "Conducting LTBs for the entire product life cycle is a common option when facing obsolescence, but is also a driver of large costs" **(Company B)** • "An LTB is one of the most common approaches to manage obsolescence" **(Company E)** • "If no substitute component is found, a bridge buy can be made to secure supply until redesign is completed" **(Company D)** • "An LTB or a bridge buy may be necessary in order to ensure supply until redesign implementation" **(Company F)** • "The most common practice to ensure availability of E&E components is to conduct and LTB when a PDN is received" **(Company H)** • "If finding a substitute component is not possible, an LTB is initiated" **(Company I)** • "Conducting an LTB is only seen as an aftermarket solution to obsolescence issues" **(Company C)**

ROM Approach: Redesign	• "Redesign is a common option when facing obsolescence, but is also a driver of large costs" **(Company B)** • "Redesign is one of the most common approaches to manage obsolescence" **(Company E)** • "A redesign can be a solution to obsolescence issue, but needs to be evaluated thoroughly before implemented" **(Company F)** • "Redesigns are often combined with bridge buys to solve obsolescence issues" **(Company H)** • "replacing components or conducting an LTB is not viable, a redesign plan is established to manage the obsolescence issue long-term" **(Company I)**
ROM Approach: Spot Market for E&E Components	• "Reaching out and finding E&E components on the spot market is seen as a last resort, but should be avoided if possible" **(Company B)** • "Searching for components on the spot market is one approach used when replacement of components or LTBs is not sufficient, but is strongly connected to high risks in terms of counterfeit components and fraudulent activities" **Company G)** • "The spot market is an alternative in finding components unavailable to procure from suppliers, but it is expensive and riskful" **(Company H)** • "To look for components on the spot market is not desirable due to high component prices and high risk of counterfeit components" **(Company I)**

In companies D, F, I, and G, searching for alternative components for substitution is the primary approach when obsolescence issues occur. At Company D, the ROM begins when a PDN is received from a supplier. The notice will be registered and elevated to a forum with parties of interest where a discussion will take place on how to move forward with the issue. A common solution is to look for alternative components that can replace the soon-to-be obsolete component. If this is not possible, a bridge buy can be made to secure supply until a redesign is made. Company D expresses that they never conduct LTBs for the entire product life cycle to stock anymore and that the LTB needs to be accompanied by a plan for the future development of the product (e.g. phase-out or redesign). Company F has a similar approach to their ROM, but they do conduct LTBs for long-term storage. Even though Company F wants to avoid that E&E components are being discontinued, they may be forced to take action in terms of replacing the obsolete component with an alternative component or conduct an LTB. In estimating quantities for LTBs, purchasing is communicating with sales and marketing in predicting the future demand and need of the component. This is described by the interviewee at Company F as challenging since it is hard to predict future market needs and forecasting future business opportunities. Company F argues that redesign could be a solution to obsolescence issues, but that the choice needs to be evaluated thoroughly. The interviewee at Company F explains that a design change is complicated and a huge driver of resources, time, and cost. Company F describes that bridge buys of discontinued components may be needed to cover supply until a redesign has been implemented.

Similar to Company D and F, the ROM at Company I and G begins when a PDN is received from a supplier. At Company I, the suppliers normally issue an LTB with a last call typically six months beforehand. Before an LTB is initiated by Company I, the interviewee explains that purchasing together with specialized component engineers investigate the possibility of using equivalent substitute components. If that is not feasible, then an LTB is initiated. The order volume is carefully estimated in collaboration with the respective product owner and supplier risk management to ensure supply to all product systems currently active on the market, i.e. demand forecasting. At Company G, one of the interviewees expressed that the company confides in that their suppliers will communicate obsolescence issues in due time, i.e. a minimum of six months beforehand, to have the ability to find substitute or equivalent components. In this process, Company G expects that their suppliers will provide suggestions of replacement E&E components.

Company B, E, H state that their primary approach when acting on obsolescence issues is to conduct LTBs and redesigns. At Company H, the most common practice to ensure availability of E&E components are to conduct an LTB when a PDN has been received from the supplier. The interviewee at Company H state that managing obsolescence is not part of the initial plan for products and may therefore complicate product management during the life cycle. If a more comprehensive redesign is needed or an LTB has been poorly allocated, then a bridge buy is usually initiated. Both Company B and E express that LTBs and redesigns are common approaches when facing obsolescence issues, but that these approaches are large drivers of costs.

Company C describes that their ROM approaches differ based on where in the life cycle the product including the obsolete E&E components reside. If the product is in series production, there is a need for a long-term solution and the primary approach is to look for alternative components, which can include the need for reverse engineering. Furthermore, a redesign can be possible but is to be avoided due to the high costs of certification and validation. If the product has reached the end of the life cycle and requires aftermarket services, an LTB is a possible approach. Company C focuses on understanding the situation and evaluating resource consumption, expiration date, and contract to conduct an accurate LTB. At Company C, LTBs is only seen as an aftermarket solution to obsolescence issues.

As a last resort when facing issues of ensuring supply and procuring E&E components, searching for components on the spot market is an approach that is mentioned by several companies. Company G describes that searching for components on the spot market by external brokers is strongly connected to high risks in terms of counterfeit components and fraudulent activities. Company G elaborates that when utilizing this approach, one needs to have identified which brokers are reliable and trustworthy and which are not. Company H mentions that the spot market can be an alternative, but "*a very expensive and somewhat risky alternative*". Furthermore, Company I state that reaching out on the spot market is not desirable due to the high costs and risks of counterfeit components. This opinion is shared by Company B that state that reaching out on the spot market should be avoided if possible.

Factors Affecting Choice of ROM Approach

Insights: There is no ROM approach that can be classified as better than the others or no approach that can be said to be the best in solving obsolescence issues reactively. The ROM approaches serves different purposes depending on the context and the prerequisites of the obsolescence situation. One major governing factor is the life cycle phase of the product that the obsolete, or soon-to-be obsolete, component is included in. In general, the earlier a product is in its life cycle, the more remaining sales volume can be expected compared to a product late in its life cycle. The earlier in the product life cycle obsolescence occurs, the more long-term solutions and ROM approaches are desirable due to higher product quantities and longer time frame. Since more remaining sales volume and revenue can be expected from the product, investments in resources and higher costs are motivated. Therefore, ROM approaches of component substitution, bridge buy, and redesign is more suitable for products earlier in their life cycles. LTBs of large volumes is not suitable due to the long-time frame, high quantities, and challenges in making accurate prognoses. The sooner in the product life cycle obsolescence occur, the more short-term solutions and ROM approaches are desirable due to lower product quantities and shorter time frame, e.g. product soon to be phased out. Since less remaining sales volume and revenue can be expected from the product, investments in resources and higher costs are less likely to be motivated. Therefore, ROM approaches of component substitution and low volume LTBs are more suitable for products sooner in their life cycles. Redesigns are not suitable due to the high resource consumption and high costs in relation to low remaining sales volume and expected revenue.

When choosing which ROM approach is best suited for an obsolescence issue, several factors need to be considered. One aspect that governs the use of different approaches is the position in the life cycle of the product including the E&E components affected by obsolescence. According to Company F, to understand the criticality and prioritization of the obsolescence case, the obsolete component needs to be evaluated in relation to the life cycle phase of the products it is included in. If the obsolete component is included in products that are still in series production, the case is more critical since it has a greater economic impact and greater financial risk due to higher volumes and being more long-term. If the component only is included in products in aftermarket services, the criticality of the case is lower since the obsolescence issue does not affect the series production and has lower economic consequences. If a case is critical and is affecting the series production, it needs to be solved as quickly as possible. Furthermore, if the product is still in series

Table 4.10: Factors Affecting Choice of ROM Approach

Finding	Examples from Data
Factors Affecting Choice of ROM Approach	• The position in the life cycle of the product including the E&E components affected by obsolescence **(Company F & C)** • Important to receive obsolescence information as early as possible to have time to act **(Company D, C & G)** • "Both LTBs and redesign are large drivers of cost" **(Company B)** • "Large costs related to development and testing are to be avoided" **(Company I)** • "Redesign requires costly certifications and validations" **(Company C)**

production and deemed critical, a redesign may be more motivated than it would have been if the product is in aftermarket services and soon to be phased out. The importance of the product position in the life cycle is further highlighted by Company C, which argues that the life cycle position decides which ROM approaches are possible and most suitable. The interviewee at Company C argues that when a product has passed series production and require aftermarket services, i.e. at the end of the product life cycle, an LTB can be conducted due to a relatively low volume and shorter time-frame. With a low volume and shorter timeframe, it is described to be easier to make accurate prognoses for future demand. Furthermore, LTB is described only as a possible ROM approach when a product is in aftermarket, never when it is in series production. The longer timeframe with no certain end-date that series production implies means that it will be "impossible to calculate volumes for an LTB" according to Company C. When a product is in series production, finding alternative components is a more suitable and long-term solution.

Company F argues that when choosing an approach, e.g. a redesign, several aspects need to be taken into consideration. Aspects of time and financial viability needs to be regarded when making decisions of ROM. Company C and D describe that the need to get information in time is important to process the issue and ways to solve it. One of the interviewees at Company D describes that when a PDN is received from a supplier, it will be registered and elevated to a forum with parties of interest where a discussion will take place on how to move forward with the issue. The importance of having time to act and communication if further highlighted by Company G that explains that the company confide in that their suppliers will communicate obsolescence issues in due time, i.e. a minimum of 6 months, in order to have the ability to act on the issues.

Several of the interviewed companies mention the cost of implementing different ROM approaches as a limiting factor. According to Company B, both LTBs and redesign are two ROM approaches that are large drivers of cost. This perspective is shared by Company I that argues that changing a product, often as a result of redesign, there are large costs related to development and testing which are to be avoided if feasible. According to Company C, finding and implementing alternative components can also induce high costs, but still relatively low cost if compared to redesign that requires costly certifications and validations.

4.2.3 Proactive Obsolescence Management

This section presents the findings from the interviews in Phase II within the conduct of Proactive Obsolescence Management within the various companies. As visualized in Table 4.6, only two of the companies (D and I) interviewed out of nine currently uses an explicit POM as a mitigating approach. The remaining seven companies either just partly utilize elements in the approach or fully lacks proactive measures. The section presents the proactive approaches as well as main findings that illustrate the companies' current conduct as a benchmark of how POM is practised in the industry. Each respective proactive approach is thereafter described further in its sections.

Inclusion or Exclusion of POM

Insights: The utilization of proactive measures and POM varies greatly between different organizations. Comparing organizations that have chosen to include or exclude POM, the determining factor of POM implementation can be linked to the expected value added in relation to the consumed resources. The companies excluding POM argue that being proactive would be too resource consuming and costly in relation to the output. The companies including POM are instead describing that their proactive processes are producing valuable output despite requiring resources and being drivers of costs.

Of the companies interviewed, several expresses that proactive measures and POM are a part of their processes in mitigating obsolescence. The interviewee at Company I describes that POM is prominent to a great extent within the organization. Engineers are monitoring various E&E component types to ensure future availability. Moreover, Company I ensure that their supplier base can deliver on set requirements, e.g. certifications and continuous communication of the current and future E&E component information. The interviewee describes that they make use of PLM monitoring software where the availability information of specific components is updated continuously by suppliers and databases. Such information could be LTB notifications, life cycle status, market availability, and BOM status.

Company E mentions that they strive to be more proactive in their OM. Within the organizations included in the corporate group, there exist proactive monitoring systems that in the future will be integrated into Company E's processes. But so far, the current conduct adequately suffices to manage upcoming obsolescence issues. When an E&E component becomes obsolete, it will be marked in the design tools not to be recommended for new development. Company E is at the beginning of a

Table 4.11: Inclusion or Exclusion of Proactive Obsolescence Management

Findings	**Examples from Data**
Inclusion of Proactive Obsolescence Management	• "The most important thing is that one transform from being purely reactive to being more proactive" **(Company D)** • By utilizing proactive measures, rushed decisions of redesign and the need for conducting LTBs with challenges of making the correct prognoses can be avoided **(Company D)** • Proactive measures are incorporated to ensure future availability by monitoring of E&E components **(Company I)** • A transition towards a more proactive way of working in mitigating obsolescence issues is underway **(Company E)**
Exclusion of Proactive Obsolescence Management	• "To regularly make follow-ups on a detailed level, i.e. on all including components would not be worth it and be too costly" **(Company F)** • The relationship between value added and resources required needs to be taken into account in how proactive measures should be incorporated in business processes **(Company F)** • The current reactive measures are deemed good enough to handle the effects of E&E component obsolescence, and further investment into proactive approaches is argued not to be "worth it" **(Company H)** • No continuous monitoring or forecasting of the life cycles of E&E components included in the products **(Company G)** • Does not see the value in being proactive since the expected value added is not being motivated by the needed resources and costs **(Company G)**

transition to a more centralized and proactive way of working with OM.

Of the different companies interviewed, Company D is the one with the most developed POM processes. The company highlights the importance of transforming from purely reactive to incorporating more reactive measures of mitigating obsolescence. The aim of the proactive measures within Company D is described as avoiding rushed decisions of redesign and the need for conducting LTBs, where the challenges in making the correct prognoses often result in a too small or too large component quantity bought. The company describes their POM being based on two inputs in general. First, by utilizing a statistical model that indicates the life cycle of a part since the introduction and latest component change, a hint on which parts that are at a greater risk of being obsolete can be identified. The company describes the model as being relatively inflexible, but still providing valuable information of guiding them in the right direction initially in their POM. Second, with the input from the model, the Strategic Category Lead together with the Technical Product Owners goes through the product and performs a reverse analysis on the including components to understand how much resources a component replacement would need if a component would become obsolete. One of the interviewees at Company D describes that this analysis is not done for the whole BOM, but for the components deemed as most critical. Furthermore, the interviewee describes that in the end, the company will have a good picture of how long the product can be kept alive without any component changes. As described by the interviewee, this process will help the company creating "refurbishment projects", where a more holistic approach on redesigns can be planned for in the products that will continue to be a part of the company's product portfolio in the future. The redesigns of the product are described as large investments, and therefore needs to be motivated from a financial perspective.

In contrast to the companies describing that they include POM in their processes, several companies express that they do not adapt or see the value in adapting proactive measure, i.e. exclude POM. The interviewee at Company F describes their POM as existing in some aspects but in general being very limited. Company H also describes a limited use of POM and explains that no pure proactive work is done except for using non-obsolete components in product development and redesign, and monitoring supplier stock. Company F does not have a process for continuous monitoring of the life cycle of the including E&E components in their products. The interviewee recounts that the material planning function is regularly following up and evaluating the product on a modular level, i.e. the outsourced electronics system, but never on a component level. Furthermore, the manufacturers and suppliers are regularly being evaluated on the supply capacity of the outsourced electronics systems, but never on a detailed component level. "To regularly make follow-ups on a detailed level, i.e. on all including components would not be worth it and be too costly" according to the interviewee at Company F. This view on POM is shared by Company H, where the interviewee explains that the current reactive measures are deemed enough to handle the effects of E&E component obsolescence, and further investment into proactive approaches is argued not to be worth it.

The interviewee at Company F elaborates on Company F's view on POM. According to the interviewee, the relationship between value added and resources required needs to be considered in how proactive measures should be incorporated in business processes. The interviewee questions what value detailed and continuous follow-ups and forecasting of each E&E component would yield in relation to costs and resources needed. In addition to this question, the interviewee also highlights if follow-ups would be necessary on component level or if it is enough to monitor the outsourced electronics systems on a higher hierarchical level. Furthermore, the interviewee questions if continuous and comprehensive proactive processes are necessary or if the OM should be initiated when the situation becomes critical.

Company G does not continuously monitor or forecast the life cycles of the E&E components included in their products. Today, Company G focuses more on the "reliability than availability in electronics", and is expecting the external manufacturers and suppliers to communicate when problems occur. One of the interviewees mentioned that it would be helpful to know which E&E components in the BOM that are critical and have a risk of becoming obsolete, but that this process is restricted by the limited resources within the company. Furthermore, the interviewees at Company G shares Company F's view on the relationship between value added and resources required by expressing that they do not see the value in being proactive in their OM since they do not expect the value added to be motivated by the needed resources and costs.

For a larger organization like Company F, the interviewee argues that it would be almost impossible to follow up all E&E components due to the vast amount of manufacturers, suppliers, and components included in all of the products in the product portfolio. The interviewee elaborates that a proactive approach may be more suitable for organizations with fewer products and fewer suppliers due to a fewer number of components to cover and fewer resources needed in the POM.

Identification of Critical Components

Insights: Due to limitation in resources, POM can not cover all components included in products. The proactive measures of tracking, monitoring, and forecasting need to be a selective process where resources available are allocated efficiently and effectively. The identification of critical components is a way of guiding where resources should be allocated. The understanding of what define critical components is key knowledge in POM. There exist specific groups of E&E components that are more likely to be critical, e.g. semiconductors, but component criticality should not be based solely on the type of component. The context of the component and the relation of the component to the product it is included in needs to be taken into considerations. Based on the input from the interviewed companies, a checklist for identifying the criticality of E&E components have been constructed. The checklist consist of six questions:

- *Is the component affecting both hardware and software functionality?*
- *Is the component affecting the primary product or part function?*

- *Will the change of the component require verification and requalification?*
- *Has the supplier of the component history of being volatile, i.e. lack in the communication of obsolescence?*
- *Is the component being single-sourced?*
- *Is the component outsourced as a unique or company-specific component?*

If the answer is no to all of the questions, the component is not identified as critical. If the answer is yes to one or more of the questions, the component is identified as a critical component.

Table 4.12: Identification of Critical Components

Finding	Examples from Data
Identification of Critical Components	• "It is important to have great knowledge of products and the critical components of products, i.e. which ones are hard to replace" **(Company D)** • "Criticality of components is defined based on several aspects including being resource-intensive, criticality for product function, and history of supply" **(Company D)** • "Critical components are components with functional customization, high level of uniqueness, are single sourced along with inducing severe risks if exposed to issues" **(Company I)** • "Criticality of components are defined by being customized after specific requirements and configured for a specific usage or function" **(Company E)**

Among the companies including POM, i.e Company D, I, and E, the identification of critical components is highlighted as an important step underlying the proactive work. In general, critical E&E components are not described as a group of specific component types but is defined by a collection of characteristics. Company D elaborates that one needs to have great knowledge of products and the critical components of products; i.e. which ones are hard to replace. The company describes that they include different factors in what is defined as critical components. One aspect is the amount of resources that are needed for the replacement of a component. One interviewee elaborates that there is a difference if a component only affects hardware or if it is affecting both hardware and software. When a component replacement is affecting both hardware and software, the change will need both hardware and software resources. According to company D, this makes a component critical since it is deemed resource-intensive and will generate a lot of verification and requalification.

Other perspectives that Company D includes in defining the criticality of a component is if the component is critical for the functionality of the product and if the supplier providing the component has a history of being volatile in terms of the short notice of PDNs and PCNs. When a component is defined as critical, it will be listed as critical and put up for extra monitoring. Functionality as a factor for defining criticality is agreed upon by Company I and E. Company I identify critical components because of their functional customization and uniqueness, but also due to being single-sourced. Company E defines critical components as being customized after a company's specific requirements and configured for a specific usage or function.

Supplier Relationships

Insights: There is a major difference in how companies view and address the supplier relationships in relation to POM. The two main positions are either to view the work of proactively mitigating obsolescence as the suppliers' responsibility, or as the shared responsibility between the company and their suppliers that should be solved collaboratively. From the data collected, the companies that transfer the responsibility of POM to their suppliers are in general the companies that exclude POM in their processes. Furthermore, the companies that collaborate with suppliers in their POM are in general the companies that include POM in their processes. The companies that work proactively in mitigating obsolescence highlights the importance of collaboration with suppliers. This relation works two-way. To work proactively, collaboration with suppliers is necessary, but in order to collaborate well with suppliers, an understanding of POM is also necessary.

Table 4.13: Supplier Relationships

Findings	Examples from Data
Transferring Responsibility to Suppliers	• "The responsibility of monitoring BOMs resides with the suppliers" **(Company H)** • The capacity and responsibility of ensuring supply is transferred to suppliers and suppliers are trusted to "live up" to this **(Company F)** • Suppliers and sub-suppliers are expected to possess knowledge and processes of addressing obsolescence issues proactively **(Company G)**
Collaboration with Suppliers	• "Working together with suppliers is one way to work more proactively in managing obsolescence issues" **(Company B)** • "One must work together with the suppliers instead of just leaving all burden to them" **(Company B)** • "It is important to work closely in partnerships with suppliers" **(Company E)** • "It is key to have continuous communication between the organization and the supplier of the current and future state of E&E components" **(Company I)**

Among the companies excluding POM in their management of obsolescence, transferring the responsibility of being proactive to the suppliers is a common approach. Company F transfer the capacity and capabilities of ensuring the supply of E&E components included in the outsourced electronics systems to the manufacturers and suppliers. According to the interviewee at Company F, reports and information of component life cycle and component obsolescence status is not communicated between the company and their manufacturers and suppliers. The interviewee stresses that in their supplier relationships, Company F wants to be guaranteed that their supplier can ensure and have ensured supply of the outsourced electronics systems and the including E&E components throughout the whole product life cycle. In the current business processes, Company F is not interested in the detailed life cycle and obsolescence status of the E&E components included in the outsourced electronics systems as long as the supplier can ensure supply.

Company H suggests that it is not viable or practicable to continuously monitor every BOM actively as the cost and resources to do so is high. Therefore, the tasks of monitoring BOM are given to the respective suppliers. According to one of the interviewees at Company G, the proactiveness in mitigating obsolescence resides further downstream in the supply chain, where suppliers and sub-suppliers are expected to possess the knowledge and processes of addressing these issues.

In contrast to transferring the responsibility of POM to suppliers, several companies highlight the importance of collaboration and cooperation with suppliers in mitigating obsolescence instead. Company E, I, and B describe that they work closely with their suppliers. Company E presents themselves to work closely in partnerships with their suppliers, of whom they allocate much of their supply. The suppliers on their behalf undertake the burden of working proactively by monitoring parts and components. Company I ensure that their supplier base can deliver on the set needs and requirements, e.g. with certifications and continuous communication of the current and future conditions of the E&E components. The interviewee at Company B has identified that working together with suppliers is one way to work more proactively: "*One must work together with the suppliers instead of just leaving all burden to them*". On the supplier side, the interviewee at Company B mentions that the need to be a general inclusion of product roadmaps on component level and that the status of the components needs to be monitored to prevent the need of LTBs. Audits of the suppliers' capabilities and suitability of supplying Company B is one way mentioned to proactively improve the robustness in procurement.

Information & Communication

Insights: The basis for proactive work is the availability of information to act on. In addition to information being available, the information also need to be communicated. This emphasizes the need for establishing a business environment, both internally between business functions and externally between company and suppliers, with guidelines on what and how to share information.

Table 4.14: Information & Communication

Finding	Examples from Data
Information & Communication	• "Good communication and getting information early is important in order to be able to plan and prevent obsolescence issues" **(Company E)** • Receiving information early facilitates possibilities to act on E&E component obsolescence **(Company I)** • "There is a lot of information available in the market, and we are dependent that this information comes to us" **(Company I)**

In POM, several companies highlight information and communication as key factors in enabling obsolescence mitigation. At Company I, the interviewee highly values gaining information about supply conditions early on to facilitate possibilities to act on E&E components obsolescence. The employee argues that "*there is a lot of information available in the market, and we are dependent that this information comes to us*", even though it can be difficult to actively acquire it. Company E argues that to be more proactive and to prevent problems related to the obsolescence of E&E components, the company emphasizes forward planning and getting information from suppliers early on. Company E highlights the importance of both internal communication, i.e. within the organization, and external communication, i.e. between the company and suppliers, to be able to plan and act on obsolescence in time.

4.2.4 Strategic Obsolescence Management

This section presents the findings from the interviews in phase II within the conduct of Strategic Obsolescence Management within the various companies. As visualized in Table 4.6, only two of the companies (D and I) interviewed out of nine currently uses an explicit SOM as a mitigating approach. The remaining seven companies either just partly utilize elements in the approach or fully lacks strategic work. Tables 4.15-4.20 presents the strategic approaches as well as main findings that illustrate the companies' current conduct as a benchmark of how SOM is practised in the industry. Each respective strategic approach is thereafter described further in its own sections.

Inclusion of Strategic Obsolescence Management

Insights: According to the interviewees, especially from Company D and I, there is much emphasis put on the benefits and long-term importance of working with SOM as a mitigation approach. Any of the obsolescence management approaches are not to be used solely on their own, but instead as complementary measures to each other. For example, long-term it is very difficult and not economically viable to entirely rely on a reactive or proactive approach, as it is impossible to cover as *aspects involved. But by implementing all OM together, much can be achieved as fewer occurrences of obsolescence happen due to proactive work, and those that could be handled reactively in well-defined processes. However, to make this happen, it is suggested that a strategic approach must be formally adopted cross-functionally to have the best effect. But, as Company D presents, it is not desirable nor economically viable to have full control over every aspect of the products. Therefore, companies are recommended to balance the benefit from a resource utilization perspective to achieve good results; one cannot stop all obsolescence from occurring, only mitigate the organizational consequences.*

Table 4.15: Inclusion of Strategic Obsolescence Management

Finding	**Examples from Data**
Inclusion of Strategic Obsolescence Management	• Explicit inclusion of OM in corporate strategy are in place foster awareness and active work on a organizational level **(Company D, E & I)** • Intentional reactive and proactive processes are essential for a long-term efficient mitigation of obsolescence **(Company D & I)** • It is not viable nor desirable to have control over every aspect in the product portfolio from a resource utilization perspective. You can mitigate but not stop obsolescence from happening **(Company F & I)**

From the result of the interviews, it is evident that only a few of the companies actively incorporate OM explicitly in the strategy and related processes, see Table 4.6. However, the interviewees also portray various informal practices throughout the organization that falls within the area of obsolescence management. Company D is one of the companies which in recent years has transitioned from working solely reactively to incorporating OM on a strategic level and has since benefited from managing obsolescence intentionally both proactively and reactively. However, the interviewees from Company D highlight that one must be pragmatic when it comes to obsolescence and what to expect from the current way of working. They express that is it difficult, and from a resource utilization perspective, not viable to cover all occurrence of obsolescence, but that the mitigation will be considerably more effective when organizational awareness is present.

The interviewee of Company I agrees with these insights and further argues that OM is present formally on a strategic level as it is an important enabler of fulfilling expectations towards customers. The existence of set purchasing processes, proactive monitoring and collaboration of designated component expertise is proof of that.

The other organizations interviewed not using a formal strategy seems to be doing so because of either immaturity in a particular area of OM, or that it yet is not deemed to be needed within the organization. Company F and G are companies that are not using SOM as their current situations and processes are considered to be structured around obsolescence issues case-by-case when they occur.

Design Ownership

Insights: From the interviews, it appears that owning the design is an advantage in the work with OM as it enables the company to monitor and making decisions on the remaining product life cycle more independently from the supplier if comparing with companies that outsource the design to a tier 1 supplier. From a strategic point of view, this is beneficial as the company can decide more freely when to discontinue products or make certain decisions in the design. Moreover, important product know-how of E&E components can be advantageous for the organization's development long-term. Apart from the OM management perspective, outsourcing design of E&E could be necessary to secure external expertise from suppliers in the design at the cost of BOM control. In those cases, close collaboration with suppliers is essential to be able to conduct sufficient OM.

Table 4.16: Design Ownership

Finding	Examples from Data
Design Ownership	• Design ownership enables control over BOM and ability to take action over life cycle **(Company D, H & I)** • "Important that product know-how remains within the organization long-term" **(Company I)**

Of the companies currently managing obsolescence relatively good and intentionally with a strategy all have in common that they put emphasis on the value of maintaining ownership of the design, and thereby also controlling the BOM. The interviewee of Company H elaborates that owning the design from Company H's perspective enables them to take action whenever an upcoming situation arises in the life cycle. This argument is also shared by Company D and I, and since the contracted supplier responsible for manufacturing the part does not have the last say, it enables them to act more effectively internally. Moreover, the interview of Company H suggests that it also enables the company to be more flexible in supporting the aftermarket and decisions of product phase-out. From the perspective of Company I, the interviewee argues that owning the design is very valuable as it facilitates that important know-how of the product portfolio is preserved within the organization long-term.

Obsolescence Management Leads and Forums

Insights: Based on the interviews, it is apparent that one of the main reasons why the topic of obsolescence management is not fully developed in the organizations is because there is no one formally responsible for handling obsolescence. When everyone is bearing responsibility, no one has the obligation of being individually responsible, resulting in that personnel active in the aftermarket services of products usually has to deal with the obsolescence issues. However, there are examples where *obsolescence leads have been appointed to lead the work with facilitate OM. The main advantage with formal leads is that the topic gets a primary focus, rather than being a low priority. Such activities as facilitating cross-functional collaboration, knowledge sharing and forums for discussion are mentioned as tools to build up organizational capabilities. Reoccurring meetings with suppliers, management and key functional competencies are mentioned as the basis of effectively acting on obsolescence long-term and before the complications has escalated.*

Table 4.17: Obsolescence Management Leads and Forums

Finding	Examples from Data
Obsolescence Management Leads and Forums	• Existence of obsolescence management leaders with mandate within the organization can drive the progress of OM excellence **(Company B)** • Cross-functional forums are enablers for obsolescence mitigation work and facilitates communication and organizational awareness **(Company B, E & H)**

Many of the companies agree that the knowledge and responsibility of managing the consequences of obsolescence currently often are unresolved within the organization and that champions structuring the work is needed to align the organizational efforts. The interviewee from Company B describes that measures have been introduced such as appointing obsolescence leads and a forum to align and drive the development of OM. According to the interviewee, it is important to involve management and cross-company collaborations in the future to be more successful and effective in their work. Clear areas of responsibility are needed to succeed, otherwise, few will feel obliged to participate. In Company I, obsolescence leads are active to further develop and lead the OM and reaches all way up to project management.

Company H utilizes leads and forums throughout the organization to ensure that there always exists a sense of responsibility for different organizational challenges. One of those forums is devoted to End-of-Life questions. Moreover, continuous follow-up meetings are set with the different suppliers are set within Company H, meaning that information sharing is enabled proactively, in addition to contract paragraphs explicitly dedicated to End-of-Life issues.

Cross-Functional Collaboration and Awareness

Insights: There is a strong consensus in the interviews that well-functioning communication and organizational awareness are essential to achieve good mitigation of E&E obsolescence. Moreover, as Company D highlights there must be an underlying understanding of the implications of obsolescence and what the respective function in the organization can do to help in the mitigation. It seems that a sense of urgency is needed to facilitate the necessary incentives to work more cross-functionally in all life cycle phases with obsolescence. Since all key functions and suppliers benefits and disbenefits depending on the obsolescence mitigation outcome, it is important to *share solutions and insights mutually in a "give and take" manner.*

Table 4.18: Cross-Functional Collaboration and Awareness

Finding	Examples from Data
Cross-Functional Collaboration and Awareness	• Mutual organizational understanding and awareness of the implications of obsolescence **(Company B)** • Inclusion and communication between functions throughout the life cycle is key prevent and early on effectively act upon obsolescence **(Company D & F)**

In all interviews, early and well-functioning communication is highlighted as a precondition for effective mitigation of obsolescence issues. Company D emphasizes the importance of engaging the whole organization in the problems and issues of obsolescence. Since the company is utilizing more and more E&E components in their products, they have highlighted the need of managing obsolescence. In the last couple of years, they have been on a journey of improving their obsolescence management. They have both identified the need of implementing proactive processes to mitigate obsolescence issues before they occur, but also to develop their reactive processes further as a complementary measure of proactive and strategic work. According to Company D, one key aspect of this is to raise organizational awareness and communicate the importance of working proactively with obsolescence. The processes of mitigating obsolescence are being based on predictions of the future, and no one can be sure what the future will look like. One of the interviewees at Company D compares it to fortune-telling, but still highlights the importance of getting it done.

The interviewee of Company B explains that it is challenging to create a sense of urgency to managers and within the organization as of present, but that it is critical to overcome how to strategically collaborate cross-functionally as obsolescence affects the performance of various functions. The interviewee further argues that Company B has begun a journey to mitigate the consequences of obsolescence in the future.

Company C describes its communication and collaboration as key since all functions and suppliers are in "the same boat" and need to work together, as well as sharing the solutions. As a result of this, the communication among the purchasers has become considerably better and now people are described to think in a more long-term perspective.

Robust Design for Obsolescence

Insights: From a strategical perspective, it appears that putting effort into robust design products containing E&E components is essential to successfully mitigate the occurrence of obsolescence. E&E components are especially difficult to account for in design because of their fast-technological development and complex nature, making *functional requirements hard to standardize. However, whenever viable, modularized, and standardized components are preferred in New Product Development (NPD) to build inherent feasibility of replacement. Therefore, preemptive mapping of critical E&E components and replacement alternatives are important before choosing an E&E component for the design. As electronic components are relatively short-lived compared to the products they are included in, redesigns are usually necessary if the remaining lifetime stretches over many years. As Company D explains, reoccurring planned facelifts to eliminate components risking becoming obsolete combined with adding other values into the product is a good way to balance resource consumption and obsolescence mitigation. This way, the occurrence of unexpected obsolescence cases can be reduced, while at the same time offering a relevant and updated product to the customers.*

Table 4.19: Robust Design for Obsolescence

Finding	Examples from Data
Robust Design for Obsolescence	• Usage of modularization and standardization of components and components for increased design robustness and order volumes **(Company D)** • Take height in implementing new hardware performance and recurrently plan for design refresh to effectively catch commencing obsolescence **(Company D)**

In the interviews, the representatives from the different companies stated that they are actively working to integrate robustness in their designs to prevent eventual product-related issues. However, there is a vast difference in the sense of how strategical these designs are in relation to obsolescence issues. There seems to be a consensus among the interviewees that, as the Company H interviewee describes it, "*it is not feasible to support electronic components forever*".

Company D expresses that they are considering obsolescence issues early in the design phase of new products. In the design phase, the company makes sure that the BOM is reviewed to make sure that no obsolete components or components at risk of going obsolete shortly are included in the product design. The company is also striving to make sure that there are alternative components, i.e. by utilizing multi-sourcing, to the components included in a product design to create possibilities of mitigating the consequences of occurring component obsolescence satisfying ways to be proactive in this regard in their processes.

One strategic approach Company D uses in managing obsolescence is to do as valuable redesigns as possible. According to one of the interviewees, the company plans their redesigns to cover and mitigate several imminent obsolescence issues. The interviewee describes that when their proactive measures in identifying critical components result in several listed components that are at risk of becoming obsolete, a decision can be made to conduct a redesign to solve several issues at the same time. The interviewee argues that there are always many things that can be covered in a redesign to maximize the value of it: "*A redesign may be driven by obsolescence, but there are also other aspects of value to cover*". As an elaboration of this statement, the interviewee explains that when conducting a redesign, the company usually tries to incorporate other value-adding activities, such as face-lifts and visual updates.

Based on market input one will have to plan for how the product portfolio should develop and how aspects of obsolescence should be incorporated. Planning for design refreshes in strategic product planning is important to avoid obsolescence surprises and crises. At the moment, Company D is looking approximately five years into the future when planning the product portfolio and planning for NPD. In this process, it is important to elevate obsolescence issues to be long-term in the planning for design refreshes of products exposed to critical E&E.

Supplier Management

Insights: According to the interviews, proper supplier management is identified as a key element of conducting E&E component obsolescence mitigation within an organization. This is particularly true for organizations with limited design ownership and BOM control, as the possibility of internal mitigation is restricted and dependence on suppliers are greater. Thus, continuous communication and close collaboration with the supplier are essential to identify and handle obsolescence issues in time. According to companies active in that context, it is important to map critical E&E components in the product portfolio and associated suppliers based on their impact on the companies' operations. As resources are finite, it is therefore viable to prioritize these suppliers based on their impact on the operations as well as their ability to work with OM, as it is not feasible to monitor the entire supplier base thoroughly adequate. Moreover, the expectations on the supplier base should be regulated by contracts that explicitly communicates the PLM and OM requirements and expectations. However, these are to be checked up upon regularly and not to be solely relied upon as there is no full assurance that mitigation is realized as agreed. What seems to be more effective long-term is to build up a two-way beneficial relationship with the key suppliers where expectations are explicitly communicated and acknowledged by both parties.

Table 4.20: Supplier Management

Finding	Examples from Data
Supplier Management	• Contractual policies clarifying and regulating reciprocal responsibilities and conduct of mitigating obsolescence **(Company F & I)** • Continuous follow-ups and communication to early on to early identify upcoming supply availability issues caused by obsolescence **(Company F & I)**

From the interviews, it is evident that good supplier management and communication is key to conduct an adequate OM, despite having design ownership or not. A key insight from the interviews in aggregate is the importance of functioning and early communication to create prerequisites to act on obsolescence issues properly.

The interviewee at Company F describes the company's supplier relationships and supplier management as a prominent aspect of managing obsolescence. The interviewee explains that the company has put a great effort in building good supplier relationships and that it is a key factor in their OM. Company F wants suppliers that are experienced and reliable, work effectively and efficiently, and have developed a plan for the parts that they manufacture in terms of validation and implementation. In general, Company F is using suppliers that are well established and have a long experience of working within the industry and the challenges it provides.

In relation to the challenges arising from obsolescence and when E&E components are becoming obsolete, the interviewee at Company F states that the company puts "*great trust in their suppliers to be able to solve problems*". The interviewee would like to see that their suppliers and their sub-supplier sign long-term agreements to ensure supply of the outsourced parts and their including E&E components.

At the same time, Company F is aware that the industry of manufacturing and supplying electronics is complicated and that the prerequisites for the companies active in the industry are changing rapidly due to changing market needs. The representative from Company I agrees with this and states that there are situations where things go wrong, especially in the communication with the suppliers' LTB notifications, i.e. PDNs and PCNs. The main issue is described as the mismatch between Company I's low ordering frequency in low quantities and the suppliers' production and supply pattern that is built on high frequency and high quantities. This mismatch might induce communicative misses, mainly because of human errors.

Company B explains that among the new actions in their organization, recurring meetings with the main suppliers have been established to map the most critical components. More emphasis has been put to create cross-functional assessments of the product and parts portfolio and to make the suppliers obligated to send PLM analysis of the availability status of the BOM so that the timeframe for action increases. This could be achieved by the ongoing development of supplier contracts where more attention has been put on PLM responsibilities and communication of such. This legal work could then be shared within a company and within a company group if there exist several subsidiaries to keep a more united approach outward, gaining bargain power.

The interviewee of Company C agrees that one cannot do business reviews on all suppliers or monitor all components as that would neither be possible from a time and resource perspective. However, one should focus on the most important suppliers and the critical components. Moreover, the relation with the suppliers is suggested to be a two-way beneficial relationship to be successful long term. It is described to be key to have a "*give-and-take relationship*", where expectations need to be explicitly communicated and acknowledged by both parties.

According to the interviewee, it can be hard for Company F to affect the suppliers and sub-suppliers since the interest of Company F and their suppliers (and sub-suppliers) can vary due to market opportunities. An E&E component significant for the purchase part outsourced by Company F can be insignificant to a supplier or sub-supplier due to other larger business opportunities, resulting in obsolescence for the component needed by Company F. In order to solve these situations, the interviewee at Company F highlight the importance of solid contracts to protect Company F from component obsolescence. Furthermore, Company G is on the other hand is also trying to establish new contracts and agreements with strategic suppliers in order to manage obsolescence, but highlights the issue of "*the more requirements you put on suppliers, the more expensive it gets*".

Company F describes that they have skilled and experienced suppliers that they put a lot of trust in. In general, the way of working with suppliers is working well due to the focus on building a good relationship between customer and supplier. According to the interviewee, the relationships are governed by contracts that include both more general agreements and more specific agreements. The general agreements determine the overall circumstances of the relation, including how the supplier should act when obsolescence occurs, logistical aspects, need for spare parts, standards that the supplier needs to comply with etc. The more specific agreements are more detailed in actions and processes, e.g. how an LTB should be managed. The interviewee at Company F describes that these contracts are protecting the business of the company in case obsolescence issues or problems occur that can not be solved. Even though the suppliers can be liable for damages, the interviewee argues that consequences, e.g. production stop, will hurt and impact the business in such a way that the contracts are not enough protection. Furthermore, the interviewee state that "*it is not viable to rely solely on contracts and create lawsuits when suppliers are unable to deliver*" and that the solutions are healthy and sustainable relationships that "*require skilled suppliers who understand their responsibilities and deliver as needed, act on deviations and present effective and sustainable solutions to problems*". When problems occur despite contracts and mutual trust, Company F works closely with their suppliers in solving the problem and helps the suppliers develop how to manage similar issues in the future.

4.3 Summary of Empirical Findings

This section aims to summarize the empirical findings from the case study, how the findings from the two different phases are related to the research questions, and how the findings will be used in answering the research questions in Chapter 5. Figure 4.1 provides a visualization of how the research questions, phases and findings are related.

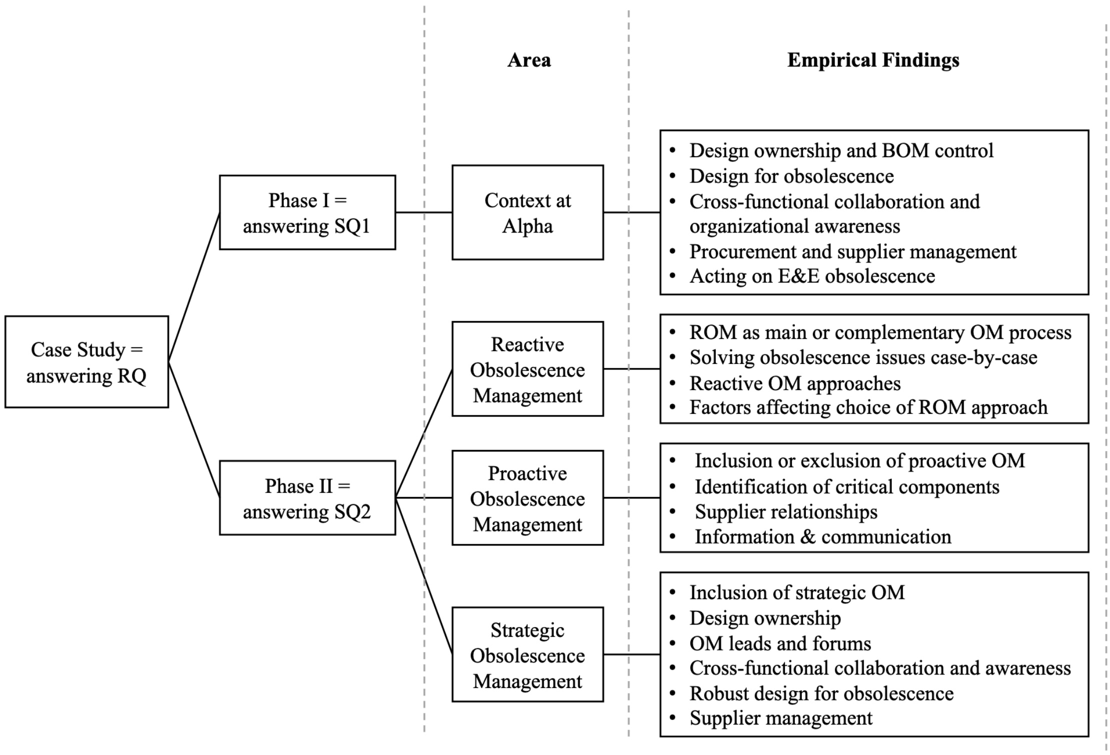

Figure 4.1: Framework of How the Empirical Findings Is Structured, Are Related to and Answers the Set Research Questions

The aim of Phase I is to answer SQ1 by presenting the context at Alpha, the common issues and measures that are being made today to mitigate obsolescence. These findings, related to answering SQ1, are structured into five areas[1]:

- **Design ownership and BOM control:** Lack of design ownership limits the conduct of monitoring obsolescence in the BOM, as well as conducting design changes as the design is owned by the supplier.
- **Design for obsolescence:** It is difficult to proactively design for obsolescence due to E&E complexity and functional uniqueness, in addition to the increasing legislation on substances used in E&E components.
- **Cross-functional collaboration and organizational awareness:** Lack of

[1]These five areas are further explained in section 4.1.

cross-functional collaboration and leadership in mitigating obsolescence in the product life cycle obstructs a unified approach.

- **Procurement and supplier management:** A broad supplier base with low supply chain transparency and bargaining power complicates the outset to put further demands on obsolescence mitigation on the suppliers.

- **Acting on E&E obsolescence:** Mainly unintentional reactive case-by-case, which could lead to higher mitigation costs and reaction time.

The aim of Phase II is to answer SQ2 by presenting the findings of the interviews with the nine benchmark companies, and thereby assessing practices how an OBM can develop strategies to mitigate obsolescence of E&E components. The findings in Phase II were analyzed and categorized into the areas of Reactive Obsolescence Management, Proactive Obsolescence Management and Proactive Obsolescence Management, where each correlating empirical finding are presented in Figure 4.1. A summary of these findings are presented in their respective areas below:

Reactive Obsolescence Management

- **ROM as main or complementary OM process:** ROM is either utilized as a main and unintentional process or as a complementary and intentional process, with the former being the most common.

- **Solving obsolescence issues case-by-case:** The complexity and uniqueness of E&E obsolescence result in a case-by-case approach.

- **Reactive OM approaches:** The different ROM approaches utilized in companies include: *Component Substitution*, *LTB & Bridge Buy*, *Redesign*, and *Spot Market*.

- **Factors affecting the choice of ROM approach:** The most suitable approach depends on the life cycle position of the product including the E&E components, timeframe, volume, and costs etc.

Proactive Obsolescence Management

- **Inclusion or exclusion of proactive OM:** The choice of including or excluding POM processes is linked to the relationship between value added and resource consumption.

- **Identification of critical components:** The limitations of resources drives the need for identification of which components to be proactively managed, i.e. critical components.

- **Supplier relationships:** Companies are either transferring responsibility of proactive measures to suppliers or collaborate with the suppliers in the proactive processes.

- **Information & communication:** There is a need for good information exchange and communication processes in the mitigation obsolescence.

Strategic Obsolescence Management

- **Inclusion of strategic OM:** Inclusion SOM is advocated to formally facilitate awareness of obsolescence implications and to deal with obsolescence issues on a structured long-term basis.

- **Design ownership:** Owning the design is seen as a strategic advantage to enable control over BOM, maintain organizational know-how, and take action over the product life cycle.

- **Obsolescence leads and forums:** Formal leadership in the transition towards comprehensive obsolescence management is advocated. These obsolescence leads are proposed to facilitate the work, awareness, and knowledge sharing within the organization.

- **Cross-functional collaboration and awareness:** Awareness of the implications of obsolescence and cross-functional communication are emphasized.

- **Robust design for obsolescence:** Mitigating obsolescence in the product design is advocated by the benchmark companies; such as design refresh planning or strategic E&E component selection.

- **Supplier management:** Contractual policies, continuous follow-ups, and collaboration are identified as good mitigation measures to obsolescence.

5

Discussion

This chapter aims to discuss the empirical findings of Phase I and II in Chapter 4 relative to the theoretical framework of Chapter 2 in order to provide an analyzed basis to answer the set research questions SQ1, SQ2, and RQ. The relation between the empirical findings identified in Figure 4.1, and the identified issues, measures and best practices are illustrated in Figure 5.1. The *identified issues and measures* are developed to answer SQ1 about common obsolescence issues and what measures are being made today. The *identified best practices* are developed to answer SQ2 about what strategies can be developed to improve mitigation of obsolescence issues. By answering SQ1 and SQ2, the main RQ of how to ensure available supply of E&E components is answered. These identified issues and best practices presented in Figure 5.1 are further elaborated on in this chapter.

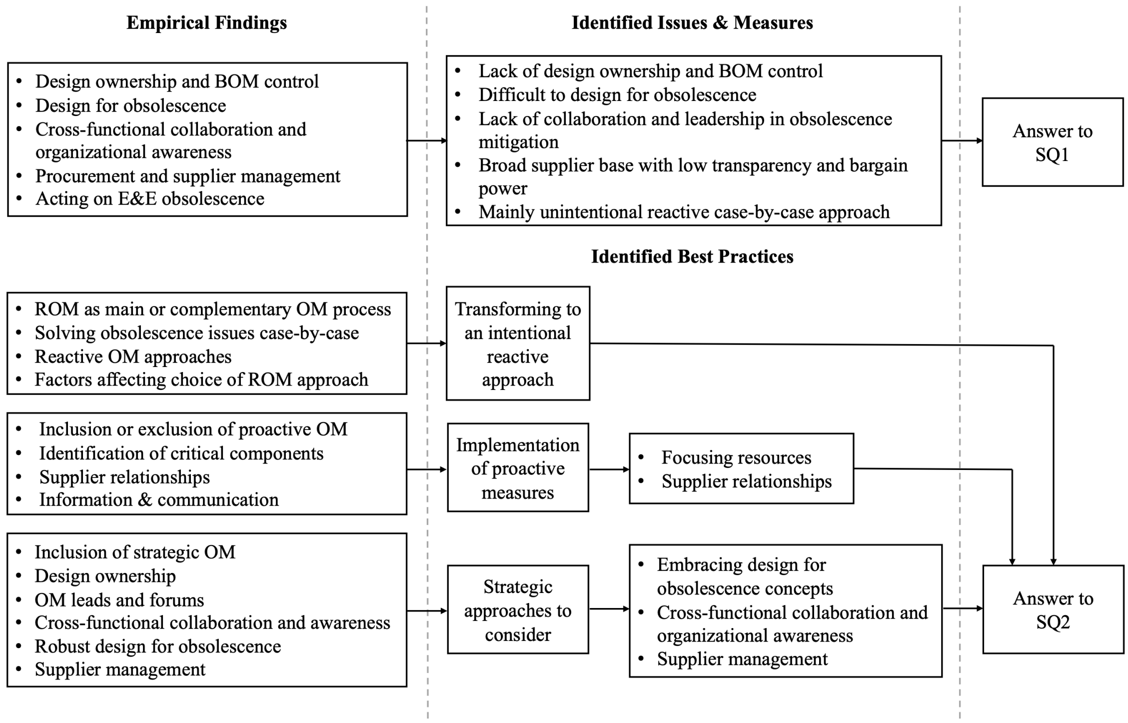

Figure 5.1: Identified Obsolescence Issues, Measures, and Best Practices

When reading this chapter, the reader need to understand that Obsolescence Management is not a dogmatic concept but rather a toolbox with different approaches that can be applied and integrated into a company's mitigation conduct depending on the respective companies' preconditions and available resources. Thus, a company seeking to introduce OM does not have to embrace all approaches presented but could adopt them incrementally. As portrayed in Figure 2.4, all obsolescence mitigation is most effective when approaches from all three areas are used together and not each one solely.

5.1 Identified Issues & Measures

Alpha is managing its obsolescence issues mainly with reactive measures. Obsolescence of E&E components is managed when issues occur and set processes of proactive and strategic approaches are missing. The situation at Alpha is not unusual, as OM in companies and organizations are dominated by and focused on reactive activities and measures (Rojo et al., 2009; Sandborn et al., 2011; Sandborn, 2013), with a focus on managing obsolescence issues after they have occurred (Sandborn et al., 2011; Singh & Sandborn, 2006). The focus on reactive and lack of proactive and strategic approaches in companies such as Alpha is described as disadvantageous long-term as it has a negative effect on costs and resource consumption. While the reactive part of OM is important, avoiding costs related to obsolescence and ensuring the supply of E&E components can be attained to a higher degree with an OM strategy including proactive and strategic approaches according to Sandborn et al. (2011) and Singh and Sandborn (2006). Furthermore, research within the theory of managing obsolescence focus on combining the three areas of OM. According to Bartels et al. (2012) and Sandborn (2008, 2013), management of obsolescence requires focusing on the three different areas of reactive, proactive, and strategic management, and the best way of maximizing cost avoidance is by combining all of the three areas (Sandborn, 2008).

Moreover, it is identified from the benchmark interviews and Bartels et al. (2012) that owning design and having control over the BOM is advantageous in companies conducting obsolescence management. Representatives from Alpha also implicitly confirm this notions as it is described that influence of design is limited when the design ownership is outsourced to the suppliers. Thereby, lack of design responsibility and BOM control is identified as an issue. Since the design ownership and knowledge of BOM are located at the suppliers, companies such as Alpha also entail difficulties of designing for obsolescence, as is presented by Company D and Bartels et al. (2012). Another unambiguous finding from the case study as well the literature is the essential precondition of cross-functional organizational awareness to perform proper conduct of obsolescence management. Presently, there seem to be issues related to a lack of sufficient collaboration and leadership concerning obsolescence in companies such as Alpha, as is depicted in the discrepancy of awareness presented in section 4.1. Lastly, there are challenges in mitigating obsolescence in supplier management due to the broadness of the current supplier base with low transparency, as it complicates adequate information flow and follow-ups needed to monitor the life cycle. Moreover, the low bargain power caused by relatively low volumes complicates the prospects of reinforcing the suppliers' responsibilities of mitigating obsolescence.

5.2 Identified Best Practices

This section provides a detailed description and discussion of the identified best practices. The best practises is grouped into the three areas of *Strategic Approaches to Consider*, *Implementation of Proactive Measures*, and *Transforming to an Intentional Reactive Approach*.

5.2.1 Strategic Approaches to Consider

This section aims to provide the reader with what best practices of SOM organizations should develop and implement in their processes.

Embracing Design for Obsolescence Concepts

An identified key aspect is to work strategically to integrate obsolescence considerations early into the design phases, so-called *Design for Obsolescence*. This is considered an area where many companies can refine their processes to impact their work of mitigating obsolescence by proactively preventing emerging E&E obsolescence from happening or causing severe damage. Thus, the issues of increasing legislation affecting products or lack of compatible E&E components could thereby be mitigated.

The integration of obsolescence considerations into early the design phase of NPD is important and is an effective way of mitigating obsolescence through intentionally choosing applicable components early in product development. This notion is shared by Bartels et al. (2012) and Rojo et al. (2009), who elaborate that technological roadmapping and internal mapping of critical components would ease this conduct by forecasting the availability of certain E&E components in the future. An insight from the empirical findings, shared by Bartels et al. (2012), is the notion that it is neither viable nor desirable to have control over all components in the products containing E&E components from a resource utilization perspective. As a consequence, it is possible to mitigate but never stop obsolescence from occurring.

Bartels et al. (2012) and Rojo et al. (2009) suggest utilizing modularization and standardized interfaces to facilitate increased access of compatible components. However, the approach might be difficult to implement in practice as several companies imply that the nature of functional uniqueness and complexity in E&E components makes such applications very limited, even though it would be a great advantage. Since it is unrealistic for E&E components to last throughout the whole product life cycle, redesigns are inevitable according to the empirical findings. This is confirmed by Singh and Sandborn (2006) and Bartels et al. (2012), who suggest using recurring redesign refresh planning to eliminate the risk of critical component obsolescence in the products. This way, the occurrence of unexpected obsolescence cases can be mitigated, while at the same time offering value-adding activities to the products balancing resources to further development and obsolescence mitigation.

A lack of design ownership and BOM control limits the mitigation of E&E components obsolescence through the strategic improvement of the design conduct. Important know-how in producing E&E products disappears when design and manufacturing are outsourced to tier 1 suppliers. A more effective approach with these preconditions would be to prioritize the improvement of the strategic perspective of supplier management in accordance to Bartels et al. (2012) through; refined and clarified contracts, mapping of the supplier base and prioritization of suppliers to focus on, as well as improve long-term consistent communication and mutual relationship building.

Cross-Functional Collaboration and Organizational Awareness

In both phases of this thesis, company interviewees stresses the importance of good communication within the organization as well as towards the suppliers. Moreover, it seems that those companies who have succeeded in their deployment of obsolescence management highlight the importance of cross-functional collaboration to early on identify and act on E&E obsolescence. According to Huang et al. (2019), communication is extraordinarily important as the product enters the latter life cycle phases to early mitigate emerging issues. There is a need for more cross-functional collaboration as organizational awareness of supporting the full life cycle of products containing E&E components is lacking. Acknowledgment and awareness are also emphasized by Bartels et al. (2012) in the initial stage as a prerequisite for successful strategic obsolescence management conduct.

Since responsibility of managing obsolescence through the entire life cycle of a product is generally undefined, a formal obsolescence lead could act as a facilitator of a unified endeavor towards a comprehensive PLM awareness and OM adoption. It is apparent from the benchmark interviews that one of the main reasons why obsolescence management is not integrated into the organizations is because there is no one principally responsible for managing obsolescence. Those companies who have succeeded in integrating OM have come further in establishing this. An obsolescence lead could facilitate cross-functional collaboration, knowledge sharing, and forums for discussion to enhance the organizational obsolescence mitigation capabilities, in accordance to the obsolescence teams proposed by Meyer et al. (2004) and Bartels et al. (2012). Once again highlighting the insight voiced in the empirical findings, recurring meetings with suppliers, management and key functional competencies are the basis of effectively acting on obsolescence long-term and before the complications have escalated.

Supplier Management

As previously described, strategic improvements of the supplier management conduct are identified as a key area to develop for organizations where lack of design ownership and BOM control limit the internal prospects of monitoring the part and component life cycle. When it comes to supplier management, there is a consensus between Bartels et al. (2012) and the empirical findings that it is not viable to continuously monitor the entire supplier base due to finite resources. Thus, mapping and prioritization are suggested based on the respective supplier's impact on the operational conduct and maturity in obsolescence management. Furthermore, if applicable, mapping of critical E&E components in collaboration with suppliers to facilitate an understanding of what components are to be secured is recommended. Such a strategic mitigation procedure is aligned to Singh and Sandborn (2006) who suggest utilizing preferred component lists to clarify communication of what components are applicable for usage. However, such actions call for sophisticated collaboration with the suppliers to provide the availability of supply.

Another aspect that has been brought up by both literature and some of the interviewees is the usage of contractual agreements to regulate the conduct of managing obsolescence and shortages in the product life cycle. Bartels et al. (2012) argue that contractual language is required to ensure effective communication and to clarify agreed responsibilities related to obsolescence mitigation between the parties. However, as interviewee F, and I describe, even though such contractual language is in place one cannot solely rely upon that the obsolescence issues will diminish as a consequence. What good is it to be settled compensation by the supplier when issues have already disturbed the company's operations? Hence, continuous follow-ups, communication of forecasts, and support to identify upcoming supply availability issues are needed. Rojo et al. (2009) suggest partnering agreements are advisable for ensuring support in supply and in dealing with obsolete E&E components. Such a partnership is also acknowledged by interviewee C who argues that the most effective approach is to build long-term mutually beneficial relationships with key suppliers. Such a transition would require reducing the supplier number to concentrate and focus on those suppliers most valuable to the organization, i.e creating partnering agreements with key suppliers. A dependency on supplier expertise in managing the life cycle of E&E components creates a need for the management of suppliers. Therefore, a more sophisticated contractual language clarifying PLM and obsolescence responsibilities of products containing critical E&E components would be a beneficial complement to the ordinary legal settlement between a company and its suppliers.

5.2.2 Implementation of Proactive Measures

Implementing proactiveness in the management of obsolescence can, in combination with implementing strategic approaches, help an organization avoid costs related to obsolescence and sustain product systems to a higher degree (Sandborn et al., 2011; Singh & Sandborn, 2006). The lack of proactiveness and POM at Alpha aligns with the majority of companies interviewed in this thesis. Of the nine companies interviewed, five are lacking proactive measures in their OM, while two have proactive processes in place and two are partly being proactive in some aspects (see Table 4.6). The exclusion or inclusion of POM is motivated by the expected value added relative to resource consumption. The companies excluding POM argue that being proactive would be too resource-consuming and costly relative to the output. The issue of POM being too resource-consuming is being addressed by Bartels et al. (2012), describing that the resources of a company or an organization are a key limiting factor in POM. But, since all organizations will not have the resources to proactively manage all components and products, there is a need for identifying and prioritizing critical components (Bartels et al., 2012). Proactive measures are therefore to be seen as something that should be adapted to a specific company context based on company prerequisites. Being proactive in OM is not to be seen as something you need enough resources for, but something you plan based on resources available. If the proactive measures are planned based on the context and prerequisites for each company, e.g. by identifying critical components, value-adding POM can be achieved for all companies.

The companies including POM in their management of obsolescence are describing that their proactive processes are producing valuable output despite requiring resources and being drivers of costs. Rojo et al. (2009) argue that several authors within the research of OM advocates for the shift from reactive to more proactive measures in managing obsolescence. This shift is illustrated by the companies including proactive measures in their processes and exemplified in the empirical findings of this thesis. The empirical findings highlights two areas important for enabling POM: *Focusing Resources* and *Supplier Relationships*

Focusing Resources

Since all companies are limited by resources, there is a need for focus resources in enabling POM. The identification of critical components is described in the empirical findings as a key and for efficient and effective POM. The constructed checklist including the six following questions illustrates how a critical E&E component can be defined:

- Is the component affecting both hardware and software functionality?
- Is the component affecting the primary product or part function?
- Will the change of the component require verification and requalification?
- Has the supplier of the component a history of being volatile, i.e. lack in communication of obsolescence?
- Is the component being single-sourced?
- Is the component outsourced as a unique or company-specific component?

If the answer is no to all of the questions, the component is not identified as critical. If the answer is yes to one or more of the questions, the components are identified as critical. The notion of identifying criticality based on certain components characteristics instead of specific component types are shared with the opinions of Bartels et al. (2012) and Sandborn (2008), meaning that the criticality of a component is based on the risk of going obsolete, the availability after obsolescence, and how problematic it will be when they become obsolete.

The identification of critical components can be compared to the steps in the proposed POM process described by Bartels et al. (2012): *Risk Analysis*, *Prioritization*, *Selection*. However, these steps assume availability of BOM an BOM control. An organization that outsources design ownership and has limitations in BOM control has different prerequisites for POM. Therefore, alternative process steps in a POM process need to be utilized, which is presented as the checklist of identification of critical components. This identification can be done internally if possible, or in collaborations with suppliers, as further developed in the next section.

Supplier Relationships

In enabling POM, collaboration with suppliers is highlighted as important in the empirical findings. The focus on supplier relationships in POM is aligned with the supplier management previously described in the strategic approaches to OM. The companies utilizing proactive measures in their OM are in general of the opinion that close collaboration with suppliers is necessary. When the design responsibility and BOM control is outsourced, the collaboration with suppliers becomes key for implementing proactive measures. The identification of critical components described above is likely to need input from suppliers. Furthermore, the fifth step of *Availability Monitoring* in the the proposed POM process described by Bartels et al. (2012) is going to need close collaboration with suppliers when the BOM is outsourced. Availability monitoring of E&E components, i.e. obsolescence forecasting, is described by Sandborn (2013) as most commonly based on BOMs and BOM analysis. When this is the case, companies outsourcing the BOM control need to make sure that the identified critical components in the BOM are either externally monitored by the supplier or communicated to the company for internal monitoring.

5.2.3 Transforming to an Intentional Reactive Approach

As previously stated, many organizations are mainly reactive when addressing issues of obsolescence, and the problems are managed when they occur. There is a common conduct of utilizing ROM as the main process and as an undeliberate choice with a lack of connection to strategic decisions, i.e. unintentional ROM. Organizations with this OM setup would benefit from developing their processes from solely reactive to also include proactive and strategic measures (Bartels et al., 2012; Sandborn et al., 2011; Singh & Sandborn, 2006), i.e. utilizing ROM as a complementary process in their management of obsolescence. Utilizing ROM as a complementary process is defined in the empirical findings as intentional ROM, i.e. allowing for obsolescence to occur and manage it reactively as a deliberate choice since the processes to handle and control obsolescence reactively are set.

Transforming from an unintentional ROM to an intentional ROM and viewing the reactive measures as complementary to proactive and strategic measures aligns with what theory states. The sixth step of *ROM Initiation* in the proposed POM process described by Bartels et al. (2012) illustrates the combination of proactive and reactive measures in managing obsolescence. This phase refers to the reactive measures launched when the components not chosen for proactive measures, i.e. not identified as critical components, become obsolete and need resolution. Even though proactive approaches and strategies are emphasized as preferable, organizations need to have prepared reactive processes when issues occur (Bartels et al., 2012; Rojo et al., 2009; Sandborn, 2013). By deciding which components to manage proactively and which components to manage reactively, companies can move from unintentional ROM to intentional ROM and develop their reactive measures to be complementary to their proactive approach.

When obsolescence occurs, the adequate ROM approach needs to be utilized based on the context and prerequisites of the obsolescence situation. In the empirical findings, the life cycle position of the product that the E&E component is included in is explained to be a major factor when choosing a reactive approach. This can be explained by the life cycle curve presented by Huang et al. (2019), and in more detail by the adapted life cycle curve including both the E&E component life cycle and the product life cycle (see Figure 2.6). The lack of overlap between the curves is illustrating the life cycle mismatch, which makes different ROM approaches more or less suitable. A larger life cycle mismatch implies that obsolescence of a E&E component occurs when the product it is included in is still in series production. This situation requires more long-term solutions due to higher product quantities, longer time frames, more remaining sales volume, and more expected revenue. This motivates larger investments in resources and costs, which means that ROM approaches of component substitution, bridge buys, and redesign are more suitable. This aligns with the argument by Bartels et al. (2012) that an approach needs to be economically viable. LTBs of large volumes are not suitable due to the long time frame, high quantities, and challenges in making accurate prognoses. This finding underpins the theory described by Bartels et al. (2012) that volume requirements and the number of products using the obsolete components are affecting the choice of ROM approach. A smaller life cycle mismatch implies that obsolescence of a E&E component occurs when the product it is included is in aftermarket support and services. This situation requires more short-term solutions due to lower product quantities, shorter time frames, less remaining sales volume, and less expected revenue. This discourages larger investments in resources and costs, which means that ROM approaches of component substitution and low volume LTBs are more suitable. Redesigns are not suitable due to the high resource consumption and high costs relative to low remaining sales volume and expected revenue. This illustrates a situation where ROM approaches need to be chosen based on economical viability described by Bartels et al. (2012), heavily affected by low volume requirements and volumes of products using the obsolete components.

6

Conclusion

The thesis provides knowledge and explores what learnings in product life cycle management and obsolescence management could be applicable for an OBM to ensure availability of E&E components in products with long manufacturing and support life cycles. Moreover, to fulfill this aim, the main research question constituted of *How can an OBM ensure available supply of E&E components with short procurement lifetime in products with long manufacturing and support life cycles?*, which was answered through two sub-research questions.

The first sub-research question *SQ1* formulated as *What common obsolescence issues does an OBM face in the procurement of the components mentioned in RQ and what measures are being made today?* is answered by the empirical findings gathered through qualitative interview with Alpha and benchmark companies, see Figure 6.1. The insights gained are that companies as a consequence of enduring E&E components obsolescence are experiencing unexpected disruption of supply that compels the companies to reallocate resources to sub-optimal obsolescence mitigating activities that impede operational conduct. It emerged that the measure of managing obsolescence at Alpha, along with the majority of the benchmark companies, currently are through a *mainly unintentional reactive case-by-case approach* with few or no consistent proactive or strategic measures. The main obsolescence issues are identified as a *lack of design ownership and BOM control*, *difficulties of designing for obsolescence*, *lack of collaboration and leadership in obsolescence mitigation*, and a *broad supplier base with low transparency and bargain power*. These findings show a discrepancy with what research theory proposes, evidently accentuating the inclusion of comprehensive obsolescence management to effectively mitigate related issues with lower cost, lead times, and operational disturbance, in addition to a better understanding of the product portfolio life cycle status.

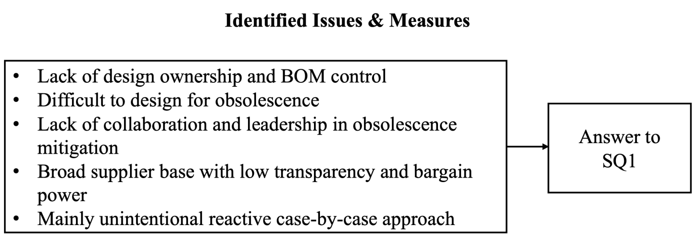

Figure 6.1: Identified Issues & Measures

Furthermore, the second sub-research question *SQ2* formulated as *How can an OBM develop strategies to improve current and future procurement to mitigate obsolescence issues related to the components mentioned in RQ?* is answered by the identified best practices developed in the discussion chapter, see Figure 6.2. These practices are *Embracing Design for Obsolescence Concepts*, *Cross-Functional Collaboration and Organizational Awareness*, *Supplier Management*, *Focusing Resources*, *Supplier Relationships* and *Implementation of Intentional ROM*. Each area is addressing mitigation efforts in the different phases of the product life cycle and the different areas of OM, from design conception to discontinuance. To sufficiently succeed in ensuring available supply of E&E components, an Obsolescence Management conduct integrating ROM, POM SOM is emphasized. The following section will further elaborate on these areas through presenting the recommendations to Alpha.

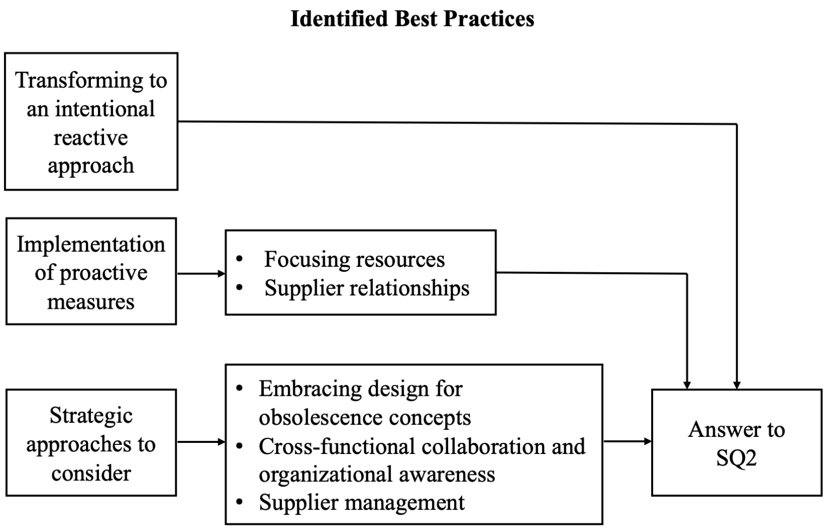

Figure 6.2: Identified Best Practices

6.1 Recommendations to Alpha

This section aims to present the set recommendations to Alpha based on the outcome of the discussion. The recommendations are applied in the context of Alpha derived from the insights made from the empirical findings and theory of obsolescence management and life cycle management considerations. In the coming section, it will be explained *What*, *Why* and *How* the proposed recommendation can be introduced into Alpha.

The theory within Obsolescence Management is unambiguous in its position that the best way of managing obsolescence is by combining the three areas of Strategic, Proactive, and Reactive Obsolescence Management. The findings in this thesis illustrate that even though many companies are mainly reactive in their management of obsolescence, the companies that employ strategic and proactive measures are experiencing beneficial effects in their obsolescence mitigation processes. Therefore, Alpha should extend the OM from being solely reactive to include proactive and strategic measures. Alphas processes for managing obsolescence should be a combination of Strategic, Proactive, and Reactive Obsolescence Management.

As the reason why these recommendations are valid to companies such as Alpha, it has its root cause in the transforming technology shifts. As Huang et al. (2019) and Rojo et al. (2009) declare, the life cycle mismatch between products and individual E&E components in present-day industries will continue to grow globally. As will the usage and importance of more complex E&E components. Hence, the relevance of conducting a well functioning obsolescence management to remain competitive and to produce customer value is even more emphasized as these trends continue. By shifting from unintentional reactive mitigation to a comprehensive and integrated OM, Alpha could increase its capabilities of mitigating obsolescence issues and unforeseen operative disruptions. Thus, reduced costs, supply chain uncertainty, and better resource allocation would be achieved long-term.

Transforming from being solely unintentional reactive to include strategic, proactive, and intentional reactive approaches is a process that will require effort, time, and resources for an organization. As an indication of how to start that process, this thesis proposes several key areas for the development of an OM including strategic, proactive, and reactive measures.

- Even though Alpha lacks the design ownership and BOM control over certain E&E at present, the long-term strategical establishment of *Design for Obsolescence* is proposed to be implemented when applicable. This is viable as obsolescence mitigation is most effective in the conception of the product design.

- Moreover, it is evident that *Cross-Functional Collaboration and Organizational Awareness* is a key prerequisite for successful mitigation of obsolescence as described in the previous sections, both internally and with the suppliers. As the responsibility for mitigating obsolescence currently appears to be undefined within Alpha, a formal obsolescence lead role or team is proposed to facilitate a unified effort of building up OM capabilities within Alpha.

- From Alphas current outset, *Supplier Management* is identified as a crucial area for Alpha to develop to ensure availability of E&E supply. Further, it is advised to map and prioritize the suppliers based on their operational impact and OM capabilities. Deeper relationships and mutual support with strategic and critical suppliers are acknowledged as preconditions for increased collaboration. Lastly, further developing contractual agreements which include clarified conduct of life cycle monitoring and obsolescence mitigation is recommended.

- To be more proactive, Alpha need to assign resources in developing and implementing their proactive measures and processes. Furthermore, *Focusing Resources* needs to be done to achieve valuable results. To do so, Alpha should follow the developed process of POM:

1. Product Selection (decide business critical products)
2. Identification of Critical Components (utilize presented checklist)
3. Availability Monitoring (in collaboration with suppliers)
4. ROM Initiation (develop intentional ROM)
5. Reprioritization (iterate process)

- The step of monitoring availability needs to be executed in close collaboration with suppliers, i.e. developing *Supplier Relationships*, which is included in the *Supplier Management* mentioned in the previous section. In the POM process, the transformation to intentional reactive measures is being incorporated. Alpha should develop a process where strategic decisions are guiding which components to manage proactively and which ones to manage reactively, i.e. *Implementation of Intentional ROM*, complementary to the POM. Furthermore, the choice of which reactive approaches to use needs to be a conscious decision and should be guided by the relationship between the life cycle position of the product and the life cycle position of the E&E components, i.e. life cycle mismatch.

6.2 Issues in Implementation

The implementation of OM in an organization will be exposed to challenges. The organizational change will require resource allocation and a will to change within the whole organization. It will be important to set aside resources for the adaptation and implementation of OM to an organization's current processes. In the early stages of implementation, there will be many short-term costs for long-term benefits. The results of obsolescence mitigation can be hidden in the sense that it can be difficult to notice when obsolescence mitigation work and easier to see when it does not work. It can be hard to measure the results of OM since it does not explicitly increase revenue but only reduce costs. Therefore, it will be important to be persistent and long-term in the incorporation of OM into an organization. Furthermore, it will be important to have cross-functional support as well as support from management to facilitate sustainable change.

6.3 Further Research

To develop the areas addressed in this thesis and the research within Obsolescence Management in general, further research should be conducted. This thesis provides insights and findings on key areas for development in an organization based on data from several different companies within the relatively broad context of developing long life cycle products containing E&E components. While this research provides a general understanding of the issues and conduct in related to obsolescence, it could be narrowed down, and future research should focus on finding contextual differences in the management of obsolescence. This research could include aspects such as differences between industries, company sizes, and product types. Furthermore, the research within OM would benefit from more case studies and specific research into different contexts. This would expand the literature within OM and both provide extended breadth and depth within the research. While this thesis provides insights and findings on key areas for development, the implementation of these areas needs to be further researched. By mapping current processes within organizations and understand how to incorporate obsolescence processes, an increased understanding on how to implement OM effectively and efficiently can be achieved. This would further develop OM research by bridging the gap between theory and implementation.

Bibliography

Bartels, B., Ermel, U., Pecht, M., & Sandborn, P. (2012). *Strategies to the Prediction, Mitigation and Management of Product Obsolescence* (1st ed.). John Wiley & Sons, Inc. https://doi.org/10.1002/9781118275474

Bryman, A., & Bell, E. (2015). *Business Research Methods* (4th ed.). Oxford University Press.

Cao, H., & Folan, P. (2012). Product life cycle: The evolution of a paradigm and literature review from 1950-2009. *Production Planning & Control*, *23*(8), 641–662. https://doi.org/10.1080/09537287.2011.577460

Coffman, J., Ganguli, N., Brown, B., & Iyer, R. (2009). Caution ahead: Transformation and disruption for automotive suppliers. *Deloitte Insights*. https://www2.deloitte.com/us/en/insights/industry/automotive/global-automotive-supplier-study.html

European Commission. (2011). REACH and Directive 2011/65/EU (RoHS): A Common Understanding (Doc. CA/36/2014). https://ec.europa.eu/docsroom/documents/5804/attachments/1/translations/en/renditions/native

Gerring, J. (2004). What Is a Case Study and What Is It Good for? *The American Political Science Review*, *98*(2), 341–354. https://doi.org/doi:10.1017/S0003055404001182

Huang, C. M., Romero, J. A., Osterman, M., Das, D., & Pecht, M. (2019). Life cycle trends of electronic materials, processes and components. *Microelectronics Reliability*, *99*, 262–276. https://doi.org/10.1016/j.microrel.2019.05.023

Knight, M. (2021). The Outlook for the Electronic Component Supply Chain in 2021. *EMSNow*. https://emsnow.com/the-outlook-for-the-electronic-component-supply-chain-in-2021/

Lynn, A. (2018). Why is there an electronic component shortage? *Electronic Specifier*. https://www.electronicspecifier.com/news/analysis/why-is-there-an-electronic-component-shortage

Meyer, A., Pretorias, L., & Pretorius, J. H. C. (2004). A model to manage electronic component obsolescence for complex or long life systems. *2004 IEEE International Engineering Management Conference (IEEE Cat. No.04CH37574)*, *3*, 1303–1309. https://doi.org/10.1109/iemc.2004.1408905

Patel, R., & Davidson, B. (2019). *Forskningsmetodikens grunder: att planera, genomföra och rapportera en undersökning* (5th ed.). Studentlitteratur.

Rojo, F. J. R., Roy, R., & Shehab, E. (2009). Obsolescence Management for Long-life Contracts: State of the Art and Future Trends. *International Journal of Advanced Manufacturing Technology*, *49*(9), 1235–1250. https://doi.org/10.1007/s00170-009-2471-3

Sandborn, P., Prabhakar, V., & Ahmad, O. (2011). Forecasting electronic part procurement lifetimes to enable the management of DMSMS obsolescence. *Microelectronics Reliability*, *51*(2), 392–399. https://doi.org/10.1016/j.microrel.2010.08.005

Sandborn, P. (2008). Strategic Management of DMSMS in Systems. *DSP Journal*, *April/June*, 24–30.

Sandborn, P. (2013). Design for obsolescence risk management. *Procedia CIRP*, *11*, 15–22. https://doi.org/10.1016/j.procir.2013.07.073

Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research Methods for Business Students* (8th ed.). Pearson. https://www.pearson.com/se/Nordics-Higher-Education/subject-catalogue/business-and-management/Research-methods-for-business-students-8e-saunders.html

Singh, P., & Sandborn, P. (2006). Obsolescence driven design refresh planning for sustainment-dominated systems. *The Engineering Economist*, *51*(2), 115–139. https://doi.org/10.1080/00137910600695643

Solomon, R., Sandborn, P. A., & Pecht, M. G. (2000). Electronic part life cycle concepts and obsolescence forecasting. *IEEE Transactions on Components and Packaging Technologies*, *23*(4), 707–717. https://doi.org/10.1109/6144.888857

Stake, R. E. (1995). *The Art of Case Study Research*. SAGE Publications Inc. https://us.sagepub.com/en-us/nam/the-art-of-case-study-research/book4954

A

Interview Guide for Phase I

Table A.1: Interview Guide for Phase I

1. Questions to Open up for Discussion
• Who are you and what is your role within the company? • Where in the life cycle of sourced electrical and electronics (E&E) component are you in general active (design/prototype - series production - aftermarket)? • What are common life cycle and component obsolescence problems for you and your company? • What are causing these obsolescence problems for you and your company? • What are the consequences when E&E components become obsolete? • If you are aware of the problems, why do you think they are not solved yet?   – What is needed for being able to solve the problem?
2. Conclusion
• Compilation of answers and verification of notes

B

Interview Guide for Phase II

Table B.1: Interview Guide for Phase II

1. Introduction

- Practical information
  - Anonymity and confidentiality
  - Use of collected data
- Presentation of us and the master thesis
  - Problem definition & aim
- Interview structure
- Definitions
  - **Obsolescence:** The situation where materials, components, parts, devices, services, and processes are no longer obtainable, i.e. non-procurable, from from their original manufacturer or supplier.
  - **E&E:** Electrical and Electronics
  - **E&E Components:** Active, passive or electromechanical components included in an electronic assembly structure, e.g. transistors, diodes, integrated circuits, resistors, capacitors, switches, power sources etc.
  - **BOM:** Bill of material (or production structure) including the components used in the part or product assembly

2. Context

- Who are you and what is your role within the company?
- Can you give us a short introduction to the characteristics of the products in your company with respect to life cycles and obsolescence?
- Can you give us a short introduction to the structure of your supplier relations with respect to design responsibilities and BOM transparency?

3. Interview Questions

Baseline

- Could you give a short introduction to your role and how you come in contact with obsolescence of E&E components in your daily work?
  - Where in the life cycle of sourced E&E components are you typically active (design/prototype - series production - aftermarket)?
- What do you see as challenges regarding the obsolescence of E&E components?
  - What are common problems for you and your company?
  - What are causing these problems for you and your company?
  - What are the consequences when components become obsolete?
- If you are aware of the problems, why do you think they are not solved yet?
  - What is needed for being able to solve the problem?

Reactive Obsolescence Management

- What are your actions when facing obsolescence of E&E components resulting in unavailability of supply from your supplier(s)?
  - What measures are being done to solve these problems when they have occurred?
  - Do you have any agreed processes of how buyers should act when obsolescence occurs within your company?
  - Do you think your reactive actions work effectively to handle obsolescence?
- Do you have an example of when things "went south" from an obsolescence perspective, i.e. a critical obsolescence issue?
  - What were the consequences?
  - What reactive actions were made?
  - What did you learn from this?

Proactive Obsolescence Management

- Are you actively trying to prevent obsolescence of E&E components from happening?
  - How are you working with mitigation of obsolescence issues before they occur?
  - Do you think your proactive actions work effectively to handle obsolescence?
- Are you tracking and monitoring the life cycle of the E&E components in your products?
  - What types of components do you identify as critical and why? How is criticality of components defined?
  - Do you use any software/system to monitor the life cycle of components?
- What information is/would be helpful to have to prevent problems related to obsolescence of E&E components?
  - Information from suppliers?
  - Information from software/systems?

Strategic Obsolescence Management

- Does your company have an explicit strategy for how to manage obsolescence of electronic components?
  - Is obsolescence management integrated in your purchasing processes?
- How do you cooperate with other business functions within the company in the work with obsolescence management?
- How do you work with your suppliers to manage obsolescence issues?
  - How and when do you communicate necessary information?
  - Do you specify obsolescence management responsibilities in your contracts with suppliers?
  - How is the responsibility divided between you and the supplier?

4. Conclusion

- Compilation of answers and verification of notes

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SUPPLY AND OPERATIONS MANAGEMENT
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
www.chalmers.se

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