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Strategic Decision Factors for Key Innovation Leaders in Undefined High-Tech Market Environments

Evidence from the Urban Air Mobility Industry

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Abstract

Advances in technology have paved the way for Urban Air Mobility (UAM) as a new means of transportation providing solutions for both inner-city and regional transportation. Novel vertical take-off and landing (VTOL) vehicles promise to be less noisy and safer, thus allowing for an integration of UAM into current mobility systems. However strategic decision factors, supporting VTOL manufacturers to successfully commercialize their innovation in a non-existent market, are still mainly unassessed. This research examines which decision factors need to be considered by VTOL manufacturers within the undefined high-tech market environment and how these manufacturers can achieve commercial success. Grounded theory is deployed to derive theoretical assumptions based on 16 expert interviews. Additionally, innovation strategy literature and the Profiting from Innovation (PFI) framework is utilized to derivate strategic implications influencing the commercial success of the innovation. Eight decision factors as well as strategic implications for VTOL manufacturers were identified enlarging current academic UAM literature. Furthermore, this research proposes an extension to the underlying innovation strategy literature. The PFI framework is enhanced by a *Peripheric Sphere,* incorporating the influence of external factors on commercial success in undefined high-tech industry environments.

Keywords: Urban Air Mobility; VTOL Manufacturers; High-Tech Markets; Decision Factors; Innovation Strategy; Profiting from Innovation

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List of Abbreviations

ATC	Air Traffic Control
ATM	Air Traffic Management
EASA	European Aviation Safety Agency
eVTOL	Electronic Vertical Take-off and Landing (Vehicle)
FAA	Federal Aviation Administration
IP	Intellectual Property
MBV	Market Based View
PFI	Profiting From Innovation
RBV	Resource Based View
UAM	Urban Air Mobility
UAS	Unmanned Aircraft System
UTM	Unmanned Traffic Management
VTOL	Vertical Take-Off and Landing (Vehicle)

1. Introduction

"*We can now say that human beings have flown a rotorcraft on another planet*" (MiMi Aung, Project Manager NASA). On April 19th 2021, the battery powered NASA drone "Ingenuity" completed its first flight on Mars (BBC, 2021). Being able to fly a drone on a planet 70 million kilometers from earth demonstrates the current stage of technology. However, flying (autonomous) vehicles are not dreams of the future, but could soon be integrated into our current mobility systems. Numerous social, economic and technological trends have poised rapid development in the urban mobility sector.

The development and maturation of technology has led to the development of various flying vehicles (McKinsey & Company, 2017). Moreover, global population and urbanization is experiencing vast growth and by the year 2050, up to 80% of the world's population is expected to live in cities. This results in an upsurge of resource and service usage in urban areas, which, in turn requires cities to improve their efficiency to maintain a healthy urban environment (MarketLine, 2019). It is argued that the recent advances in technology, autonomy, and electric propulsion as well as the ongoing urbanization are paving the way for Urban Air Mobility (UAM) to be integrated into current mobility systems (Shamiyeh et al., 2018; Roland Berger, 2018). Companies focusing on UAM aim to bring urban mobility into the third dimension by integrating flying vehicles into the multimodal mobility concepts of cities, regions and countries (Horvath & Partners, 2019). It is expected that these vehicles will be electrically propelled and are able to vertically take-off and land (Uber Elevate, 2016). These vehicles will be hereinafter referred to as VTOL (Vertical take-off and landing) vehicles.

In the last year alone, companies involved in the production of these vehicles have secured massive funding exceeding the one-billion-dollar mark (Lufthansa Innovation Hub, 2021). Additionally, within the next 30 years, it is expected that there will be more than 100,000 passenger drones, up to 50,000 daily trips, and a market value of more than $500 billion in the U.S. alone (Roland Berger, 2018; Booz, Allen & Hamilton, 2018).

1.1. Relevance

Within recent years, the emerging UAM industry has gained much attention from both media as well as literature (Straubinger et al., 2020; Kellermann, Biehle, & Fischer, 2020). Besides the large media coverage, academic scholars have examined various aspects of this new mode of transportation (Zhou et al., 2019; Silva et al., 2018; Fredericks et al., 2018; Rothfeld et al., 2018; Shamiyeh et al., 2018; Vascik & Hansman, 2017; Vascik et al., 2018). However, these scholars each focus individually on technological aspects, regulatory, operational and infrastructure issues, and public acceptance. Yet, a holistic view and research of the vehicle manufacturer and the challenges it faces has thus not been taken. This is also echoed by Straubinger et al. (2020) who highlight the missing business perspective on the UAM industry.

This research focuses on the manufacturer of UAM passenger vehicles from a business strategy perspective. As the associated technological composition of the vehicle and the resulting vehicle design and service is intended to create a new market, it represents a radical disruptive innovation (Bower & Christensen, 1995; Henderson & Clark, 1990). Therefore, the business perspective of the VTOL manufacturer as the innovator is analyzed on the basis of innovation strategy literature.

Innovation is a widely discussed topic as it is argued that firms need innovation to compete for market share (Prahalad & Hamel, 1990; Kaplan & Norton, 1992; Tushman & Anderson, 1986; Christensen, 2001). However, before a firm is able to compete in the market, it has to consider various aspects, which influence its innovation and market entry. This notion has been prominently picked up by Teece (1986) who constitutes a framework on how innovators can profit from their innovation.

In order to identify what aspects UAM vehicle manufacturers need to consider, this research builds upon the Teecian school of thought. Throughout this research it became evident that the current UAM literature largely disregards the business perspective on UAM manufacturers while, at the same time, a research gap in innovation strategy literature neglecting external aspects emerging from undefined high-tech markets has been identified. The following underlying research question intends to address the aforementioned deficiencies in both UAM and innovation strategy literature.

1.2. Research Question and Objectives

The purpose of this research is of exploratory nature (Saunders et al., 2019), as it addresses the above described relevance by identifying the key decision factors to be considered by VTOL manufacturers to succeed in the undefined UAM market. Hence, this research aims at answering the following underlying research question:

Which decision factors need to be considered by key innovation leaders when entering an undefined high-technology market environment and how can they achieve commercial success? – Evidence from the UAM industry

The objectives of this research are to identify decision factors which are perceived important for VTOL manufacturers in the undefined UAM market to be commercially successful. Additionally, the existing academic UAM literature is extended and the research gap in UAM literature omitting the business perspective on VTOL manufacturers is addressed. Moreover, this research aims at providing a theoretical framework closing the identified research gap in innovation strategy literature. Furthermore, strategic implications for VTOL manufacturers are derived and guiding recommendations are drawn.

1.3. Methods

In accordance with the nature of the research question and the research objective, this research applies a qualitative approach with an exploratory focus on people's behavior and opinion (Saunders et al., 2019). As constructivist grounded theory is applied, this research is based on individual opinions and interpretation of realities and context (Charmaz, 2006). Hence, this research adheres to the philosophy of interpretivism. Following the literature review, semi-structured expert interviews are conducted. In order to derive meaning and data from the interviews, a two-step coding technique was applied to build theory. Existing literature and derived data are continuously compared to ensure the integrative nature and abductive reasoning. Consequently, the methodology used provides the foundation for deriving the findings of the research.

1.4. Main Findings

By applying the above outlined methods and by addressing the aforementioned research question and objectives, eight decision factors were identified which are perceived as highly important for VTOL manufacturers to be commercially successful. Further, interrelations of the abovementioned eight decision factors and measures to overcome challenges emerging from the factors have been identified. In a second step, the identified decision factors were juxtaposed to, for one, the current UAM literature status and, for another, to the innovation strategy literature. Here, it emerged that the decision factors partially overlap with current UAM literature aspects, however, several extensions and additions are identified. With regard to innovation strategy literature, this research extends the Profiting from Innovation (PFI) framework (Teece, 1986) by adding an additional layer (*Peripheric Sphere)* which considers external influences on an innovator's market entry and commercial success. Further, it became apparent that the identified *Peripheric Sphere* influences an innovator's strategic orientation, which, following the underlying strategic innovation theory, so far has not incorporated external factors emerging from an undefined market environment. Thus, this research provides an extended framework which can be utilized by innovators in undefined high-tech market environments to frame their strategic orientation. The findings can be attributed to adjacent markets, however, as this research only examined a narrow industry environment, validation of this notion is needed and further research should be conducted.

1.5. Thesis Structure

This research is structured as follows. Chapter *2* outlines the current stage of the UAM industry. And is followed by a literature review in chapter *3*. First, a review of the current academic UAM literature with particular emphasis on considerations or factors that have been raised by other researchers for successful implementation of the technology and service is given. This is followed by a thorough review of innovation strategy literature with special focus on the work by Teece (1986) as well as other scholars building on his findings. Chapter *4* sketches the methodology used for this research in greater detail. Chapter *5* unveils the findings gathered from the conducted interviews. The following chapter *6* relates the results to the literature cited. Furthermore, chapter *6* extends both the UAM literature as well as the innovation strategy literature. Additionally, implications for both innovation strategy and UAM strategy are drawn and recommendations for VTOL manufacturers are depicted. Chapter *7* entails a discussion of this research. Lastly, limitations and further research is discussed before concluding this research in chapter *9*.

2. Industry Overview

After introducing the research topic and the research objective, the succeeding chapter aims at providing a sound overview of the UAM industry. Emphasis is placed on technological development and the resulting emergence of VTOL vehicle manufacturers in recent years.

The evolution and maturation of technology has led to the development of various flying objects and related ventures (McKinsey & Company, 2017). Drones are already being used in the private and commercial sectors and intensive development is being conducted on the introduction of drones for cargo and passenger transport. The recent technological advances in autonomous driving (Fu et al., 2019) and electric propulsion (Shamiyeh et al., 2018) make UAM a valuable future mode of transportation (Roland Berger, 2018).

Passenger air mobility-focused ventures have the vision to bring urban mobility into the third dimension by integrating flying vehicles into the multi-modal mobility concepts of cities, regions and countries (Horvath & Partners, 2019). Thus, an additional mode of transport will be added to the current mobility mix alleviating transportation congestion on the ground (Uber Elevate, 2016). The service will be performed by "a network of small, electric aircraft that take off and land vertically (VTOL aircraft - Vertical Take-off and Landing)" (Holden & Goel, 2016, p. 2). These vehicles will use so-called vertiports, which serve as take-off and landing points (Vascik & Hansman, 2019). Additionally, charging-, service- and maintenance infrastructure is foreseen to be integrated into vertiports (Horvath & Partners, 2019).

Similar to other modes of transportation such as ride-hailing services, passengers are expected to book on-demand air taxis using a digital platform (Roland Berger, 2018). The service will be then carried out between the available vertiports. Moreover, the propulsion of the vehicles is expected to be electrical. Even though it is argued that the service will be autonomous (unpiloted), a piloted transition phase will be necessary (Horvath & Partners, 2019). The particular design of the vehicles, the specific propulsion modality, distance of the service and potential seats varies for the different vehicle concepts and manufacturers (Roland Berger, 2018; Lufthansa Innovation Hub, 2021; Horvath & Partners, 2019; Shamiyeh et al., 2018). Therefore, UAM will be referred to as the industry of VTOL vehicles and their surrounding ecosystem with the VTOL manufacturer as the inventor and producer of the vehicles.

UAM has gained much attention in recent years. This is mainly due to the emergence of several start-ups designing and engineering futuristic vehicles, which could service as a new urban transportation mode. However, the idea of urban mobility taken to the air is not a new phenomenon. The usage of helicopters as air taxis has been existent for many years in megacities like New York, Sao Paulo and Tokyo (Roland Berger, 2018). However, recent media coverage on UAM is not targeting conventional helicopter services, but refers to startups such as Volocopter, Lilium, Joby Aviation or EHang and their current up-rise (EHang, 2021; Volocopter, 2021; Lilium, 2021b; Joby Aviation, 2021).

As described above, helicopters currently dominate the short-haul air transportation. However, these helicopter services are operating in a high-price segment whereas (electric) VTOL vehicles could prove more efficient and cheaper. Various reports have shed light on the current development within this emerging field of air transportation wherein it is stated that more than 250 companies try to get a stake in this emerging industry (Lufthansa Innovation Hub, 2021; Roland Berger, 2018; Pelli & Riedel, 2020).

In 2020 alone, VTOL vehicle manufacturers secured more than $1 billion in venture capital (Lufthansa Innovation Hub, 2021). Most notably, Joby Aviation, a California-based VTOL manufacturer, secured a total of $796 million from investors such as Uber, Toyota and Intel since its formation in 2016 (Crunchbase, 2021b). In addition, the two most prominent European manufacturers are Germany-based Volocopter and Lilium, both of which received more than $350 million in funding (Crunchbase, 2021a; Crunchbase, 2021c). In March 2021, Lilium announced its intention to list on the NASDAQ through a merger with Quell (Lilium, 2021c). Besides venture-backed startups, a number of aircraft manufacturers, airlines, technology companies, and car manufacturers have also stepped up their activities in this area. Of note are Airbus' UAM activities, which were officially launched in 2016 (Airbus, 2016). The company is currently developing the CityAirbus, an electric four seat multicopter

(Airbus, 2021). Moreover, automotive manufacturer Hyundai established its UAM division in 2019 and announced plans to invest $1.5 billion in air taxi technology by 2025 (Lufthansa Innovation Hub, 2021; Hyundai Motor Group, 2021).

Needless to say, developing the technology, entering the market and ramping up production is a capital intensive undertaking. However, the level of investment in the market also suggests that UAM will develop into a means of mass transport (Lufthansa Innovation Hub, 2021). Among the key promises of the service are: reduced transportation time, improved flexibility, demand oriented mobility, increased safety through autonomous systems, sustainability through reduced pollution, and reduced strain on existing infrastructure (Horvath & Partners, 2019). What is more, some expect that by 2050 up to 100,000 passenger drones could be in service (Roland Berger, 2018). NASA is expecting up to 50,000 daily trips by air taxis and airport shuttles in the U.S. alone and Booz, Allen and Hamilton (2018) predict a U.S. market worth $500 billion.

Thus, several regions and cities around the world are testing the applicability of UAM and its ability to be integrated into existing mobility systems. For example, Ingolstadt and the Munich metropolitan area are exploring UAM as an addition to their current transport systems (Ploetner et al., 2020). Moreover, several cities such as Dubai, Singapore, Dallas, Los Angeles and Tokyo have announced to provide initial proof of concept (Roland Berger, 2018). *Figure 1* exemplifies how UAM could be integrated into current mobility systems.

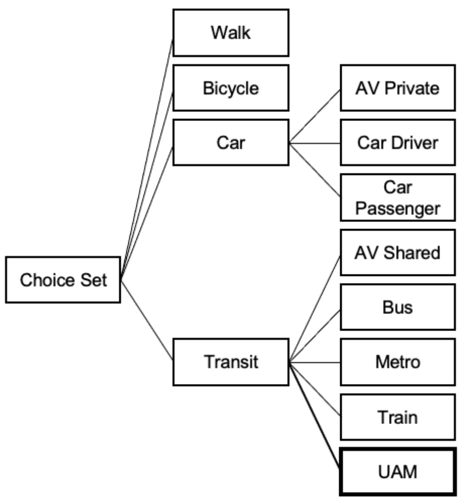

Figure 1: Mode Choice Nesting Structure (Ploetner et al., 2020)

However, the positive market expectations are confronted with a range of non-negligible difficulties and challenges that need to be overcome to operate commercially successful. The Booze, Allen and Hamilton (2018) report found that the commercial realization of the service faces significant legal- and regulatory-, weather-, certification-, public perception- and infrastructure- constraints. Additionally, the Uber Elevate report (2016) points out challenges such as battery technology, vehicle efficiency and reliability, safety and air traffic control.

Taking into account the aforementioned constraints, the UAM industry today is still in the early development phase. Establishment, initial investment and product development of most of the manufacturers have taken place in the last 10 years. Due to the nature of the technology and conditions, none of the manufacturers are yet commercially operating. However, ambitions are high and the first demonstration flights have been carried out. In 2019, Volocopter made its first one minute long piloted demonstration flight in Singapore (Volocopter, 2019). Moreover, the Chinese manufacturer eHang is running its global demonstration tour and has presented the vehicle in 39 cities across eight countries. Besides, the company started offering tourist sightseeing flights in several Chinese cities (EHang, 2020). Furthermore, most of the named manufacturers have announced plans to launch their commercial operations within the next decade (Sarsfield, 2021).

Above all, the industry shows very strong momentum, high expectations and huge potential, while at the same time a number of challenges and constraints need to be overcome. Hence, this research focuses on decision factors influencing the commercial success of VTOL vehicle manufacturers.

After providing an overview on the evolution of the UAM industry, the subsequent chapter provides a review of the academic UAM literature and thus identifying aspects influencing the introduction of the UAM service. Thereafter, the strategic innovation literature is outlined.

3. Literature Review

This chapter reviews existing UAM literature as well as literature in the areas of innovation strategy from a key innovation leaders point of view. First, the current academic UAM literature is reviewed. Here, a particular focus is put on aspects or considerations that have been raised by other researchers for successful implementation of the technology and service. Second, the nature of the industry is defined as a high-technology market and lastly, strategic innovation management literature is presented with a specific concentration on innovation profitability.

3.1. Industry Literature Review

After portraying the current state of the UAM industry in chapter *2*, the subsequent section aims at providing an overview of current academic research strands in UAM literature. As developments in recent years offer the technological feasibility to introduce VTOL vehicles in the near future, the topic is gaining increasing attention from both industry and research (Straubinger et al., 2020; Kellermann et al., 2020).

Research has focused on a variety of problems surrounding UAM. Technological feasibility has been assessed and research has been conducted on different propulsion types, vehicle designs (Zhou et al., 2019; Silva et al., 2018) and specific components, such as batteries (Fredericks et al., 2018). Furthermore, integration in existing modes of transportation, transportation modeling, and operational simulations have been examined (Rothfeld et al., 2018; Shamiyeh et al., 2018). Considerations of market entry factors, operational constraints, infrastructure, and public acceptance should also be mentioned (Al Haddad et al., 2019; Vascik et al., 2018; Chancey & Politowicz, 2020).

Nevertheless, the field is still fairly young and certain areas remain comparatively unexplored. As found within the systemic literature review performed by Kellermann et al. (2020), most literature addresses one of the following five problematic aspects: vehicle technology, regulatory aspects, infrastructure requirements, operational concepts and public perception and adoption. Therefore, the following section discusses the problem in more detail to provide an understanding of the industry and the issues discussed.

Vehicle Technology

The emergence of autonomous technology (Fu et al., 2019), distributed electric propulsion (Shamiyeh et al., 2018), battery storage and electric power transmission (Al Haddad et al., 2019) brought up various different VTOL vehicle concepts, ranging from fixed-wing to multicopter concepts. Thus, many scholars urged the importance of vehicle design and development (Straubinger et al., 2020; Shamiyeh et al., 2018). Early research in the field of UAM focused on the technological implications and vehicle design requirements (Uber Elevate, 2016). As the study was carried out on behalf of Uber, the vehicle requirements were formulated from the perspective of an operator. The phrased requirements also refer to the different scope of the vehicles. Among the most important (technological) requirements for UAM aircraft design are range, seat capacity, cruise speed, hover efficiency, cruise efficiency, maintenance costs and direct operating costs (Straubinger et al., 2020). Moreover, questions on vectored thrust, lift and cruise and overall vehicle design (i.e. wingless multicopter vs. fixed wing vehicle) need to be answered (Rajendran & Srinivas, 2020). While some manufacturers aim to offer on-demand inner-city transportation, others favor intra-city connections whereas some want to offer regional flights. The different concepts mostly vary in terms of distance, carry-on weight and propulsion type (Shamiyeh et al., 2018). In essence, it is stated that the vehicle design and technology is an important element in the deployment of an UAM transport system.

Regulatory Aspect

Another important consideration that is commonly noted by scholars is the multi-layered *Regulatory Aspect* that needs to be defined and that has to be considered (Kellermann et al., 2020). The *Regulatory Aspect* is twofold. First, there appears to be no legal framework yet, and second, there is no vehicle certification. As noted by Michelmann et al. (2020), the interaction with people, cities, regulators and other third parties is essential to architect the elements of the UAM industry. In addition to the legal environment, the certification process is perceived as a major hurdle to establish commercial operations (Straubinger et al., 2020). Moreover, the certification process requires the airspace authorities, such as FAA and EASA to set standards for vehicle technology, infrastructure and service operations. However, the aforementioned airspace authorities have recently stated to launch certification guidelines for both vehicles and vertiports (Straubinger et al., 2020).

Infrastructure Requirements

As outlined by Straubinger et al. (2020), the *Infrastructure Requirements* to establish the novel service include the development of ground infrastructure and traffic management systems. The ground infrastructure, so-called vertiports, are those places where take-off and landing will be performed. There is still very little research in this field, however, scholars have outlined potential infrastructure placement opportunities. In addition, the importance of intermodal connectivity within other modes of transportation is addressed. Furthermore, the design of the vertiports and the idea of standardized vertiports to accommodate various types of vehicles is discussed. Even though the service is not requiring routes, the three-dimensional airspace needs to be connected and controlled to ensure safe traffic above populated areas (Vascik & Hansman, 2017). Thus, an air traffic management system needs to be introduced. At this point, regulators, authorities and technology providers need to introduce a stable system.

Operational Concepts

The *Operational Concepts Aspect* mainly deals with the potential business model approach and interaction within the UAM industry (Straubinger et al., 2020). First, the decision whether an inner-city or intra-city service offering is performed distinguishes whether the focus lies on the commute or on the take-off and landing infrastructure. Second, the different UAM sub-markets, their interrelation and integration have been conceptualized. Here, vehicle manufacturers, vehicle operators, platform providers, service providers, ground infrastructure providers, maintenance and repair providers, insurance providers, communication infrastructure providers and unmanned traffic management (UTM) providers have been identified. However, Straubinger et al. (2020) acknowledge that little research in the field of UAM market actors has been conducted. Lastly, integration with other modes of transportation is considered vital for the *Operational Aspects* of UAM as interconnectedness results in increasing efficiency (Rothfeld et al., 2019).

Public Perception & Adoption

Although helicopter services are long established, they are not a widely used mode of transportation. Therefore, the UAM service offering and the ambition to become a mass transportation mode can be perceived as a completely new mode of transportation. The perception of the technology by the public and potential users is a frequently discussed topic within UAM literature (Straubinger et al., 2020). It is noteworthy that the UAM service not only affects potential users but also affects the public. Vehicles are flying above private and public properties, use common airspace, generate noise and are visible. Therefore, the general public perception of the service needs to be considered. Several studies investigated the public perception and adoption factors (Al Haddad et al., 2019; Yedavalli & Mooberry, 2019). The study performed by Yedavalli and Mooberry (2019) assesses the public perception of UAM and identifies the two factors safety and noise as the most prevailing. Furthermore, the preference study conducted by Al Haddad et al. (2019), which is assessing user acceptance and adoption of UAM, identified trust and safety as key components. In addition, performance expectancy, service reliability, on-time performance and environmental impact was mentioned by participants of the study.

Reflecting on the above aspects and considerations, it can be said that scholars have contemplated the aspects through various lenses (Ploetner et al., 2020; Shamiyeh et al., 2018; Rajendran & Srinivas, 2020; Al Haddad et al., 2019). The industry has been analyzed as a whole, future market and demand scenarios were outlined and individual aspects examined. Thus, as noted by Straubinger et al. (2020), a multitude of factors for successful UAM adoption emerged. The vehicle manufacturer, who is considered the inventor of the technology and the key innovation driver, lies at the core of the UAM industry. However, the VTOL manufacturer as the key innovation driver has not yet been considered as the unit of analysis in the prevailing literature. Therefore, this research is motivated to identify the factors that matter most to the manufacturer, the specific challenges they face, and how they can successfully commercialize their innovation in the long term. What has been identified so far serves as a guide for this purpose. The following sections outline the prevailing strands of strategic management literature in the field of innovation management theory. In addition, a sound theoretical background is provided guiding the interview design and further expanding the current UAM literature in section *6*.

3.2. (High)-Technology Markets

As already sketched in the aforementioned chapter *2* and *3.1*, the UAM industry has its peculiarities. Manufacturers have received large amounts of funding, product development is tedious and commercial flights have not been carried out yet. The purpose of this section is to provide a background on the nature of (high)-technology markets and how this is intertwined with innovation, technology performance and adoption.

According to Dosi (1982), technology is defined "*as a set of pieces of knowledge both practical and theoretical, know-how, methods, procedures, experience of success and failures and also of course physical devices and equipment*" (Dosi, 1982, p. 152). Further, the origin of technological change and innovation is divided into two categories: "demand-pull" and "technology-push". While the first acknowledges that innovative activities stem from changing market requirements, the latter is defined as an autonomous process emerging from continuous research and development activities. However, the two categories cannot be considered in isolation, as they are interconnected in the course of the emergence of an innovative paradigm. This leads to an interactive mechanism that combines the complex structure of feedbacks between the economic environment and the inventor's technological changes (Dosi, 1982).

In addition, high-technology is referred to as the companies and activities involved in the development, manufacturing, or use of the most advanced machines, equipment, and methods (Cambridge Dictionary, 2021). Moriarty and Kosnik (1987) have attributed the following characteristics to high-technology markets: uncertainty about the market as well as uncertainty about the technology and volatility in competition. The OECD has classified the following industries as high-technology industries based on their overall R&D intensity: Aerospace, computers and office machinery, electronics-communications and pharmaceuticals (1997). Steenhuis and de Bruijn (2006) extensively reviewed the different definitions for high-technology industries and introduced two aspects, namely *complexity* and *newness*, to solve inconsistency issues. While *complexity* refers to the complexity of a product or the complexity of the process to create the product, *newness* refers to the need in some industries to constantly update products or process. In accordance with the notion of the OECD (1997), Steenhuis and de Bruijn (2006) also acknowledge aerospace vehicles as high-technology products with a high product complexity.

Furthermore, high-technology markets are characterized by ongoing change and improvement. One of the most prominent contributions is displayed by the technology s-curve, first introduced by Foster (1986). It states that the performance of a technology shows slow initial improvement, but once the basics of the technology are established, it begins to accelerate as the technology is increasingly understood. Eventually, diminishing returns set in as the technology approaches its intrinsic limitations. In addition to technology performance improvements over time, the technology diffusion theory introduced by Rogers (2003) also applies the technology s-curve stating that the rate of technology adoption is initially slow and accelerates as the technology improves. Besides, Rogers (2003) notes that many technologies become valuable when complementary resources are developed that make adoption worthwhile. As a result, Dosi's (1982) approach combines the two views by introducing technology trajectory as the path a technology takes by improving its performance and diffusion rate.

In summary, high-technology markets are characterized by great complexity such as difficult development processes, uncertain markets, high research and development intensity. After defining technology and high-technology and explaining technological innovations the classification of UAM as a high-technology market is justified. Where the manufacturer is represented as the inventor and driver of technological improvement.

Technological innovations can be seen as one of the main drivers of high-tech markets. As outlined above, however, high-tech markets are associated with many challenges for companies. Whether a company can lead its innovation to commercial success depends on various factors. Within the field of innovation, a firm that is first to commercialize a new product design concept is defined as the *Innovator* (Teece, 1986). Whether an innovator can profit from its innovation and what considerations he must make has been widely discussed by various scholars. In the case of the UAM industry, it can be argued that the innovation in question is of disruptive nature as the technology is aiming at creating a new market (Bower & Christensen, 1995). More precisely, the technology can be classified as a radical innovation where a new dominant design emerges and the linked components pose a new architecture (Henderson & Clark, 1990). This line of argumentation follows the Schumpeterian view of creative destruction (Schumpeter, 1911).

One of the most prominent theories is represented by the PFI framework, first introduced by Teece (1986). In the following, the two main strands of strategy literature are briefly outlined, whereinafter the innovation strategy literature is discussed in more detail.

3.3. Innovation Strategy

To understand the different angles on how firms can gain competitive advantage, the two main strands of strategy literature, namely the resource based view (RBV) and the market based view (MBV), are briefly discussed. The basis of the analysis will be the work of Teece (1986) who established a framework for the profitability of technological innovation based on the value split between innovators, successors (imitators), and firms holding assets needed for the innovation. Teece provides a conceptual model for reasoning through the practical complexities of developing an innovation from idea to market (Winter, 2006). The profiting from innovation (PFI) framework outlines the strategic considerations which managers must reference in order to capture value from innovation (Teece, 2006). This framework has been widely used as a basis for other strategic literature, as well as expanded and adapted by various scholars.

3.3.1. Market-based View vs. Resource-based View

The market-based view (MBV) and the resource-based view (RBV) are perceived as the two most prominent views of business strategy. Both respond from different angles to the fundamental question of how companies can achieve a sustainable competitive advantage. Hence, for a better understanding, the following section provides a brief introduction into the two fields.

Market-based view

The MBV was significantly coined by Porter (1979) whose research is based on the results of Mason (1939) and Bain (1956) who already described an “outside-in” approach at that time. In essence, the MBV implies that decisions on the positioning of the company are oriented to the situation of the market. Based on the structure conduct performance paradigm (Mason, 1939; Bain, 1956), Porter (1979) developed his five forces model which entails two industry dynamic factors a firm must consider: the firms positioning against competitors and the industry attractiveness. Porter (1985) further identifies that firms can gain competitive advantage either through differentiation or cost policies which, in turn can result in in three possible strategies: cost leadership, differentiation or a combination.

Resource-based View

The RBV can be traced back to Barney (1991) and examines the resources needed by a firm to gain competitive advantage. It therefore takes an inside-out approach. If a company succeeds in creating a unique value creation strategy in the competitive environment that also cannot be imitated, it has gained sustained competitive advantage (Barney, 1991). According to the author, the resources a firm holds in order to gain this advantage need to be valuable, rare, imitable and not substitutable (VRIN model). Prahalad and Hamel (1990) argue that a company's core competencies are those that are essential for a company to deliver core customer value. In general, the RBV states that a firm should focus on internal capabilities and utilize their resources to generate competitive advantage.

Having reviewed the two strands of the strategy literature, the next section focusses on the literature on innovation profitability.

3.3.2. Innovation Profitability

In his landmark article, Teece (1986) provides a framework within he identifies three pillars defining value distribution among innovators, followers (imitators) and firms holding related capabilities necessary for the innovation in an existing market: the *Appropriability Regime*, the *Dominant Design Paradigm* and *Complementary Assets*. In essence, the PFI framework serves as a powerful template for an innovator's strategy formation and business model selection. Each element of the framework demands careful analysis and reflection in its own right.

Appropriability Regime

Appropriability is the degree to which an innovator can capture the returns derived from the innovation. The extend of capture is dependent on the characteristics of the technology as well as the legal environment and the accessibility and ownership of complementary assets required to launch the innovation on the market which, in turn define the strength of the appropriability regime (Teece, 1986). The *Appropriability Regime* refers to the degree of how the innovation can be imitated and therefore illuminates the nature of the technology and the ability to protect its intellectual property (Teece, 1986). A tight *Appropriability Regime* displays an environment where the innovation is easy to protect whereas a weak *Appropriability Regime* represents an environment where the technology is easy to imitate and therefore hard to protect. Furthermore, "*the degree to which knowledge is tacit or codified also affects ease of imitation*" (Teece, 1986, p. 287). While codified knowledge is more subject to imitation, tacit knowledge is difficult to articulate and therefore difficult to transpose.

Market Evolution/Dominant Design

Whether a technology design has reached general acceptance or not is reflected in the dominant design paradigm. Teece (1986) distinguishes between the preparadigmatic stage and the paradigmatic stage of a branch of science. In the early stage of an industry, competition is mainly focused on product design (Abernathy & Utterback, 1978; Dosi, 1982). In this preparadigmatic stage, competition is focused on trying to identify the design that will prevail.

In the paradigmatic phase, however, access to complementary assets will be essential as prevailing designs start to show on the market. Teece (1986) argues that once a dominant design prevails, competition will move from design towards cost leadership. At this stage, the appropriability of a technology or innovation is a key factor. If the innovation is easy to imitate and a dominant design has emerged, followers can adapt the innovation leaving the innovator in a disadvantageous position.

Complementary Assets

The third concept within the PFI framework is represented by *Complementary Assets* (Teece, 1986). According to the author, *Complementary Assets* are defined as assets or capabilities needed to successfully commercialize and market a technological innovation. These can be marketing services, manufacturing or after-sales support. Teece (1986) determines three types of *Complementary Assets*: generic assets, co-specialized assets and specialized assets. Generic assets are multi-purpose assets, which do not have to be adapted to the innovation. If there is a unilateral dependence between the innovation and the complementary asset, the asset is defined as specialized. Co-specialized assets entail a bilateral dependence between asset and innovation. *Figure 2* visualizes the argument, that the "*know-how in question [needs to] be utilized in conjunction with other capabilities or assets*" (Teece, 1986, p. 287). The outer layer symbolizes various *Complementary Assets* needed for a successful commercialization. "Other" exemplifies that there could be other and/or more *Complementary Assets* depending on the innovation in question.

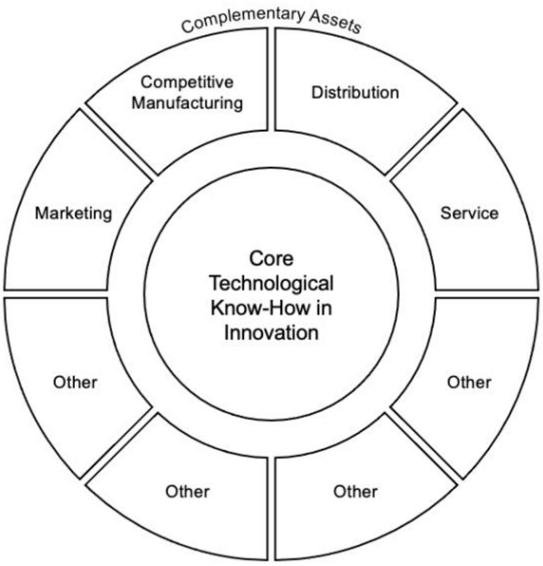

Figure 2: Complementary Assets (Own Illustration based on Teece (1986))

Implications for strategy

Further, two extremes of strategic directions are outlined: namely complete integration and contracting (Teece, 1986). Throughout this research, contracting may also be referred to as outsourcing. These two terms can be treated as synonyms for the same meaning. In essence, complete integration refers to the action of integrating all *Complementary Assets* needed for the innovation to be successful. On the other side, contracting mirrors full dependency on externals to access *Complementary Assets* (Teece, 1986). The study argues that through contracting, the innovator does not have to incur capital expenditures to internalize the required resources. A contracting strategy is worthwhile when the *Appropriability Regime* is tight and the *Complementary Assets* are manifold and accessible. In addition, contracting can attribute solidity to the innovator, especially if it is relatively unknown (Teece, 1986). On the contrary, Teece claims, that the innovator relinquishes control and must rely on the contract partner, which creates the risk that the latter will not adhere to the agreement or even imitate the innovation.

Complete integration, on the other hand, differs from contracting modes by typically simplifying incentive alignment and control. Innovators can capture “spillover benefits” (Teece, 1986, p. 295) generated by an increasing demand for the complementary asset they hold. The decision on whether to integrate a *Complementary Asset* is also impacted by the cash position of the innovator and the capital expenditures required to integrate. Teece (1986) reasons that an innovator can gain the great benefit from integration when the innovation is not marketed yet and/or the appropriability regime is tight. However, once the innovation is public, it becomes crucial for an innovator to secure the key *Complementary Assets* as these are likely to become so called “bottlenecks”. If the *Complementary Assets* are substantial, integration is justified whereas a minority position might prove sufficient if the innovator is cash constrained (Teece, 1986).

In general, decisions on whether to enter into contractual agreements or whether to integrate are dependent on the nature of the *Appropriability Regime*, the stage of the *Dominant Design* (i.e. whether a dominant design has emerged or not) and the accessibility and nature of *Complementary Assets* needed for the innovation to be commercially successful (Teece, 1986). *Figure 3* visualizes the decision flow on whether to integrate or contract for a *Complementary Asset* dependent on the *Appropriability Regime* and the nature of the asset. Based on an innovator’s *Appropriability Regime*, its access to *Complementary Assets* and its cash position, an innovator can either engage in contracting or integration.

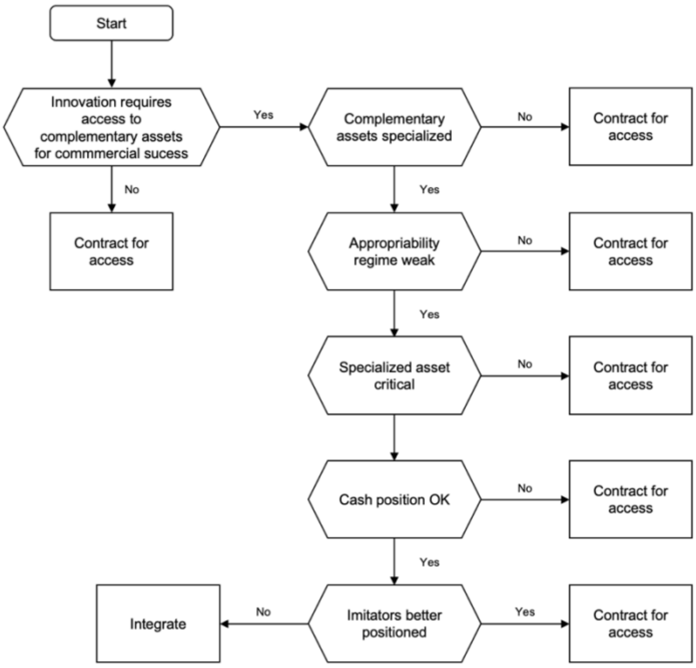

Figure 3: Flow Chart Integration vs. Contracting (Teece 1986)

The decision on whether to integrate or to contract requires the innovator to properly evaluate the company's existing capabilities and/or its ability to develop new capabilities in a cost-effective and timely manner (Teece, 2010). In essence, the PFI framework serves as a powerful template for an innovator's strategy formation and business model selection. Each element of the framework demands careful analysis and reflection in its own right.

3.3.3. Extended Innovation Profitability Theory

This section recites a number of academic scholars who have built their studies on Teece's findings. As the PFI framework stipulates the main theoretical source of this research, an overview of extensions and continuations is provided.

Vertical integration in industries with high technological change is also discussed by Afuah (2001) who claims that in environments of high technological change, firms are better off without vertical integration. However, if a company faces high uncertainty, vertical integration can be favorable. Rothaermel et al. (2006) build on Teece's (1986) findings of a mixed mode approach to integrating vs. contracting by alleging that a simultaneous pursuit of vertical integration and strategic outsourcing contributes to a company's competitive advantage and thereby to the overall performance of the firm.

Jacobides et al. (2006) extend Teece's (1986) findings by adding "industry architectures" and "factor mobility" to the framework. Industry architectures are referred to as "*sector-wide templates that circumscribe the division of labor*" (Jacobides et al., 2006, p. 1200) (i.e. the ecosystem surrounding the innovation) and factor mobility as an extension to complementary assets by separating complementarity and mobility in distinctive components. Furthermore, the authors argue that Teece's theory is particularly pertinent to the design of the innovator's business model in terms of whether to integrate or contract for a complementary component or activity.

Moreover, Pisano and Teece (2007) cluster two critical spheres for strategic decisions: the intellectual property environment and the architecture of the industry which have pervasive influence on who profits from innovation and which, under certain conditions, can be shaped by managers toward a firm advantage. The intellectual property environment can be attributed back to the appropriability regime introduced by Teece (1986). Industry architecture, as defined by Pisano and Teece (2007), relates to the degree of specialization of market actors (integration vs. contractual agreements). Teece (2010) further applies his PFI framework to business model design where he argues that technological innovation alone does not guarantee commercial success. Successful commercialization of a technological innovation requires a good business model design and execution, joined by thorough strategic analysis. Suarez (2004) highlights the importance of the appropriability regime and complementary assets for achieving technological dominance.

Teece (2006) himself reflects on his PFI framework acknowledging subsequent contributions and achievements. Further, the author draws connections to the strategic management literature on resources and dynamic capabilities. Likewise, Teece illustrates refinements to his PFI framework wherein, among other suggestions, he introduces the element of "*Complementary Innovations*" to his theory. He argues that the importance of complementary technologies was not considered at the time of the PFI framework's publication. However, if a key part of a technology is missing or not sufficiently developed, the entire system or product fails. Therefore, complementary technology can be seen as a bottleneck asset. Complementary innovations were treated as complementary assets, however, Teece (2006) notes that complementary innovations play a significant role today and are therefore carved out of complementary assets and presented as a separate element of complementarity. Nevertheless, complementary innovations are still classified as generic, specialized or co-specialized.

Building on this, Ching et al. (2014) frame the choice an innovator has between control and execution: an innovator choosing *control* is engaging in activities which are aimed at preventing future competition to secure rents (i.e. intellectual property protection, disclosures, etc.). This is coupled with upfront investments and a delay in market entry, whereas an innovator choosing to invest in *execution* is aiming to secure rents by developing capabilities designed against future competition.

Strengthening the Teecian (1986) line of argument that an innovator can engage in either vertical integration or contractual agreements (or one of myriad alternatives in-between), Gans (2017) advocates the entrepreneurial choice between competitive and cooperative commercialization strategies. In an existing market, a start-up can either collaborate (i.e. through licensing, alliances, etc.) with incumbents or go to market on its own (i.e. engage in competition). Building on the above, Gans et al. (2018) developed an entrepreneurial compass juxtaposing the dimensions *execute* vs. *control* and *compete* vs. *collaborate*. The latter is facing the attitude towards incumbents whereas the first deals with the attitude towards the innovation. *Execute* vs. *control* is based on the nature of the appropriability regime, which, as outlined earlier, can be seen either as given or as shapeable. *Compete* vs. *collaborate,* in turn, refers to the degree an innovator is engaging in partnerships (or not) and can be attributed to the accessibility and nature of complementary assets.

3.4. Research Gaps

The previous literature review identified research gaps in both industry-specific and innovation strategy literature. This section is intended to provide a summary of the identified gaps.

On the one hand, the industry-specific literature lacks a business perspective through the lens of the manufacturer as innovator. On the other hand, while a number of problematic aspects have been addressed in various publications in this field, the factual strategic decision factors that a VTOL manufacturer has to consider to be commercially successful have not yet been the subject of research. Even though the innovation strategy literature addresses strategic decision factors for innovators, it should be mentioned that the theoretical formulations outlined above presuppose an existing market for an innovator to enter. However, in the case of the UAM industry, the market is perceived to be undefined and thus additional factors could impact an innovator's strategic decisions. While current innovation strategy literature refers only to market evolution, appropriability and complementarity, the industry-specific literature discusses engagement with external stakeholders. This notion is echoed by Teece (2006), who addresses expanding the PFI framework with external considerations as an element of future research.

For this reason, the identified research gaps underscore the research objectives to identify strategic decision factors that are important to VTOL manufacturers and to provide a theoretical framework that incorporates the research gaps raised.

The following chapter *4* presents the methodology chosen to answer the underlying research question and fill the identified research gaps.

4. Methodology

In this chapter, the methodological approach of the research as well as the research design are introduced. This research investigates the key decision factors to be considered by VTOL manufacturers to succeed in the undefined high-technology UAM market. Since this research addresses questions from a "what", "why" and "how" perspective and the results are subject to interpretation to be meaningful, the research follows a qualitative approach (Saunders et al., 2019).

In the succeeding section the underlying research philosophy will be discussed followed by a depiction of the applied methodology and methods. The subsequent section justifies why grounded theory, following the approach of Charmaz (2006), has been selected. In addition, interview design, data collection, data analysis and reliability and validity will be outlined and analyzed.

4.1. Research Philosophy

According to Saunders et al. (2019), a research philosophy reflects systems of beliefs and assumptions about the evolution of knowledge. Thus, the research philosophy depicts the fundamental belief systems and knowledge development of the researchers and defines how the research question is understood, how methods are used and how findings are interpreted (Crotty, 1998). Besides, the research philosophy serves as a guiding arch for the research design and hence provides the methodological framework of an analysis. The business- and management literature acknowledges five research philosophies, namely positivism, critical realism, interpretivism, postmodernism, and pragmatism (Saunders et al., 2019).

Next, a research can be divided into three major distinct philosophical assumptions: the ontological-, the epistemological- and the axiological assumption. Ontology deals with the nature of the world and reality in which the research object and phenomenon is chosen. Epistemology focuses on assumptions about knowledge and what researchers contribute towards knowledge. Axiology is concerned with the role values and ethics play in the scientific research (Saunders et al., 2019).

With regard to the undefined market environment UAM poses, this research is based on individual opinions to create a new and richer understanding and interpretation of realities and context. Hence the research is following the interpretivism approach, this implies that phenomenas are viewed through the lens of different groups of people. Various experts within the same field of expertise will have different opinions based on their experiences, social backgrounds and ethics (Saunders et al., 2019). According to the aforementioned interpretivism philosophy, realities are socially constructed and follow the meanings that are ascribed to experiences and actions (Saunders et al., 2019).

As Saunders et al. (2019) point out, research philosophies can be differentiated in terms of where their assumptions fall on the objectivism–subjectivism continua. While objectivism assumes that social reality is external to us and others, subjectivism embodies that social reality is made of its social actors, perceptions and actions. The underlying logic of interpretivism contrasts with positivism and emphasizes the subjective perspective, as humans are different from physical phenomena and are always subject to individual opinions (Saunders et al., 2019).

To explore the scientifically unexploited business perspective on the UAM market, it is presumed that the literature and interviewees make assumptions and that their opinions are perceived as acceptable knowledge. Guided by the philosophical assumptions and beliefs, a research strategy emerged where face-to-face interviews help to develop a constructivist grounded theory and explore factors that provide an understanding of the status quo and future implications that ultimately lead to the epistemological stance (Saunders et al., 2019).

Having defined the philosophy of the research, the approach to theory development can be inductive or deductive (Saunders et al., 2019): an inductive approach to theory takes the development of theory as a result of data observation while a deductive approach moves from known theory to data. As our research began with a review of the innovation strategy and UAM literature, a deductive theory approach was employed. However, the subsequent research follows a inductive research approach as grounded theory is used to explore an untapped research area and develop theory from knowledge. According to Saunders et al. (2019) combining an inductive and deductive approach (e.g. going back and forth) is seen as an abductive approach which is widely seen within business and management research.

4.2. Research Strategy

As mentioned in the foregoing paragraph, this research deploys grounded theory as the research strategy. Originally developed by Glaser and Strauss (1967) in response to much research that followed a positivist philosophy at that time, grounded theory was introduced "*as a process to analyze, interpret and explain the meanings that social actors construct to make sense of their everyday experience*" (Saunders et al., 2019, p. 205). Although the original grounded theory approach (Glaser & Strauss, 1967) has been divided into different strands of research, at its core lies an observation or interview from which the generated data is then coded to summarize the meaning (Saunders et al., 2019). Simultaneous data collection and analysis as the core component of grounded theory behaves largely the same in the different research strands (Saunders et al., 2019).

Grounded theory is referred to as an orderly and emergent strategy to collect and analyze qualitative data. With its explorative focus on people's behavior, the grounded theory approach is used in a wide range of business- and management topics (Saunders et al., 2019). As reflected in the aforementioned interpretivist research philosophy, data is subject to interpretation and realities are socially constructed. Thus, the constructivist grounded theory developed by Charmaz (2006) is the explicit strand this research follows. The constructivist grounded theory approach leaves the researcher with more flexibility and reflexivity to apply an abductive approach by investigating a phenomena with participants and other data sources (Charmaz, 2006).

Opinion is divided on prior theory building in the application of grounded theory. While Glaser and Strauss (1967) emphasized researchers to conduct the literature review after the analysis of data to circumvent preconceptions, the constructivist grounded theory strand encourages researchers to conduct a previous literature review (Charmaz, 2006). The literature review guides the researcher to explore the choice of the area and the method to be used (Ramalho et al., 2015). Moreover, the constructivist approach acknowledges that the previously acquired knowledge, the ethical background and thus the researcher presence in the research product is never (Ramalho et al., 2015).

As described earlier, within grounded theory conducted interviews are subject to a coding process to derive theory from data. Saunders et al. (2019) admit that the interview coding techniques used by grounded theorists are still relatively undefined and overlapping. Since the two-step technique (initial coding and focused coding) introduced by Charmaz (2006) offers a flexible approach, this research follows the subsequent coding procedure. During the initial coding stage, collected sentences, phrases and words are disaggregated and coded with a label. The codes initially assigned are very intuitive and often gerund, as the goal is to derive meanings from the studied subject. According to Charmaz (2014), the successive focused coding implies a decision on how to group and how to focus on a narrowed set of code to derive meaning from data. Codes with the ability to aggregate larger units of data are becoming focused codes. This process of re-condensing and narrowing codes is a back and forth integrated process and ultimately results in theory from the data. The coding process is more of an emerging rather than a linear process. In addition, the simultaneous analysis of data is recommended to explore evidence for emerging categories and ultimately derive theory (Charmaz, 2006). The coding process is discussed in more detail in the data analysis section *4.5*.

Considering the research question of the thesis in connection to the philosophy of interpretivism and abductive reasoning while applying constructivist grounded theory, this research relies on qualitative data (Saunders et al., 2019). This research is carried out using qualitative data from primary sources comprising of UAM expert interviews and the use of academic literature. While the initial literature will be used to contextualize the research and identify potential research gaps (Saunders et al., 2019), the semi-structured interviews are coded and used to develop the grounded theory aiming at building theory and extending knowledge (Charmaz, 2014). The exact interview process of this research will be elaborated in more detail in section *4.4*.

According to Saunders et al. (2019), literature suggests four distinct research purposes, namely exploratory, descriptive, explanatory or evaluative. The research purpose stands in close connection with the research question anticipated to be answered and the underlying research objectives. Descriptive studies aim at generating a data-based and accurate picture of a phenomenon, explanatory studies focus on studying the causal relationships between variables, while evaluative studies concentrate on how well something works and an exploratory study aims at uncovering "*what is happening and gain insights about a topic of interest"* (Saunders et al., 2019, p. 186). As this research is investigating the UAM industry business view, which has received little scientific attention and by deploying ground theory as the underlying methodology, this research can be classified as exploratory. Exploratory research is mainly conducted by interviewing focus groups and/or experts as well as reviewing literature. This research deploys expert interviews as well as literature screening.

In regard to the time horizon of a research, Saunders et al. (2019) distinguish between cross-sectional, limited to a time frame and longitudinal research which represent studies repeated over an extended period. As the design of the research objective and question as well as the qualitative grounded theory approach with interviews conducted over a course of time, this research follows a cross-sectional time horizon. However, since the literature screened, analyzed and used to answer the research question and objective emerged over a considerable period of time, this research has elements of a longitudinal study (Saunders et al., 2019).

The UAM industry is perceived as a relatively new technology with an undefined market situation. Therefore, academic literature, reports and news articles in the field of UAM have been screened to build up a deep industry knowledge. As emerged throughout the literature review and urged by Straubinger et al. (2020), the business strategy perspective on the industry is yet relatively undiscovered. In addition, the investigation of strategic decision factors in an undefined market environment has also not been adequately studied from the perspective of VTOL manufacturers. As this research focuses on the VTOL manufacturer representing the innovator of the vehicle, innovation strategy literature serves as the guiding theoretical foundation. More precisely, the PFI framework introduced by Teece (1986) serves as the underlying principle. The PFI framework serves as a powerful template for an innovator's strategy formation and business model selection. Each element of the framework demands careful analysis and reflection in its own right. The theoretical foundation has been extended by other relevant literature (*3.3.3*) building upon Teece's findings (Afuah, 2001; Rothaermel et al., 2006; Jacobides et al., 2006; Pisano & Teece, 2007; Suarez, 2004; Ching et al., 2014; Gans, 2017; Gans et al., 2018).

4.3. Data Collection

In the subsequent section the process of data collection will be explained in greater detail. When following an abductive approach to theory, the collection of data *"[…] is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection*" (Saunders et al., 2019, p. 153). Thus, throughout the research primary qualitative data has been collected. Whilst primary data has been used to address the research question, literature was gathered from other scholars and re-used to develop a theoretical background to orchestrate primary data collection and ultimately help to build the theoretical framework and answer the research question (Saunders et al., 2019).

Literature on the one hand side, was gathered to develop a deeper understanding and overview of the passenger UAM industry and current research stand. While screening the literature, the absence of business standpoints on the passenger UAM market was explored

(Straubinger et al., 2020). On the other hand, constructivist grounded theory stresses the importance to conduct a literature review (Charmaz, 2006). Thus, the academic research in the field of UAM has been enriched with primary data while the strategic management literature, more precisely the academic literature on innovation strategy has been screened to develop a theoretical backbone to guide the research. Applying academic literature has two advantages. First, it adds longitudinal elements to the cross-sectional character of the research. Second, quality of the research is assured as the academic literature applied stems from peer reviewed journals and books (Saunders et al., 2019). Hence, the reliability and validity of the literature is ensured.

In accordance with the explorative constructivist grounded theory research strand introduced by Charmaz (2006), qualitative primary data was collected. The interview process began in March 2021 by reaching out to potential interview partners and companies. The potential interview partners were contacted through the network of Bauhaus Luftfahrt e.V. and the personal network of the researchers. In total, 16 interviews were conducted with 20 interviewees from 16 different organizations and companies: Six research institutes, four infrastructure providers, three manufacturers, two regulatory authorities and one consultancy firm (Appendix A). All 20 interviewees hold notable roles within their organizations with yearlong experience in the passenger UAM industry. Hence, the interviewees offered relevant, high-quality comments and standpoints on the questions posed. Through the diverse backgrounds and viewpoints on the industry, a holistic perspective is ensured. All interview partners were asked to sign a form allowing data collection and processing (Appendix B). The data protection clause ensures the anonymity of the interviewees and the companies they belong to throughout the research.

The interview data collection process started with a pilot interview which was conducted on the 18th of March 2021 to appraise the guideline of the semi-structured interview. The pilot interview helped to review and subsequently revise the interview guideline, process and structure. Due to the quality of the interview and the expertise of the interviewee the researchers decided to include the content of the pilot interview into the analysis. Subsequently, the conduction of the following 15 interviews took place from March 22nd 2021 until the April 1st 2021. The explicit design of the interview process is explained in more detail in the following section *4.4*.

4.4. Interview Design

Due to the exploratory nature of the study, only non-standardized semi-structured interviews were conducted using an interview guide to address a variety of topics and questions. Concurrently, deviations occurred from interview to interview (Saunders et al., 2019). In this manner, consistency was assured throughout the interview process as the examined variables reappeared in the interview guide (Appendix C). Yet, the uniqueness of each individual was accommodated by allowing the flexibility to adjust the order of questions depending on the interview situation, disregard unrelated questions, or develop new questions to allow for the elaboration of specific observations (Saunders et al., 2019). Hence, one overarching interview guide was developed for all interview partners. The interviewees received a document three days prior to the interview that included a brief introduction to the research approach and objectives of the study as well as three guiding questions.

To manage challenges in respect of the deluge of information during an interview and its processing, all interviews were recorded with the consent of the interviewees using Microsoft Teams recording function. In a second step, the recorded interviews were transcribed using both a transcription software (trint.com) and manual finetuning. This served two main purposes: On the one hand, the interviewers were able to focus exclusively on the interviewee and record additional questions asked during the recording. On the other hand, the transcribed interviews serve as a basis for conducting initial and focused coding and develop grounded theory (Saunders et al., 2019).

Due to the present Covid-19 situation, all interviews were conducted virtually. On an average, the interviews lasted for approximately 30 minutes. Each interview opened with an introduction round as well as a short introduction to the research objectives and the purpose of the research. Following the introduction, the interviewee was made aware of the confidential treatment of his/her statements and the permission for recording of video and audio was obtained. Every interview was opened by a broad question where the interviewee was asked to "*describe the current state of the passenger UAM market*" from their point of view. This opener allowed the interviewee to state his/her current perception of the UAM market as well as the interviewers to follow up on certain statements. In addition, the opening question was used to introduce the subsequent question where the interviewee was asked to name "*factors which need to be considered by a VTOL manufacturer to be successful in the emerging UAM passenger market*". In conformity with the concept of a semi-structured interview, two out of three types of questions suggested in the literature were asked, namely open and probing questions. Questions were adapted and modified as the interview progressed and new insights emerged. The expertise of the interviewees on certain subtopics additionally influenced the order and flow of the questions (Saunders et al., 2019). The interviews were concluded by a final question in which the interviewee was asked to name "*the one factor, which, in their perception, is the most important for a VTOL manufacturer to consider to be successful in the emerging UAM market*".

All interviews were recorded in both audio and video. The recordings were transcribed using a language processing application. It should be noted, however, that the transcripts produced by the language processing application were not always entirely correct and therefore had to be revised manually. In respect to the confidentiality of the data, neither audio recordings nor transcripts will be included in the appendices. The interview transcript protocols were identified by an alphanumeric number to ensure anonymity.

The transcripts serve as the basis for the initial and focused coding used in this analysis. A more detailed explanation of the latter will follow in section *4.5*.

4.5. Data Analysis (Coding)

As outlined in the research strategy, the conducted interviews are subject to a coding process to derive theory from data. This section aims at explaining the approach of the coding process in detail. As described in the previous section, the recorded interviews were transcribed. The transcribed interviews were then imported into a qualitative data analysis software for further processing and coding. As recommended by Charmaz (2006), the researchers started with the initial coding process by reading through the interviews, deriving meanings and providing codes that contain gerunds to best describe the circumstance.

By staying close to the original text, more than 200 codes were identified after the first five interviews. Interviewees were explaining similar subjects in different words and coding was conducted by both researchers. Thus, the researchers applied a first condensation and alignment process based on several criteria. First, codes with alike meaning were unified and potentially renamed. Second, codes with low frequency, such as only occurring once, were removed or merged with similar meanings, and finally, codes that occurred with no additional value to answering the research question were dropped. After applying the first condensation, the meaningful codes amounted for 63. Subsequently, all other interviews were coded utilizing the codes from the first iteration while adding codes if necessary. Having finished the initial coding process of all interviews, the codes were again re-iterated and condensed to a number of 48 codes. This was achieved by re-applying the measures mentioned above as well as intensively comparing code data of alike codes to distinguish the stability of their difference.

The focused coding process was started by using color groups to visually differentiate thematic groups of codes. In addition, the fetched code snippets within and across color groups were compared and rearranged to deduce a coherent structure, thus the backward and forward integrated process of revising code was ensured. As a result, the remaining 48 initial codes were consolidated in 12 focused code groups, representing the meaning of a range of codes (*Table 2*). Again, code snippets within and across each focused code group have been amended to ensure persistency. Lastly, thematically adjacent code groups have been combined to develop eight conclusive, evident and plausible factors from the focused code groups.

The importance of each factor is represented by the number of quotes allocated with the eight factors representing a cumulated sum of 678 quotes. The distribution of quotes is presented in *Figure 4.* The *Value Chain Factor* and *Social & User Acceptance Factor* incorporating 50% of quotes. The ensuing four factors cumulate the number of quotes to 629 thus the first six codes represent 90% of quotes, whilst the last two factors sum up to 10%.

The coding scheme comprising of initial and focused codes and the derived factors are subject to further analysis in the subsequent chapter *5*.

4.6. Reliability and Validity

As stressed by Saunders et al. (2019), all researchers care about the quality of research as they want others to accept it and contribute to theory. Since quality of research is hard to amplify, a well thought out research design and methodology can help to ensure quality of research. In order to ensure quality, reliability and validity have been introduced as factors to proof consistency and appropriateness of the research. While reliability applies to the replication and consistency of the findings, validity refers to the appropriability of the measures used. The aforesaid adapts well to the positivist research philosophy, whereas the qualitative interpretivist research philosophy often rejects them as inappropriate. Since this research follows a qualitative interpretivist research approach, the researchers acknowledge that reality is socially constructed.

Nonetheless, the researchers recognize the evidence of the concepts of reliability and validity (Saunders et al., 2019). Since the research reflects the socially constructed interpretations of experts within the UAM industry, a particular setting at the time conducted is reflected. Hence, the described methods and research design can serve as subject to similar studies in different fields to improve quality and thus internal reliability. Moreover, the in-depth qualitative methods applied, e.g. conducting and coding 16 interviews, serve to study the subject and incorporate the internal validity of the research. In contrast, external validity to qualitative research has been questioned as generalizability is difficult to achieve. However, the findings of this study can be further applied to other innovation settings to test the rigor of the research. Moreover, chapter *6* contrasts the findings to acknowledged literature from the field of innovation, proofing the external validity.

5. Findings

This chapter strives to present the findings gathered throughout the interviews by applying grounded theory. The gathered data will be systematically presented and interpreted following the methodology outlined in previous chapter. Section *5.1* introduces the identified decision factors and outlines each factor in more detail. Section *5.2* juxtaposes the factors and discusses the interrelations. Section *5.3* introduces measures suggested by interviewees, which can influence the identified decision factors.

5.1. Decision Factors

This section outlines the responses to the interview questions as well as to the research objective of identifying which decision factors need to be considered by key innovation leaders when entering an undefined high-technology market and how they can achieve commercial success. Throughout the coding process, the following eight decision factors emerged as those having the biggest impact on a VTOL manufacturer's commercial success:

- Value Chain Factor
- Infrastructure Factor
- Marketing & Research Factor
- Affiliated Innovations Factor
- Environmental Factor
- Regulatory Factor
- Social and User Acceptance Factor
- Launch Strategy Factor

The following *Table 1* as well as *Figure 4* illustrate the distribution of interview quotes to the above mentioned factors. It should be noted that for this analysis only those factors perceived as critical by the interviewees are considered. A total of 678 quotes have been identified and serve as the basis for the decision factor formation.

Factors	Quotes	% of total	Cumulative
Value Chain Factor	172	25,4%	25,4%
Social & User Acceptance Factor	163	24,0%	49,4%
Infrastructure Factor	92	13,6%	63,0%
Regulatory Factor	86	12,7%	75,7%
Launch Strategy Factor	61	9,0%	84,7%
Affiliated Innovations Factor	45	6,6%	91,3%
Marketing & Research Factor	31	4,6%	95,9%
Environment Factor	28	4,1%	100,0%
Total	**678**	**100,0%**	

Table 1: Distribution of Quotes

Figure 4 visualizes the distribution of quotes. The importance of each factor can be classified based on the frequency of the quotes. As stated earlier, only those factors considered key by the interviewees were taken into consideration. Therefore, the categorization of importance is biased towards strong importance.

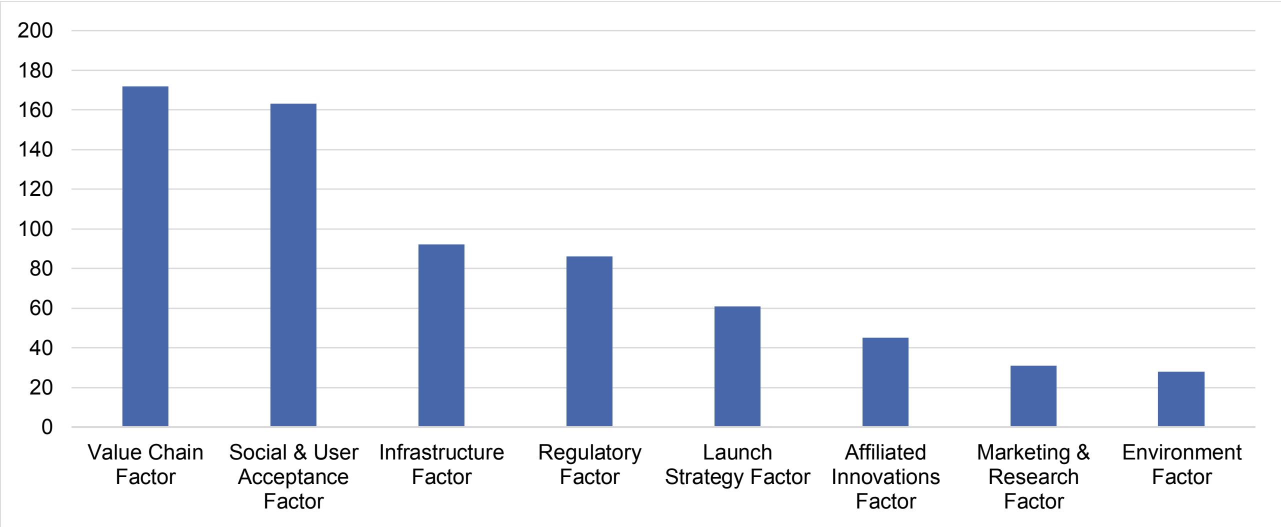

Figure 4: Decision Factors Ranking

As UAM experts from various background were interviewed, their perception of the importance of the different factors differ accordingly. *Figure 5* visualizes the bias per interview in relation to the eight identified decision factors. Every line represents one of the 16 interviews. Due to the anonymization of the interviews, it is not shown which interviewee is represented by which line. If, for instance, an interviewee solely argues in favor of the *Launch Strategy Factor*, this factor would show a high number of quotes in *Table 1*, even though it might be only quoted by a few interviewees. However, in this case, the same tendency as shown in *Table 1* can be observed. The "V" shape of the graphic shows that the *Social & User Acceptance* and the *Value Chain Factor* were indeed the most named factors throughout all interviews. Only few outliers exist which can be explained by the industry background of the interview partner. However, a strong consistency can be investigated, which strengthens the assumption of the factor importance made in the following paragraph.

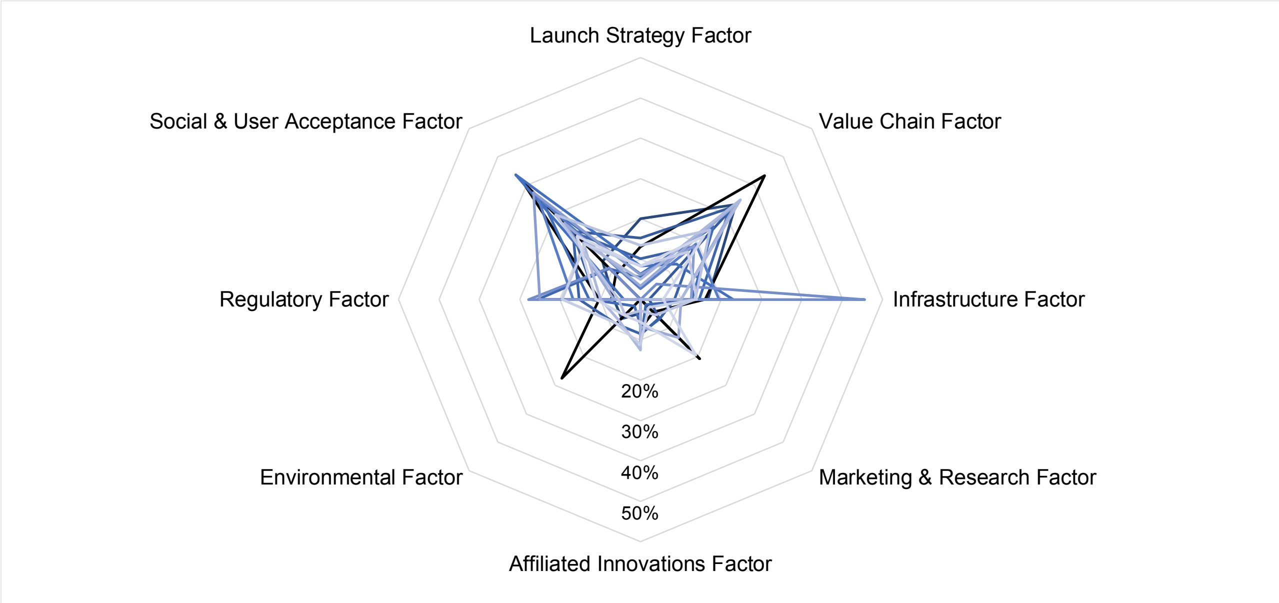

Figure 5: Interviewee-Factor Weighting

In the following, the eight identified factors will be outlined in greater detail. Every subsection concludes with a table displaying examples of which codes are used for which factor. *Table 2* summarizes the coding process of the identified factors.

Factor	Focused Code	Initial Code
Value Chain Factor	Partnerships & Ecosystem	entering into partnerships Integrating Supply Chain requiring ecosystem
	Service & Operations	integrating operations integrating platform integrating services offering affordable service requiring operations
	Sourcing & Manufacturing	access to suppliers and resources integrating manufacturing outsourcing manufacturing requiring maintenance requiring manufacturing
Social & User Acceptance	Social & User Acceptance	achieving transparency creating public acceptance creating social acceptance focusing on user

		handling noise introducing society privacy concerns requiring public acceptance requiring safety requiring trust
Regulatory Factor	Lobbying	requiring lobbying Talking to authorities
	Regulatory Requirements	requiring certification requiring regulation requiring standardization
Infrastructure Factor	Infrastructure	creating an infrastructure integrating into mobility systems requiring charging infrastructure requiring infrastructure requiring landing infrastructure requiring traffic management system
Launch Strategy Factor	Launch Strategy	geographic regulatory differences importance of speed to market protecting technology waiting might pay off
Affiliated Innovation Factor	Affiliated Innovations	dependence on other innovations requiring good batteries autonomous technology
Marketing & Research Factor	Marketing & Communication	requiring communication requiring marketing
	Research	conducting research requiring research
Environmental Factor	Sustainability	achieving emission free transportation achieving sustainability requiring environmental friendliness

Table 2: Factor Coding Process

5.1.1. Value Chain Factor

As stated above, the *Value Chain Factor* consists of three elements: *Sourcing & Manufacturing*, *Service & Operations* and *Partnerships & Ecosystem*. This is substantiated by the fact that these three components represent all aspects of the entire UAM value chain. Following Porter (1985), the value chain is divided into primary and secondary activities. Primary activities comprise of inbound and outbound logistics, operations and services. Secondary activities are seen as the firm's infrastructure, human resource management, technology and procurement (Porter, 1985). Therefore, quotes allocated to *Sourcing & Manufacturing* and *Service & Operations* are directly linked to a firm's value chain. *Partnerships & Ecosystem* enable access to value chain resources and are therefore also assigned to this factor.

Within the first two components, namely *Sourcing & Manufacturing* and *Service & Operations*, the interviewees suggest two possible methods for manufacturers to shape their value chain, that is, integrating versus outsourcing. However, there are significant differences in the distribution of these two strategies among the individual components of the *Value Chain Factor*. For *Sourcing & Manufacturing*, the interviewees advocate for both integrating and outsourcing whereas for *Service & Operations*, integration is the dominant argument. *Partnerships & Ecosystem* prove to be vital especially when engaging in outsourcing of value chain activities.

Sourcing & Manufacturing

With regard to *Sourcing & Manufacturing*, both integrating and outsourcing strategies are argued. More precise, a combination of both seems to be the common ground for most of the interviewees meaning that certain aspects of *Sourcing & Manufacturing* should be integrated whereas others should be subject to outsourcing. In essence, it is stated that a manufacturer should engage in integration in the early phase as well as integrate manufacturing of parts where he has the ultimate expertise or where "*there is no standard and [therefore] no suppliers yet, meaning that you have to do everything on your own"* (Interviewee M). On the contrary, many argue in favor of outsourcing as it might be difficult, especially for startups, to build up a well-functioning supply chain in-house as this entails high costs and expertise which is often not given for smaller companies. Moreover, outsourcing the production of certain parts where a supplier has more expertise and know-how can reduce costs and enable the VTOL manufacturer to focus on its core technology. In addition, a manufacturer can leverage a partner's supply chain expertise, especially when mass production is needed. What is more, some parts needed to build a complex vehicle are highly specialized and can be sourced more cost efficient than developing them in-house.

"Try to partner as much as possible so that most of the standard parts can be outsourced and [keep] the disruptive technology inside." (Interview D)

Service & Operations

By contrast, opinions on *Service & Operations* focus rather one-sidedly and unilaterally on integration. First and foremost it can be said that the overarching belief is that the VTOL manufacturer will not only build the vehicle but will also be the one operating it. As the manufacturer has the deepest know-how of the technology "*they know best how to operate it safely"* (Interview I). Additionally, it is argued that the manufacturer will also operate its own service and booking platform allowing them to maintain control over customer data and collecting information about passenger behavior. By doing so, the manufacturer can "*evaluate [the] technical specification and optimize it for the needs of [the] passengers"* (Interview L). Furthermore, it is noted that future revenues will be generated to a large extent from operations and less from vehicle production, which further reinforces the integration of this part of the value chain. Yet, it is also argued that in the long term service providers may enter the market and try to capture market share from the VTOL manufacturers.

Partnerships & Ecosystem

The third element of the *Value Chain Factor* is represented by *Partnerships & Ecosystem*. In contrast to the other two, this element is present throughout the entire value chain process. According to the interviewees, partnerships are particularly important in the *Sourcing & Manufacturing* process of the value chain. Especially when a manufacturer decides to outsource, partnerships are crucial.

"[…] when it comes to large scale production beyond the prototype phase, [the manufacturers] will work with well-established manufacturing companies."
(Interview F)

As stated earlier, access to certain specialized resources can be achieved by partnerships with suppliers of the needed resources (i.e. IT technology, control stick, etc.). In addition, if parts become standardized, partnerships with suppliers which produce or in-license these parts can reduce costs for the VTOL manufacturer. Moreover, a manufacturer can benefit from strategic partnerships with companies that have a high level of manufacturing competence such as the automotive industry. In addition to value chain activities, strategic partnerships with large corporations can also bring other advantages. In particular, large corporations "*have a huge outreach from a sales perspective […] and also a good lobbying setup"* (Interview N) which might help the VTOL manufacturer to "*push the vehicle through certification"* (Interview M) thus simplifying regulatory challenges (*5.1.6*). In order to operate their services, manufacturers need to either enter into partnerships with providers of infrastructure or build up an infrastructure ecosystem (*5.1.2*).

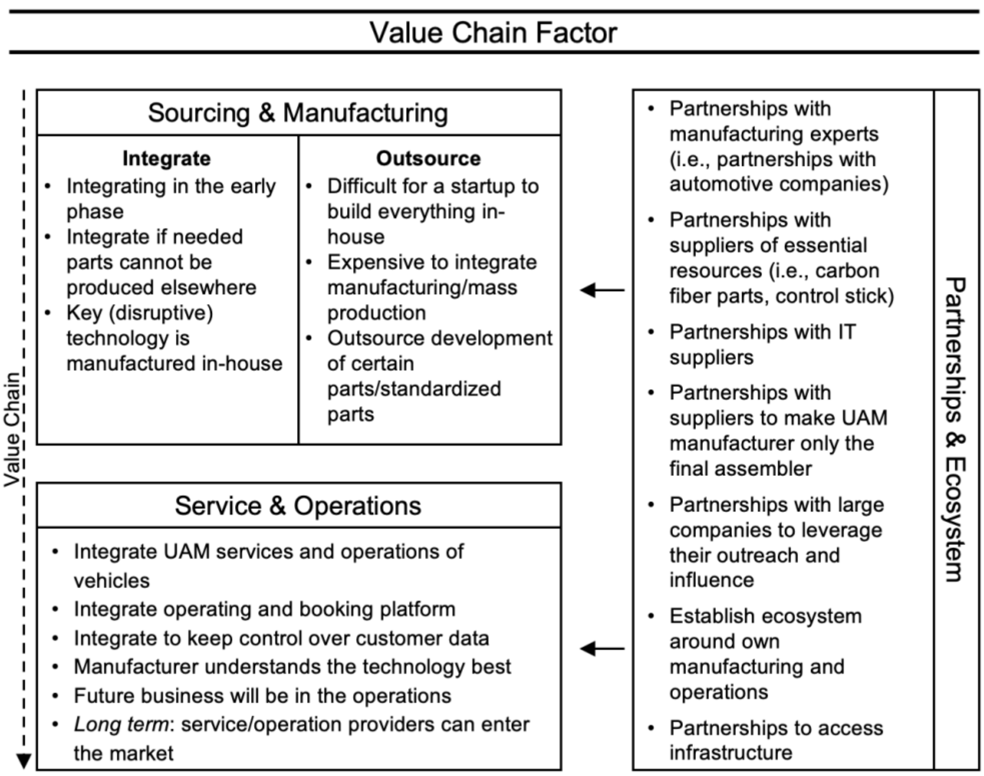

Figure 6: Value Chain Factor Variables

To sum up, the *Value Chain Factor* depicts a consideration with various aspects and therefore a large impact on the VTOL manufacturers business. Along the value chain, it needs to be decided whether to integrate or outsource and what partnerships to enter. Moreover, "*having an ecosystem in place […] helps to commercialize [the] vehicle"* (Interview M). Both, *Sourcing & Manufacturing* and *Service & Operations* are impacted by *Partnerships & Ecosystem,* however, the dependency on the latter is greater if the VTOL manufacturer decides to outsource (*Figure 6*). It is noteworthy, that within *Sourcing & Manufacturing* a tendency towards outsourcing can be seen whereas integration dominates *Services & Operations*. Moreover, the high proportion (47%) of quotes allocated towards *Partnerships & Ecosystem* highlights the importance of this element of the *Value Chain Factor*.

Code	Example
Sourcing & Manufacturing	*"As soon as it gets to anything which is already mass produced or if there is a lot of supply, you shouldn't try building it yourself because it's more expensive and there's no reason to do so." (Interview D)* *"For example carbon fiber parts are not necessary to produce in-house but buy it from multiple suppliers." (Interview E)* *"We're currently in seed stage so we only starting to build the supply chain." (Interview D)*
Service & Operations	*"[The manufacturers] would like to focus on their aircraft and the operations. This also includes the whole booking process […]" (Interview F)* *"We do want to be operating the platform that everything runs on." (Interview E)* *"[…] most of them would like to keep control of the customer interface. They don't want to use Uber because then Uber would own the customer data." (Interview B)*
Partnerships & Ecosystem	*"I think they will definitely rely on partnerships." (Interview G)* *"I would say it's important to have partnerships in place." (Interview B)* *"First, we need to have an ecosystem and we need to ensure that all those actors are present […]" (Interview O)*

Table 3: Quote Examples Value Chain Factor

5.1.2. Infrastructure Factor

Infrastructure in this context is defined as those facilities and systems needed for an UAM vehicle to commercially operate. To clarify, the airline industry cannot operate without airports just like cars cannot drive without roads and gas stations. The *Infrastructure Factor* comprises of four distinct components: the *Landing*-, the *Charging*- and the *Air Infrastructure* as well as the *Integration into Mobility Systems*. While the first three define the infrastructure required to operate a VTOL vehicle, the last refers to the integration of UAM into existing mobility systems. The *Landing* and the *Charging Infrastructure* somewhat describe the same facility, also referred to as the ground infrastructure, however, due to the explicit mentioning of the *Charging Infrastructure* as an important element, these two were separated.

Landing Infrastructure

The *Landing Infrastructure* element encompasses various aspects: where will the infrastructure be build, how is it regulated, and who will be operating it. Two different opinions prevail regarding the location of the landing infrastructure, also referred to as vertiports. Vertiports are specified landing and takeoff locations for UAM vehicles (Booz, Allen & Hamilton, 2018). On the one side, it is argued that these vertiports should be placed at major traffic junctions such as train stations or airports in the outskirts of a city. In addition, it is stated that the infrastructure will need a lot of space and therefore VTOL vehicles "*will [not] fly into inner city areas"* (Interviewee H). On the other side, it is claimed that the landing infrastructure "*needs to be in urban areas […] in order to be successful"* (Interview M). Here it is argued that vertiports that are placed on "*skyscraper[s], roof tops, and parking garages […] are going to be absolutely critical"* (Interview F).

"I think any eVTOL commercialization activity in Europe has to start [within] the current airport system. I don't see that activity starting from non-airport locations which are not covered by ATC currently" (Interview J)

Even though some manufacturers are developing their own vertiports (Lilium, 2021a), the general perception is that there will be third party operators and owners of the landing infrastructure as "*the costs of infrastructure and the commercial risk to operate infrastructure* *is too high for [manufacturers]"* (Interview F). Therefore, the manufacturers are advised to enter into partnerships (*see 5.1.1, Partnerships & Ecosystem*) to get access to infrastructure. Moreover, it is claimed that the landing infrastructure will be provided by "*governments, private investors, and public private partnerships"* (Interview N) strengthening the proposition that manufacturers will most likely not operate the vertiports themselves.

Two further aspects influencing the choice of location are regulatory requirements *(5.1.6*) as well as noise and privacy issues within social acceptance (*5.1.7).* One aspect of regulation is displayed by the required standardization of vertiports. The landing infrastructure needs to have "*industry standards in order to ensure that a Lilium [jet], a Volocopter and a Hyundai vehicle can use the same Vertiport"* (Interview M). Adding to that, cities and municipalities (e.g. those setting the regulations) want "*vertiports independent of manufacturers"* (Interview K) to ensure that different types of vehicles can use the same landing infrastructure.

Charging Infrastructure

The required standardization of the *Landing Infrastructure* can also be applied to the *Charging Infrastructure*. The *Charging Infrastructure* implies a vital element of the UAM infrastructure as UAM vehicles are currently powered by batteries which need recharging or replacement as "*the range is relatively limited"* (Interview F). With that, the question prevails where "*the energy [will] be allocated, stored, distributed*" and what happens "*at the end of the life cycle of [the batteries]"* (Interview O). Some argue that "*the energy for recharging is renewable"* (Interview I). However, this spans the arc towards environmental issues within the industry (*5.1.5*). In addition, the question is raised whether batteries will be exchanged or whether the vehicles will be charged directly, and if so, how fast they will be charged.

Air Infrastructure

However, the ground infrastructure (*Landing- and Charging Infrastructure)* displays only one aspect of the required infrastructure. Once the vehicle is in the air, it needs to be managed and controlled by an air traffic control (ATC) system. Here, the question is raised whether *"[there is enough [air] capacity and agency capacity to control all these flights"* (Interview F) or if a new, more automated ATC system is needed. Moreover, regulations will define the air infrastructure as, especially within cities, VTOL vehicles will "*access local and public air* *space […] which is handled by regulators and agencies"* (Interview O). In addition, many cities, such as New York City and London, have bans on flying to inner-city areas, which also make it difficult to access inner-city areas. Furthermore, it is argued that these vehicles will not "*move freely like they prefer around any city. There will be defined corridors […] for vehicles to fly"* (Interview G). Besides, it is still unanswered how UAM and commercial aviation flows can be brought together, especially at airports where no-fly zones for any vehicles but airplanes exist. This paths the way for the forth element, namely the *Integration into Mobility Systems*.

Integration into Mobility Systems

There are two aspects of integrating UAM into already existing mobility systems. First, as described above, UAM needs to be integrated into the air infrastructure and be able to operate without interfering commercial aviation. Second, UAM should be integrated into regional mobility networks consisting of mass transit, metro and train connections in order to prove its complementary nature. The first is covered by the above stating the necessity of advanced ATC systems and regulatory requirements. However, the latter should not be neglected.

"[Train stations] are one of the best places to land the air taxi so that people can transition from the airport to the next long distance train station." (Interview B)

It is argued that the locations of vertiports need to be selected carefully to prevent "*passengers [taking] a cab to the vertiport, take a Volocopter and take a cab again"* (Interview L). To counteract this, research on travel behavior should be conducted and passenger and travel flows have to be analyzed (*5.1.3*). The beforementioned decision on whether a landing infrastructure should be placed in the city center or the outskirts of a city is also determined by the degree of integration into existing mobility systems. In many cities, "*train and mass transit are incredibly efficient modes of transportation for very high density areas*" (Interview H) supporting the strategy of locating vertiports at transportation junctions where passengers can easily change mode of transportation to trains and/or metros.

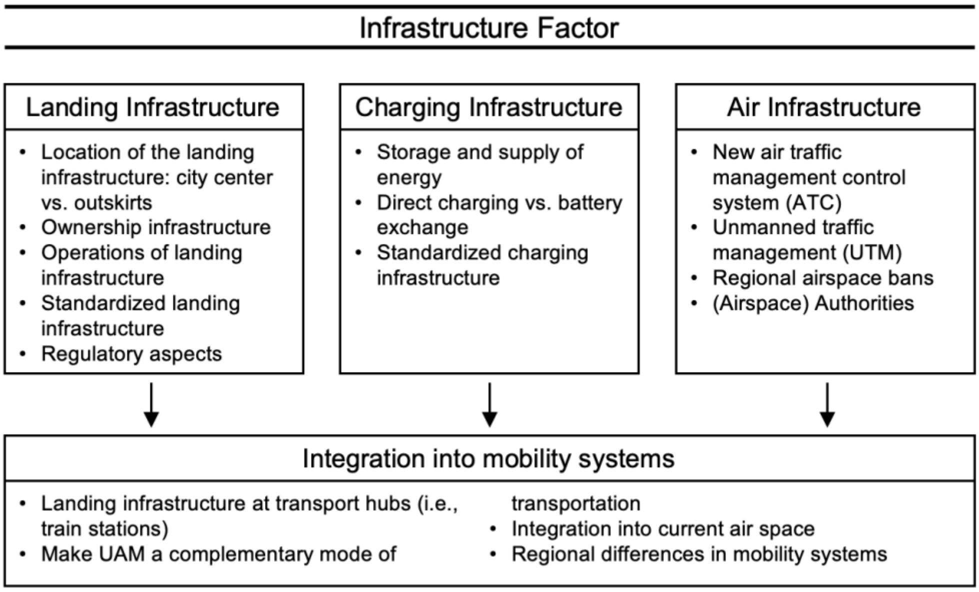

Figure 7: Infrastructure Factor Variables

In summary, the UAM infrastructure constitutes another critical factor for the success of a manufacturer, as it is indispensable for the operation of the vehicle. As visualized in *Figure 7*, the *Landing-*, *Charging-* and *Air Infrastructure* influence the *Integration into Mobility Systems* element. Both, the ground infrastructure, namely the *Landing-* and *Charging Infrastructure*, as well as the *Air Infrastructure* are vital for the vehicle to operate properly. Since it is argued that manufacturers will not operate the vertiports themselves, partnerships with infrastructure providers and the optimal location of the vertiports are of particular importance. Likewise, the efficient integration into existing mobility systems as well as the complementarity of UAM is of high relevance. Therefore, the *Infrastructure Factor* depicts another important factor to consider by VTOL manufacturers.

Code	**Example**
Landing Infrastructure	*"We are looking for a vertiport location pretty close to the passenger terminal to minimize walk ways between the different touch points." (Interview J)* *"You need an airport for bringing passengers there and then you take them from there somewhere else." (Interview N)*
Charging Infrastructure	*"You need to handle the charging infrastructure." (Interview G)* *"The charging infrastructure should be such that it can cater to any kind of the most generic types of air taxis." (Interview F)*

Air Infrastructure	*"[…] the ATM and UTM solutions and the access to the local air space needs to be considered." (Interview O)* *"The traffic management will be also critical to solve." (Interview B)*
Integration into Mobility Systems	*"And if this is sort of a complementary mode of transportation, which at reasonable cost can actually lead to significant time savings […]" (Interview H)* *"I would worry about the network and how it integrates with other modes of transportation." (Interview H)*

Table 4: Quote Examples Infrastructure Factor

5.1.3. Marketing & Research Factor

The *Marketing & Research Factor* stems from two distinct elements. First, the *Marketing & Communication* element and second, the *Research* element. Both promote the importance for UAM manufacturers to interact with external stakeholders. While the latter element emphasizes that more research activity is needed to increase the stock of knowledge on both technological and sociological matters, the *Marketing & Communication* element stresses the importance of promoting the product and service through branding, public relations and the overall communication with stakeholders.

Marketing & Communication

Marketing is defined as the "*activity […] and process for creating, communicating, [and] delivering offerings that have value for customers*" (American Marketing Association, 2021). With regard to the *Marketing & Communication* element, interviewees strain the importance of "[*investing] a lot of money into marketing and PR to convince people*" (Interview B) of the benefits the service will deliver and of the advantages a single firm has. Marketing activities should accompany a manufacturer's activities in establishing a well-known brand in order to benefit from the realization of use cases, partner development and product launch. Not only promoting a service, but also "*a clear communication strategy addressing the positive as well as the negative aspects*" (Interview C) is needed. Most importantly, this would usher manufacturers to create transparency and social and user acceptance (*5.1.7*). Additionally, the communication strategy can help addressing potential partners and regulatory bodies at the right point in time.

"It is important to remember that manufacturers need to be transparent, they need to communicate with all stakeholders, they need to engage certain stakeholders at certain times. Recognizing this and building it into the plan is essential." (Interview E)

Research

The *Research* element describes how important it is for manufacturers to both conduct research themselves and rely on further research performed by others in the field. The purpose of research is to systematically search, document and publish new results and increase the level of knowledge about a particular problem (OECD, 2015). Since the UAM industry is still very unexplored, research is needed in all areas with regard to the strategic decision factors of UAM manufacturers. On the one hand, research is needed to improve the core technology and affiliated innovations. For example, to research longer-lasting batteries, *"low[er] failure in autonomous flight"* (Interviewee L) and *"AI, machine learning and trajectory systems*" (Interview P). On the other hand, additional research is required to improve demand projection and the integration of VTOL landing infrastructure (*5.1.2*) into the existing infrastructure. Furthermore, "*research [needs to be conducted] with customers, […] but also with the public*" (Interview C) in order to acquire further insights into social and user acceptance, privacy and safety concerns, and possible use cases. Therefore, manufacturers are advised to initiate additional research projects, either internally or in research partnerships with academic institutes, partners or consultancies.

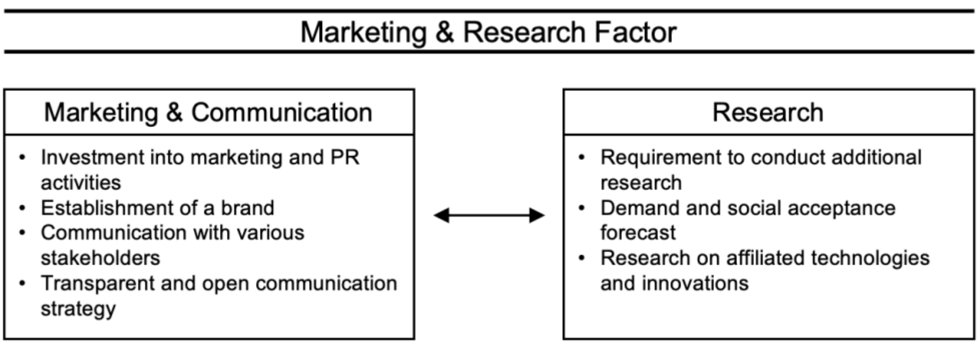

Figure 8: Marketing & Research Factor Variables

In conclusion, the *Marketing & Research Factor* is an important factor that needs to be considered by VTOL manufacturers. Two thirds of the quotations are attributed to the *Research* element, while the remaining quotes are allocated to the *Marketing & Communication* element. Thus, the research focus is of somewhat higher importance. Thematically, the two are closely related, as the focus is on interaction and communication with stakeholders. In addition, *Research* is strongly interconnected with other factors, as it usually helps to develop deeper insights into a subject and, if possible, to come up with solutions. The results of research are communicated to the external environment by means of a communication strategy and are thus a marketing tool. The interrelations of the two elements are also shown in *Figure 8*.

Code	Example
Marketing & Communication	*"As an eVTOL manufacturer obviously marketing and public relations management is important to be successful." (Interview E)*
	"Having a worldwide brand is important to be able to generate synergies in terms of investments and customer reach." (Interview O)
Research	*"Manufacturers should conduct more research, including potential customers, but not only with customers, but also with the public, because they will be affected by the technology flying over them" (Interview C)*
	"Manufacturer's rely on technology and thus they have to invest into fundamental research to overcome this." (Interview P)

Table 5: Quote Examples Marketing & Research Factor

5.1.4. Affiliated Innovations Factor

The *Affiliated Innovations Factor* consists of innovations that are considered important for the further and future development of UAM, but do not yet exist as such and are therefore needed. Furthermore, the VTOL manufacturers have only little influence on the development of these innovations, as they lie outside of their area of competence. Accordingly, all manufacturers are dependent on these affiliated innovations. The two main elements of the *Affiliated Innovations Factor* are depicted by the *Energy Supply* and *Autonomous Technology.* In addition, certain innovations are mentioned which can be referred back to the *Infrastructure Factor* (*5.1.2*) such as a "*superior charging infrastructure*" (Interview F) as well as an UTM system capable of handling autonomous flying vehicles.

Energy Supply

The energy supply of VTOL vehicles is strongly build upon batteries. Almost all current VTOL manufacturers incorporate electric propulsion into their vehicle design (Booz, Allen & Hamilton, 2018). This is a trend which can be observed in the entire mobility industry, especially "*automotive companies are now switching more or less to e-vehicles*" (Interview B). Many emphasize that the developments in the automotive industry can spill over to UAM resulting in better batteries within a couple of years. In order to successfully operate a VTOL vehicle, the batteries powering the vehicle need to improve as "*batteries mean a better aircraft and a better aircraft is a better service*" (Interview E). Moreover, the battery technology is perceived as a "*critical element because it is the biggest weak spot of the technology*" (Interview F) and current energy density in batteries is perceived as not capable of "*cover[ing] longer distances, especially if [the vehicle] needs to hover [in order] to land and take off in the cities*" (Interview F). As a result, "*very energy dense batteries*" (Interview D) are required. Furthermore, these batteries cover a significant weight share of the vehicle which may result in "*more batteries to carry around batteries*" (Interview G). Therefore, "*storing the same amount of energy in a lighter battery*" (Interview P) is required. What is more, batteries are claimed as the "*the most expensive component*" (Interview G) further emphasizing the importance of batteries. Even though VTOL vehicles are planned to operate partly or fully electric, sustainability is not a given. Especially batteries pose as a double-edged sword. On the one hand, they stand for alternative sources of energy, on the other hand, sourcing and "*recycling of [battery] parts and components*" (Interview O) is antithetical to the sustainable image of e-mobility (*5.1.5*). Accordingly, other energy sources such as "*hydrogen storage*" (Interview D) are discussed.

"Better batteries mean a better aircraft and a better aircraft is a better service - so aircraft battery technology is definitely a critical technology" (Interview E)

Autonomous Technology

Whether VTOL vehicles will fly autonomously or not has also been discussed throughout the interviews. The general perception is that autonomy will become relevant in the future, however, it is not clear at what point in time this will occur. Even though autonomous driving is already partially in use and on the rise, the interviewees urged that "*3D versus 2D […] is a totally different thing from a control [and] interaction [perspective]*" (Interview M). Nevertheless, autonomy is perceived as an important additional innovation needed for the UAM industry. For one, it is argued that autonomy "increases the safety and reduces the operating cost" (Interview O) by removing the pilot. This measure of making the pilot redundant also "*increases the amount of passengers in a vehicle*" (Interview L) thus resulting in higher efficiency. Further, autonomous flying vehicles are in need of advanced "*coordination between the ground infrastructure and the aircraft*" as well as "*precision landing systems that allow the aircraft to navigate and land on the infrastructure*" (Interview I), e.g. UTM systems, linking the need of affiliated innovations to the *Infrastructure Factor* (*5.1.2*). Moreover, autonomous flying, and autonomous mobility in general, is subject to many regulatory questions (*5.1.6*) which are still unanswered (Booz, Allen & Hamilton, 2018).

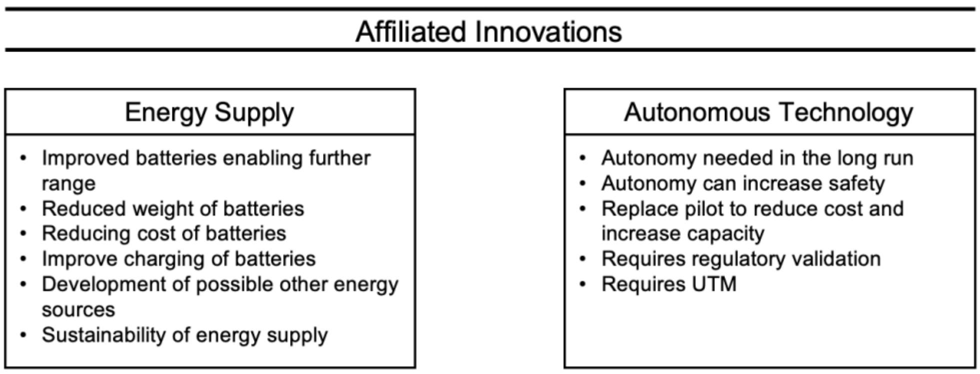

Figure 9: Affiliated Innovations Factor Variables

As stated above, both innovations in energy supply as well as advances in autonomous flying are of high importance for future operations of VTOL manufacturers. *Figure 9* summarizes the two main elements of the factor. In essence, it can be said that the UAM industry and VTOL manufacturers have to consider the *Affiliated Innovations Factor* as "*the performance of the vehicle and then the performance of the business is dependent on other innovations*" (Interview P).

Code	Example
Energy Supply	*“I think the battery technology is going to be a critical element.” (Interview F)* *“Other innovations like a good battery are critical.” (Interview B)*
Autonomous Technology	*“I think to autonomous flying will be will be necessary” (Interview M)* *“It is more about focusing on autonomous systems.” (Interview L)*

Table 6: Quote Affiliated Innovations Factor

5.1.5. Environmental Factor

The *Environmental Factor* emerged from the emphasis that interviewees placed on sustainability in all its variants. Thus, the *Environmental Factor* describes the expectations of social and sustainable impacts associated with the manufacturing and operation of the vehicles and its components. Growing concerns about climate change and environmental degradation have become a frequently discussed public topic, that impacts consumers, policy makers, investors and businesses (Capgemini, 2020). The general perception of the sustainability of the aviation industry is relatively poor, therefore, achieving environmental friendliness has particularly become a strategic matter within the industry (Capgemini, 2020). The importance of sustainability in the adoption of innovations has already been discussed by Kim and Muborgne (2000) as one of the six utility levers. As passenger UAM aims to provide a new means of transport to address increasing urban congestion and traffic pollution the expectations are high (Roland Berger, 2018).

“Nowadays, you can't just throw more polluting products on the market that increase the energy demand of the transport sector.” (Interview C)

Accordingly, the manufacturers are encouraged to *“go beyond building the aircraft in a sustainable way with sustainable suppliers and sources, but also to go further in the value chain […] so that the manufacturers become part of the solution and not contribute to the problem”* (Interview E). An important point raised to achieve sustainable production and operation of the vehicles occurs when *“batteries get more powerful and cope with fewer* *charging cycles"* (Interview M) (*5.1.4*). Additionally, even though the vehicle is sustainably sourced and energy consumption is neutral, VTOL vehicles should also have the ability to relief ground traffic and create shared public value.

Environmental	
Sustainability	
• Emission free manufacturing • Sustainable powertrain of vehicle • Sustainable batteries	• Reduction of pollution when operating the service • Creation of benefit for society to maximize public value

Figure 10: Environmental Factor Variables

To sum up, the *Environmental Factor* comprises of the requirement to produce and operate a sustainable vehicle with special emphasis on an emission free mode of transport. Even though the factor shows the lowest quote frequency, its interweaving with the *Social & User Acceptance Factor* (*5.1.7*), being the second most quoted factor, balances its weight. Moreover, the public pressure for a change in mode of transport and the quick reaction of car manufacturers underlines the significance (Capgemini, 2020). Thus, it can be concluded that the *Environmental Factor* is of high importance for the success of VTOL manufacturers and cannot be ignored. *Figure 10* summarizes the key elements of the factor.

Code	**Example**
Sustainability	*"[manufacturers] should pay more attention to the benefits of the technology for the general public and how this technology can be used in a socially and environmentally sound way." (Interview C)* *"Manufacturers are seeing a big trend towards sustainability, vehicles have to be zero emission. Zero emissions means more than carbon footprints, it's NO_x, it's noise pollution, visual pollution and so on." (Interview O)* *"[Manufacturers need to] provide air taxi services and […] need to make sure that they're […] sustainable in all the meanings of the word." (Interview E)*

Table 7: Quote Examples Environmental Factor

5.1.6. Regulatory Factor

The *Regulatory Factor* consists of regulatory requirements, namely *Certification, Regulation* and *Standardization,* which are considered by respondents to be important for the commercial establishment of the UAM service, as well as *Lobbying* as a means for manufacturers to influence the process of setting regulatory requirements. As stated above, the regulatory requirements are split into the following three elements: *Certification, Regulation* and *Standardization.* While the *Certification Process* is claimed as the starting point to get the vehicle in the air and operate it, the *Regulations* are the legal framework of policymakers to frame the resulting activities and ultimately provide the structure for *Standardization* regarding the charging and landing infrastructure.

Certification

The *Certification* process is perceived as the starting point, because *"if the vehicles are not certified, they are not able to fly"* (Interview B). Subsequently, if they are not able to fly it is not possible to operate the service. Due to the specificities of air transport in terms of safety, environmental impact and complexity of the technology, formal and long-established processes that coordinate certification of conventional aircrafts prevail. Likewise, the certification process of an established air vehicle can take several years. The responsibility to carry out the certification process lies with aviation authorities such as the European Aviation Safety Agency (EASA) or the US Federal Aviation Administration (FAA) (Straubinger et al., 2020). Therefore, certifying a new type of transport vehicle requires the setting of new standards and thus requires even more time and financial resources. The *Certification* process entails the technological certification of the vehicle as well as the authorization to perform a transport service. Particular attention will be paid to noise and safety as outlined in section *5.1.7*. As a result, manufacturers have to be prepared to master a long and costly certification process that requires "*a lot of flight test maturity […] in a real environment, possibly above a city*" (Interview P). Moreover, in terms of certification speed and modality the process in each geographical region is different (*5.1.8*), thus requires time, experience and financial resources.

"The certification process requires an experienced team and engineering skills to get an aircraft certified, especially for commercial transport this is critical to success." (Interview I)

Regulation

Certification is followed by the establishment of a regulatory body that stipulates and guides the introduction of the new mode of transport. Policymakers are encouraged to introduce laws that provide guidelines for both the infrastructure and the vehicle operations (Michelmann et al., 2020). First, *"ATM and UTM solutions [need to get access] to the local airspace"* (Interview O). Second, manufacturers require *"the federal level of politics [to provide a] clear framework, which is defining […] sustainability [and] integration into other modes of transportation"* (Interview C). Lastly, *"the political decision makers at the local level [have to be] on board […] to support the projects and provide space for infrastructure"* (Interview F). Accordingly, policymakers are juggling with the environmental concerns (*5.1.5*), social and user acceptance (*5.1.7*) and infrastructure requirements (*5.1.2*) making the process highly complex.

Standardization

While the vehicle operation is perceived to be integrated (*5.1.1*), the operation of vertiports is likely to be delivered by specialized providers (*5.1.2*). Thus, the *Standardization* element emerged from interviewees perception that infrastructure needs to be accessible for all players on the market. To first, "*justify the investments into the vertiport infrastructure*" (Interview F) and second, to profit from the network of different infrastructure providers and not exclude certain operators. Therefore, the charging and landing infrastructure is requested to be standardized to run "*these vertiports independent of manufacturers*" (Interview K). As a result, policymakers and municipalities are asked to set standards for the aforementioned infrastructure to provide an orientation for vehicle manufacturers.

Lobbying

As described above, certification approval, regulation and standardization are not in the hands of manufacturers. In addition to developing a first-class vehicle that complies with all regulations, "*regular communication with the certification agency*" (Interview E) and "*governors of regions, […] federal governments and mayors*" (Interview N) is critical for the approval and regulations process of the vehicle and service. The *Lobbying* element explains the constant communication that manufacturers need to engage in to influence the regulatory approval process to get their vehicle and operating concepts approved. First, having a strong partner network (*5.1.1*) and second, investing into marketing and research (*5.1.3*) activities can enhance the awareness for an individual manufacturer and increase influence and power in the lobbying process.

"Getting access to decision makers is critical" (Interview N)

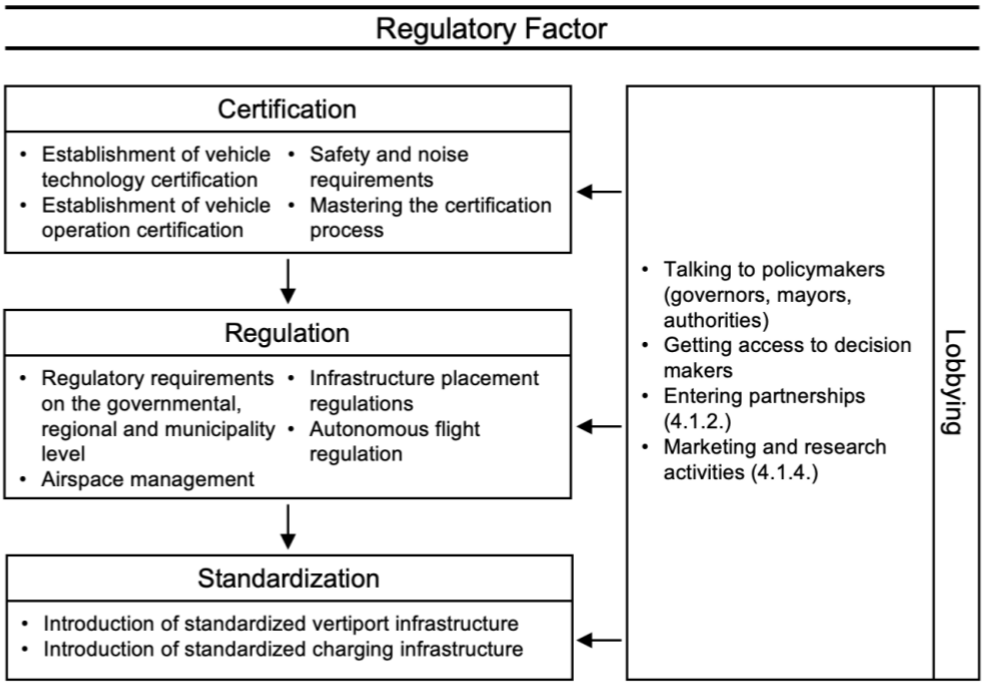

Figure 11: Regulatory Factor Variables

To conclude, the *Regulatory Factor* is the fourth most important factor to be considered by VTOL manufacturers. The factor consists of four elements (*Figure 11).* While *Certification, Regulation and Standardization* describe the formal measures that policymakers and authorities have to undertake, *Lobbying* describes the actions that manufacturers can take to influence the approval process. The regulatory process includes a lot of decision makers on all governmental levels, shows regional differences and has savior implications on the success of the industry. In essence, *"If the vehicles are not certified, they are not able to fly"* (Interview B).

Code	**Example**
Certification	*"One key role will definitely be hold by EASA or FAA, they need to define the certification background and the required safety levels" (Interview G)*

	"[Certification] is one of the key pillars that [manufacturers] need to drive forward, and it is obviously, first, very expensive, [...] it takes a long time and it is not clear yet which vehicle design or designs will receive certification." (Interview B)
Regulation	*"every time you build a piece of aviation infrastructure, of course, it depends on the jurisdiction" (Interview I)* *"the success for autonomous aircraft is both a technical question as well as a regulatory question" (Interview F)*
Standardization	*"vertiport manufacturers [need to] align on a standard which can actually be used by any eVTOL vehicle" (Interview M)* *"[manufacturers] need [...] to understand if there is a charging standard, [since they] want to make sure that the vehicle is compatible" (interview P)*
Lobbying	*"being in regular contact and exchange and [having] a good relationship with the agencies can be really important" (Interview E)* *"delivering a new mode of transport means you have to start talking to politicians and the governments and position yourself to provide a solution for the current traffic problems [...] Thus the political angle is important." (Interview N)*

Table 8: Quote Examples Regulatory Factor

5.1.7. Social & User Acceptance Factor

The *Social & User Acceptance Factor* is considered by almost all respondents to be one of the, if not the, most important factor. It can be broken down into the following five elements: *Safety, Noise*, *Privacy, User* and *Public Perception. Safety, Noise* and *Privacy* are claimed as the overarching influences on social- and user acceptance of which *Safety* and *Noise* have an impact on both the *User* (e.g. passenger) and the *Public Perception* whereas *Privacy* does not affect the *User* but only the *Public Perception*. The two remaining elements, namely *User* and *Public Perception,* entail further aspects of the *Social & User Acceptance Factor*.

Safety

The *Safety* of the VTOL vehicle is argued as crucial. If a manufacturer cannot provide a safe vehicle, it will be impossible for the manufacturer to be successful if it cannot "*convince people that it's safe to fly with you*" (Interview D). Moreover, "*if in your car something fails, you have a good chance that you can just drive to the site. If something fails in your airplane, your chances are slim*" (Interview D). This emphasizes the importance of a safe vehicle. "*If* *a manufacturer risks too much and things like that come down, then we will have an issue on the whole industry*" (Interview F) potentially paralyzing the entire industry.

"One of the most important things is […] that the aircraft itself is absolutely safe. I think that's the sine qua non that has to be absolutely certain." (Interview F)

Another aspect of safety is displayed by the handling of ground security. If UAM is seeking to enter mass transportation, it needs to make sure that "*every passenger using a VTOL vehicle is screened [prior] to boarding which is not the case if you compare it to, for example, taxi rides*" (Interview N). Additionally, it needs to be assured that these vehicles, especially when autonomous flying is in place (*5.1.4*), are not subject to any kind of "*hijacking as that would be fatal because then you have 9/11 multiplied by 100 and then those vehicles turn into flying bombs*" (Interview N). In addition to proving that the vehicle is safe, manufacturers "*need to deal with the certification*" (Interview G) as the safety of the vehicle and the problem-free operation within urban areas needs to be assured by regulators (*5.1.6*).

Noise

Secondly, VTOL manufacturers have to cope with *Noise* issues. It is argued that most of the current manufacturers' vehicles are too loud to operate in urban areas. Especially in western countries, "*societies […] are very sensitive to any form of new disruption in terms of noise*" (Interview H). In turn, if a manufacturer's vehicle "*is significantly quieter than other aircraft, they should be allowed to fly into more urban or more dense environments than others*" (Interview I). Additionally, dedicated "*air streets above [cities] can be more acceptable for inhabitants*" (Interview G) regarding noise issues (*5.1.2).* Nevertheless, for most regions regulators will set maximum noise pollution limits which need to be reached by manufacturers (*5.1.6*). Furthermore (see *Public Perception*), manufacturers will face difficulties with justifying a noisy vehicle above urban areas if the public believes that "*only rich people are using it*" (Interview H).

"I think the first thing that you need to overcome is noise. If [the vehicle] is going to be loud, it's not going to fly in a city." (Interview H)

Privacy

Another not-negligible element of the *Social & User Acceptance Factor* can be seen in the privacy implications of UAM. Concerns are expressed regarding the overflight of private property: "*a vehicle flying over private area or flying over a crowd of people, there are big safety questions and private data issues*" (Interview L). VTOL manufacturers must also consider the portion of the public that does not use the service but is still directly affected by it. As stated above, dedicated "*air streets above [cities]*" (Interview G) could also counteract privacy issues within urban areas. Just as noise issues are a major problem in Western countries, privacy issues are of much greater importance in "*Western, especially European, countries than in other regions*" (Interview B). In line with *Noise* and *Safety* issues, regulations on *Privacy* will also influence operations.

User

Two of the above, namely *Safety* and *Noise*, define the user acceptance of those flying with the vehicle. VTOL manufacturers all face "*the same challenge where people will not trust it initially*" (Interview I). As mentioned earlier, security must be ensured to build trust in the technology, both with the public and with users. One element that has been mentioned is the user's perception that technology from certain geographic areas is inferior to others, which leads to mistrust from the outset. "*The way a vehicle looks also has an effect on trust*", therefore, trust can also be "*influenced by the design of the aircraft*" (Interview I). In accordance, it is argued that "*focusing on the user from a design perspective*" (Interview M) and "*design[ing] the vehicle and understand[ing] what is perceived as valuable by the customer*" (Interview P) can enhance user trust in an early phase. Here, marketing and research activities can contribute additional value (*5.1.3).*

"It all starts with an understanding the demand and where people want to fly based on where they travel" (Interview P)

The issues with Boeing's 737-MAX aircraft display a good example of how much a manufacturer can suffer from a security failure. After two fatal accidents with 346 deaths, the aircraft type was grounded worldwide for over one and a half years (NY Times, 2019).

This resulted in a massive cancellation of aircraft orders with Boeing delivering 60% less in 2020 compared to 2019 (*Note*: the coronavirus pandemic also contributed to the reduction) (Reuters, 2021). Additionally, a passenger survey revealed that 40% will not board a 737-MAX aircraft (Forbes, 2019).

In addition to creating trust, it is argued that a VTOL manufacturer should provide a "*user friendly design, including physical space, vibration reduction, and noise damping*" (Interview P). Moreover, in order to predict user demand for their operations, VTOL manufacturers should engage in research and marketing activities to "*get an understanding of where people want to fly*" (Interview P).

Public Perception

The perception of the public is mainly shaped by the three elements mentioned above, namely *Safety*, *Noise*, and *Privacy*, however, other variables also influence the public perception of UAM. One major problem is displayed by the fact that "*the majority of people will only endure the noise but will not benefit from [UAM] because they cannot afford it*" (Interview K). This stipulates the perception of the public that UAM is first and foremost for the rich and wealthy proportion of society and that the majority of the public does not derive any value from it. Consequently, a VTOL manufacturer has to consider the cost of the service "*because [the manufacturer] needs to make it available to a broad part of the society. Otherwise, it's perceived a rich man's toy*" (Interview H).

"If this takes off as a rich people's toy then that's going to be a problem"
(Interview H)

Moreover, the added value of UAM has to be communicated to the general public and the technology needs to be gradually introduces towards the mass. It is argued that "*once you see air taxis services taking off on a more regular basis, no matter where in the world, it becomes something more normal and people will get used to it*" (Interview F). Nevertheless, one must convince the public that "*this is a new way of transport*" (Interview G), "*it can lead to significant time savings*" (Interview H) and also "*promote the economic benefits of urban air mobility*" (Interview C). Ultimately, VTOL manufacturers have to realize that "*it is* *important to take citizens and their opinions into account in the development process*" (Interview K).

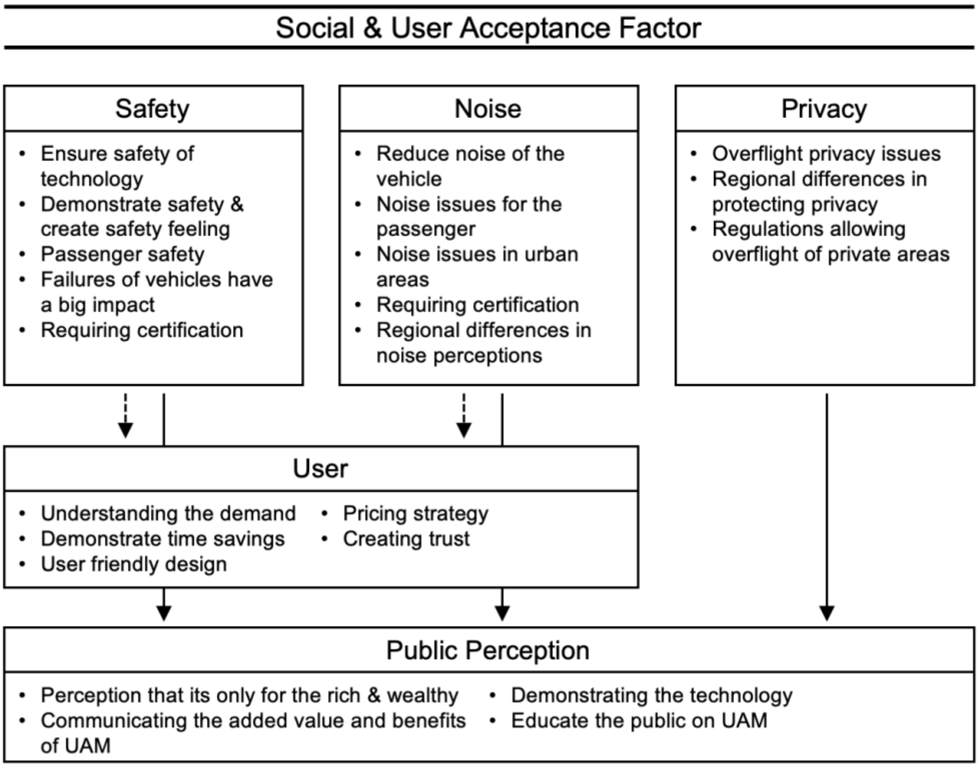

Figure 12: Social and User Acceptance Factor Variables

To sum up, the *Social & User Acceptance Factor* is inevitable for successful market introduction as well as sustainable operation of UAM. The factor comprises of five elements divided into two levels (*Figure 12)*: *Safety*, *Noise* and *Privacy* depict the first level. The first two have a direct impact on *User* whereas all three shape *Public Perception*. In addition, *User* and *Public Perception* further entail variables influencing the *Social & User Acceptance Factor*. What is most important to understand about the *Social & User Acceptance Factor* is the fact that social acceptance takes time and that "*you can't accelerate social acceptance the same way you can accelerate technology*" (Interview D).

Code	**Example**
Safety	*" I'm not sure how high the safety feeling is or will be." (Interview K)* *" As you can see in manned aviation the safety of all flights is an important factor." (Interview L)*

Noise	*" You need to improve the noise footprint." (Interview O)* *"Western societies are highly sensitive to any form of new disruption in terms of noise." (Interview H)*
Privacy	*" It is really a political issue with the protection of private data." (Interview L)* *" I have this technology over my head, even if I'm not flying." (Interview C)*
User	*" I think the interesting question is how big the user acceptance will be." (Interview G)* *" Users like it if it's not noisy, if it's user friendly, and if it actually provides time savings." (Interview P)*
Public Perception	*" Air taxis are often seen as VIP aircraft, something that is only accessible for the very rich people." (Interview F)* *" At some point people will maybe prefer specific types of aircraft." (Interview I)*

Table 9: Quote Examples Social & User Acceptance Factor

5.1.8. Launch Strategy Factor

The *Launch Strategy Factor* comprises of two main strains of opinions. On the one hand, it is argued that a quick-to-market strategy would be beneficial to VTOL manufacturers, but on the other hand, intellectual property protection and later market entry could also be the winning strategy. A third element of the launch strategy factor is depicted by the target market a manufacturer should move into first. A total of 61 quotes support the launch strategy factor of which approx. 50% argue in favor of the first-mover strategy.

Geographical Differences

Throughout the interviews, it became evident that the choice of target market has a significant impact on the launch strategy. Some geographic regions show a more propitious starting point for fast market entry compared to others. These geographic regions are characterized by different variables such as the regulatory landscape (*5.1.6*) as well as the social acceptance (*5.1.7).* Regions showing more openness towards "*new technologies such as the U.S. or even Asia, will be the first markets where this type of new transport will be launched"* (Interview B). Another variable influencing the choice of target market and therefore the choice of launch strategy is the social perception of a new technology. For example, *“[In] India […] people are much more used to noise and emissions where this new mode of transport will not really cause a difference”* (Interview N) compared to European countries. In general, it can be said that the choice of target market has an influence on the choice of market entry strategy.

Speed-to-Market

The first mover advantage is perceived to give a company a competitive advantage by being the first actor in a market segment (Lieberman & Montgomery, 1998). It is argued that, especially for startups engaging in UAM, *Speed-to-Market* is an important factor to consider as they rely on funding and financing and need to deliver results in order to secure funding to further develop their product. However, it is also stated that over pacing the speed to market could result in an technological inferior vehicle.

“The startup companies have to show results. If they don't show results, investors will fall off and then they will become bankrupt. The risk is that they over pace and they are presenting a product which is nice and shiny, but it is not 100 percent engineered and final.” (Interview N)

Moreover, moving into the market fast puts the manufacturer in a favorable position when negotiating for potential partnerships. What is more, patent protection is argued to “*get expensive really quick”* (Interview D) and to be time consuming which might leave the manufacturer in an unfavorable position compared to its competitors. In addition, a *Speed-to-Market* strategy offers the manufacturer the opportunity to capture the early adopter market and thus allowing to enter the *technology adoption life cycle* (Bohlen & Beal, 1957; Rogers, 2003; Foster, 1986) at an early stage. Additionally, it is stated that manufacturers “*bring their vehicles on the market to have prototypes up in the air to do testing, commissioning, permitting to get all the necessary licenses”* (Interview N). Thus, an early market entry can also path the way to faster certification (*5.1.6*) of the technology.

Second Mover

On the contrary, it is argued that protecting intellectual property and choosing to enter the market at a later stage may also be of advantage to manufacturers. It is claimed that improving and protecting the technology, in particular "*anything that is critical for the functioning of the aircraft or not yet existing"* (Interview E), should be subject to protection. Beyond that, if a manufacturer manages to overcome technological challenges that the entire industry faces, it might prove vital to protect the IP. Another argument in favor of a later market entry is based on the advantage of endurance as "*as soon as the market is maturing, there will be some kind of consolidation"* (Interview D). Additionally, endurance can pay off when the market is not ready and early movers spend a lot of resources without generating value. It is further argued that, if an manufacturer holds and protects a superior technology, "*imitation might take a while and [the manufacturer] can serve the market alone"* (Interview H) resulting in a favorable market position.

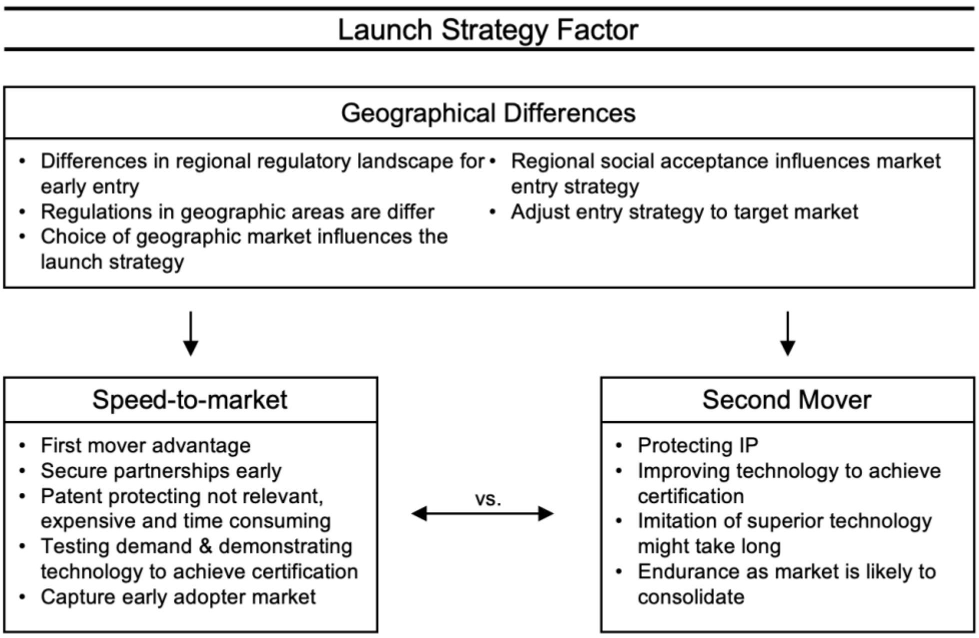

Figure 13: Launch Strategy Factor Variables

In summary, the *Launch Strategy Factor*, which includes the choice of target market and the choice between a *Speed-to-Market* or *Second Mover* strategy, is an important decision for a VTOL manufacturer thus comprising a key factor for future success. *Figure 13* visualizes the factor interrelations and stipulates that the choice of geographic region influences the market entry strategy. Based on the results, a tendency towards *Speed-to-Market* versus *Second Mover* market entry can be observed.

Code	Example
Geographic differences	*"Regions and countries that are more open for new technologies such as US or even Asia, will be the first markets where this type of new transport will be launched." (Interview B)* "*There are some countries like Singapore, or other Asian countries where regulations are not as tight." (Interview F)*
Speed-to-market	"S*peed to market or time to market is more important in this case, especially for startups." (Interview B)* *"I would run to market with something because there will be an early adopter market in some cities." (Interview H)*
Second Mover	*"I think you want to have IP in everything that's critical on you." (Interview E)* *"It might make sense to keep these ideas or inventions secret in the beginning and apply for patent protection." (Interview B)*

Table 10: Quote Examples Launch Strategy Factor

In summary, all of the above factors are perceived essential to consider as a VTOL manufacturer in order to be successful in the emerging UAM market. The subsequent section relates the eight decision factors to each other.

5.2. Interrelations of Decision Factors

The eight factors identified in section *5.1* are each individually of great importance to VTOL manufacturers, however, there are also non-negligible interdependencies among the individual factors. The identified interrelations also stem from the conducted interviews and will be outlined in the following. *Figure 14* illustrates the interrelations of the eight decision factors. For the sake of comprehensibility, each factor has its own depiction. This section serves to illustrate the aforementioned connections in more detail. In principle, it can be noted that there is a great interdependence of the individual factors. The *Regulatory Factor* in particular shows high relevance, as it is interrelated with every of the remaining seven factors.

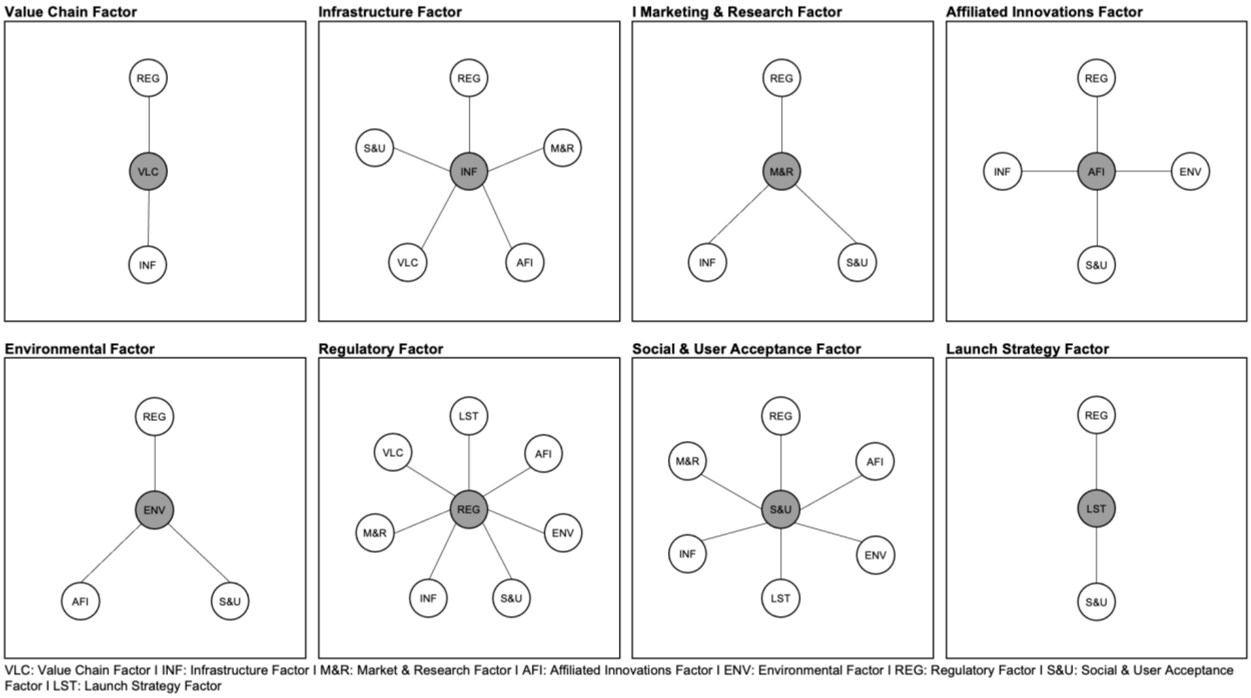

Figure 14: Decision Factor Interrelations (Individual)

With regard to the *Value Chain* Factor, and particularly the *Partnerships & Ecosystem* element, it is argued that entering into strategic partnerships with established, influential firms can help "*push the vehicle through certification"* (Interview M) illustrating the interrelations between the *Value Chain Factor* and the *Regulatory Factor*. By, for example, setting guidelines for components, regulatory authorities can have a further influence on value chain activities. Moreover, partnerships with infrastructure providers demonstrate the link to the *Infrastructure Factor.* It is argued that "*it's important to partner with already existing companies who possess a lot of relevant infrastructure*" (Interview B).

Besides the interrelations with the *Value Chain Factor*, in particular the partnerships element, the *Infrastructure Factor* shows links with four other factors. For one, landing- and charging infrastructure, especially in urban areas, are subject to regulations which are not yet established (*Regulatory Factor*). Additionally, "*every time any piece of aviation infrastructure [is built], it depends on the jurisdiction*" (Interview I). Moreover, "*noise will be a big factor in connection with where they can land*" (Interview I). Therefore, vertiports and ground infrastructure in inner-city locations require social acceptance of the potential disturbances UAM causes (*Social & User Acceptance Factor*). Additionally, research on passenger flows needs to be carried out in order to determine traffic junctions where vertiports can be placed (*Marketing & Research Factor*). What is more, the charging infrastructure is dependent on the innovations of batteries or other energy sources as the charging infrastructure needs to develop accordingly (*Affiliated Innovations Factor*).

As already mentioned above, the *Marketing & Research Factor* shows interrelations with the *Infrastructure Factor* in terms of research on passenger flows and travel behavior. Additionally, the *Marketing & Research Factor* shows two more interactions with other factors. First, engaging in marketing and research activities can raise the profile of an individual manufacturer and increase influence and power in the lobbying process (*Regulatory Factor)*. Second, "*a clear communication strategy addressing the positive as well as the negative aspects*" (Interview C) of the technology can contribute to social acceptance (*Social & User Acceptance Factor*). Moreover, "*focusing on the user from a design perspective*" (Interview M) and therefore actively engaging with the future user can further shape the *Social & User Acceptance Factor.*

The *Affiliated Innovations Factor*, respectively its two main elements *Energy Supply* and *Autonomous Technology*, shows four interrelations with other factors. The *Energy Supply* element has an influence on both the *Environmental* and the *Infrastructure Factor* whereas *Autonomous Technology* is connected to the *Regulatory* as well as the *Social & User Acceptance Factor*. The degree to which current batteries are sustainable is a highly controversial issue. Sustainability will play a major role in the development of new or better batteries or alternative means of propulsion (*Environmental Factor*). Second, as stated earlier, innovations in the energy supply of VTOL vehicles also have an influence on the ground infrastructure, in particular the charging infrastructure. Infrastructure providers will need to adapt their facilities to changes in the energy supply of VTOL vehicles (*Infrastructure Factor*). Autonomous technology, on the other hand, is highly governed by regulations as questions such as liability, responsibility, error-proneness and insurance are still open (Booz, Allen & Hamilton, 2018). Further, the social & user acceptance of autonomous technology, especially the fact that "*autonomous [technology] needs to ensure safety*" (Interview O), adds another variable to the equation.

Likewise, the *Environmental Factor* imposes similar interrelations as the *Affiliated Innovations Factor*. Besides the link to the *Affiliated Innovations Factor* outlined above, it is connected to the *Regulatory Factor* as well as the *Social & User Acceptance Factor*. Regulatory bodies, policymakers, authorities and municipalities will take environmental and sustainability aspects into account when deciding on guidelines and regulations. Moreover, "*scrutinizing on how this technology can be used in a societal and environmental sound way*" (Interview C) as well as the fact that the public is striving for more and more sustainability and "green" modes of transportation is displaying the link to the *Social & User Acceptance Factor.*

As already presented in the preface of this section, the *Regulatory Factor* shows interrelations with all seven other factors. This is mainly due to the fact that UAM, and especially VTOL vehicles are a new technology which require high safety standards and have a strong influence on the public. Regulations can determine the entry strategy of a VTOL manufacturer (*Launch Strategy Factor*), determine the manufacturing process (*Value Chain Factor*), decide where ground infrastructure can be placed (*Infrastructure Factor*), affect the development of new batteries (*Affiliated Innovations Factor*) and set the guidelines for sustainable operations (*Environmental Factor*). At the same time, regulations are needed for the air infrastructure (*Infrastructure Factor*), as well as for the deployment of autonomous technology (*Affiliated Innovations Factor*). Moreover, regulators need to take the *Social & User Acceptance Factor* into account when making decisions and setting directives.

The *Social & User Acceptance Factor* shows interrelations with all but the *Value Chain Factor*. As these interrelations have already been outlined in the above, this part will be kept shorter. In principle, the *Social & User Acceptance Factor* directly influences the *Launch Strategy Factor*, *Infrastructure* Factor, the *Affiliated Innovations Factor* and *Regulatory Factor*. The *Marketing & Research Factor* is interacting with the *Social & User Acceptance Factor* as it aims to influence the public and user perception of the technology. The *Environmental Factor* is closely connected to the *Social & User Acceptance Factor* as a trend towards sustainability in general can be observed throughout societies.

Lastly, as stated in *5.1.8,* the *Launch Strategy Factor* consists of three elements of which the *Geographical Differences* have a major impact on the launch strategy. These *Geographical Differences* are shaped by two variables which can also be found in the identified factors: the regulatory landscape (*5.1.6*) of a region as well as the individual social acceptance (*5.1.7*) in a certain geographical area. Regulations differ from country to country, as well as from region to region. Therefore, a VTOL manufacturer's launch strategy is influenced by the target market regulations. A geographical region's regulatory landscape can either serve as an entry argument ("*regions and countries that are more open for new technologies […] will be the first markets where this type of new transport will be launched*" (Interview B)) or depict a barrier a VTOL manufacturer has to overcome to launch its services. In addition, the social acceptance of a new technology also varies in different regions of the world. As "*western societies are very sensitive to any form of new disruption*" (Interview H), VTOL manufacturers need to take the *Social & User Acceptance Factor* into account when outlining their market entry strategies.

In conclusion, it can be said that the eight identified decision factors show high interrelations between each other. *Figure 15* visualizes the complexity of the interweaving. The *Regulatory Factor* exhibits the most interrelations whereas the *Launch Strategy Factor* and the *Value Chain Factor* show the least interconnections. In essence, it can be stated that there is no independent factor but all factors are intertwined with each other.

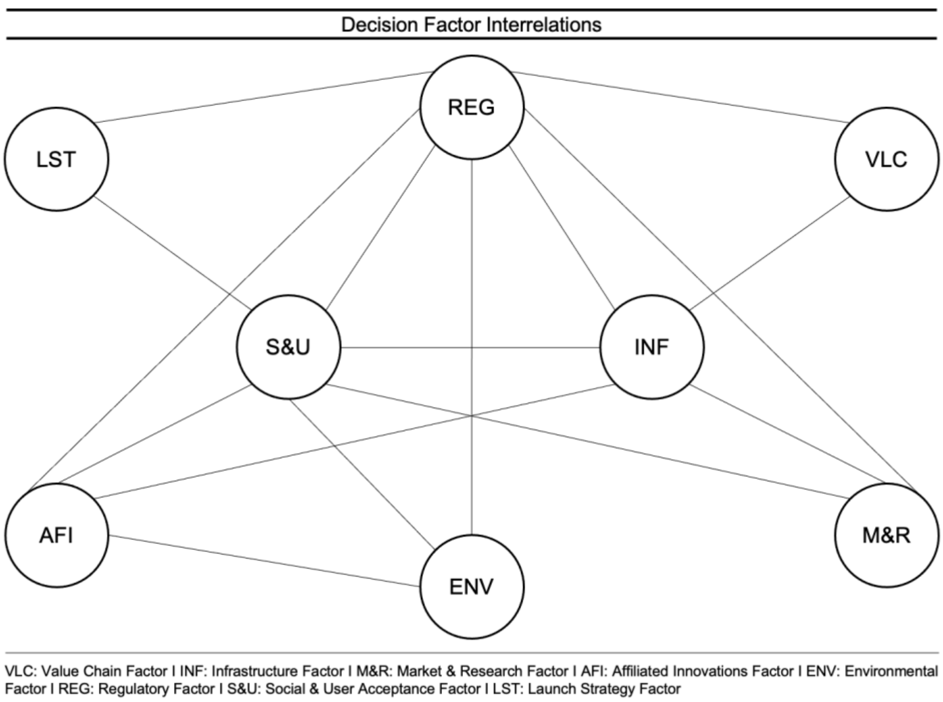

Figure 15: Decision Factor Interrelations (Combined)

5.3. Measures

The interviews identified not only decision factors, but also actions to address the challenges posed by these factors. These are outlined below. *Partnerships & Ecosystem* and *Lobbying* pose measures that influence one specific factor. As these elements have already been discussed in the previous sections, this section solely focuses on the *Use Case* measure which is deemed to influence all decision factors either directly or indirectly (*Figure 16*). 14 out of 16 interviewees argue that *Use Cases* are important for a successful commercial launch of VTOL manufacturers. A total of 48 quotes underpin the relevance of this measure.

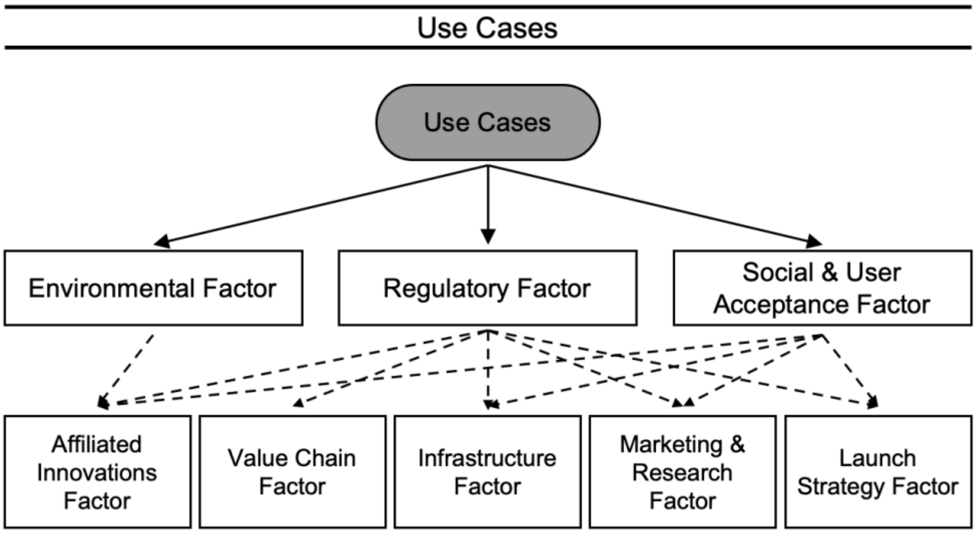

Figure 16: Use Cases Impact

Use Cases are perceived as "*part of a strategy of trying to look at all stakeholders in all possible ways*" (Interview E). Moreover, it is argued that "*there is no way to avoid [use cases]*" (Interview J) and that "*demonstrations are needed for both public and regulatory bodies*" (Interview F). Additionally, *Use Cases* can "*facilitate convincing all different stakeholders [and] politicians*" (Interview J). Moreover, *Use Cases* are needed as "the technological proof needs to be carried out" (Interview M). Performing "*use cases [to show] how sustainability would be achieved*" (Interview C) further emphasizes the impact of *Use Cases* on the decision factors.

In general, *Use Cases* are described as measures which are necessary to showcase the well-functioning technology of a VTOL vehicle to both achieve social and user acceptance but also convince policymakers of the reliability of the vehicle.

The public and regulatory bodies will never rely on well-designed PowerPoint charts only" (Interview F)

Potential applications of *Use Cases* can be demonstration flights, as happened in 2019 when Volocopter tested their vehicle in the Stuttgart area (Spiegel, 2019). Additionally, *Use Cases* in the emergency sector are also discussed. "*Demonstrating that those vehicles are saving lives*" (Interview D) or "*that you can transport an injured person to the hospital super-fast*" (Interview C) can contribute to the social acceptance of the technology. In particular, *Use Cases* at various air rescue providers or the ADAC (Europe's largest automobile club) are outlined. Furthermore, a "*military use case*" (Interview P) was also discussed. As depicted in *Figure 16*, *Use Cases* have a direct influence on three of the eight decision factors which, in turn influence the remaining five factors. This two level influence is justified by the interrelations outlined in section *5.2*.

In summary, *Use Cases* are seen as an important instrument for achieving social acceptance, proving the technology and its reliability, as well as an accelerator for certification and regulation. Therefore, *Use Cases* can be utilized as a tool to overcome the potential challenges posed by the decision factors.

6. Analysis

In the following, the above identified decision factors, which are perceived as important to deal with the uncertainty in the market and to be successful in the emerging UAM market, will be juxtaposed in opposition to, first, the industry literature outlined in section *3.1* and second, to the strategy innovation literature delineated in section *3.3*. In this regard, a theoretical framework for high-technology, innovation driven and undefined markets is established. In a next step, implications for both innovation strategy and UAM strategy are derived. Lastly, recommendations for VTOL manufacturers are discussed.

6.1. Extending UAM Industry Literature

Existing UAM literature, as outlined in section *3.1*, identifies five aspects which are perceived as important to cope with as a VTOL manufacturer. In the following, these will be compared to the in section *5.1* identified factors. *Figure 17* illustrates the juxtaposition.

Academic scholars emphasize the importance of the *Vehicle Technology* for successful implementation of an UAM service. In particular, range, seat capacity, cruise speed, hover efficiency, cruise efficiency, maintenance costs and direct operating costs are argued as the main requirements for the UAM vehicle design (Straubinger et al., 2020). Additionally, questions on the overall vehicle design, thrust and propulsion, and power distribution are perceived to be of high importance. Since this research focuses on the VTOL manufacturer itself and the factors that influence successful future deployment and operation, the specific technological composition of the vehicle is not subject of this research and will therefore not be discussed further. As a result, the *Vehicle Technology* element identified in section *3.1* cannot be related to one of the identified decision factors in section *5.1*, however, great importance is attached to vehicle design and technology and is regarded as a basic prerequisite. Nevertheless, some indirect similarities can be drawn. For one, the above described *Noise* and *Safety* elements of the *Social & User Acceptance Factor* have an influence on the vehicle technology. For another, the vehicle's design and technology needs to be certificated and therefore links to the *Regulatory Factor.*

Next, the *Regulatory Aspects* raised by literature and outlined in section *3.1* states that there is no legal framework yet and, secondly, there is no vehicle certification available. In tandem with the legal framework, the certification process is believed to be a major hurdle to the commencement of commercial operations (Straubinger et al., 2020). In addition, the certification process demands that airspace authorities such as the FAA and EASA set standards for vehicle technology, infrastructure and service operations. This argumentation is also mirrored in the above identified *Regulatory Factor*. Furthermore, the *Regulatory Factor* extends the aspects outlined in section *3.1* by the elements *Standardization* and *Lobbying*.

Another aspect mentioned in the UAM literature that is echoed in the decision factors is represented by the *Infrastructure Requirements* that reflect the *Infrastructure Factor.*

Scholars point out that the development of ground infrastructure and traffic management systems is needed. Furthermore, potential infrastructure placement opportunities are outlined and the importance of intermodal connectivity within other modes of transportation is addressed. Moreover, the required standardization of vertiports is stated. Similar to the decision factor interrelations of the *Infrastructure Factor* and the *Regulatory Factor*, this shows the intertwining of *Infrastructure Requirements* with *Regulatory Aspects* as standardization tangents both elements. Moreover, the requirement of air traffic management systems is stated both in UAM literature as well as within the *Infrastructure Factor*. Therefore, *Infrastructure Requirements,* as argued by literature, coincide with the *Infrastructure Factor* identified in section *5.1.2*.

The *Operational Aspects* stipulated by literature observe two facets: first, based on the decision of whether to conduct an intra-urban or intra-city service, a distinction is made as to where the emphasis is on commuting or take-off and landing infrastructure. Second, the various UAM submarkets, their interconnectivity and integration were conceptualized (Straubinger et al., 2020). The authors predict that the following ten types of market players will be present in the UAM market: vehicle manufacturers, vehicle operators, platform providers, service providers, ground infrastructure providers, maintenance and repair providers, insurance providers, communication infrastructure providers and UTM providers. However, it is stated that so far only little research has been conducted on *Operational Aspects* as well as market actors. The *Operational Aspects* identified by the literature can be collated to a sub-category of the *Value Chain Factor*, namely the *Service & Operations* element. Whereas it has so far not been stated who will be the operator of the VTOL vehicles in the UAM market, it is apparent from the above that it is perceived that the VTOL manufacturers themselves will act the vehicle operators and the service providers. Further, the *Value Chain Factor* delineates *Sourcing & Manufacturing* and *Partnerships & Ecosystem* as elements not stated in the literature.

In contrast to the *Social & User Acceptance Factor* identified in section *5.1.7*, the *Public Perception & Adoption* outlined in section *3.1* also includes the environmental aspect of UAM. This was separated within the decision factors as an importance of the independent character of the *Environmental Factor* was recognized. However, the different aspects on *Public Perception & Adoption* elaborated throughout the UAM literature coincides in large parts with the *Social & User Acceptance Factor* outlined in *5.1.7.* For one, literature argues that noise, safety and privacy are the most prevalent elements within *Public Perception & Adoption*. For another, literature recognizes the separation of social acceptance and user acceptance which has also been identified within this research.

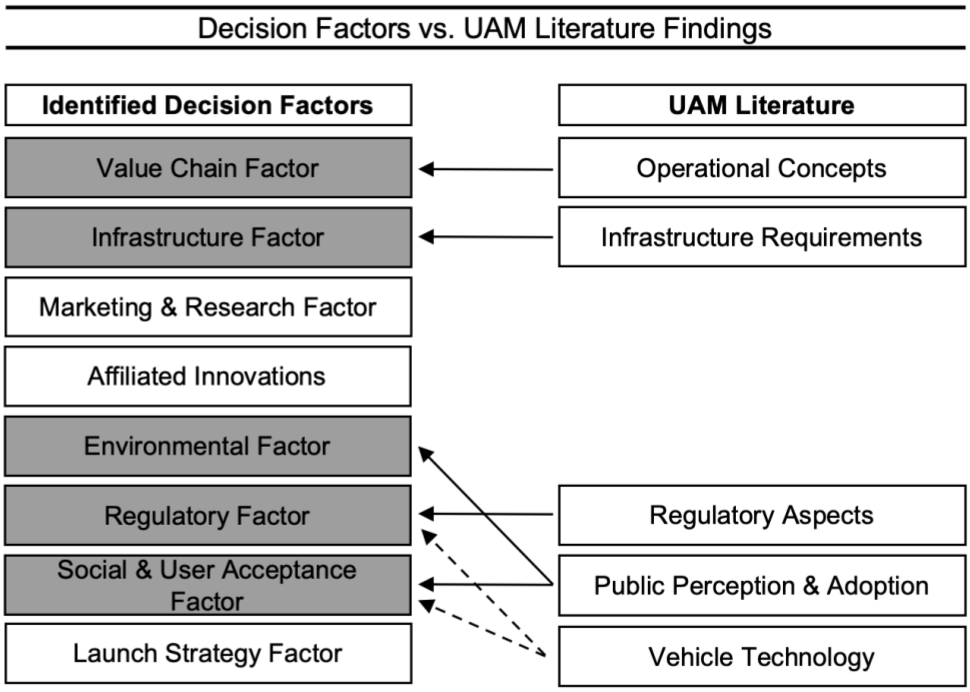

Figure 17: Decision Factors vs. UAM Literature Findings

As illustrated in *Figure 17*, only five of the eight decision factors can be associated with the findings from the UAM literature. Therefore, this research contributes to current UAM literature findings regarding the problematic aspects identified by Kellermann et al. (2020) by both extending already existing findings as well appending new aspects, namely the *Marketing & Research Factor*, the *Affiliated Innovations Factor* and the *Launch Strategy Factor.* Elements of these factors have already been mentioned in parts of the existing literature, but have not yet been consolidated as such.

6.2. Extending Innovation Strategy Literature

As elaborated in section *3.3*, innovation strategy, particularly the PFI framework, serves as the basic theoretical framework for this research. Teece's (1986) PFI framework consists of three main elements, namely the *Appropriability Regime*, the *Market Evolution/Dominant Design* and *Complementary Assets*. Further, Teece argues that, based on the nature of the appropriability regime and the availability of *Complementary Assets*, a firm can either engage in an integration or outsourcing strategy. Teece (2006) extends the elements by the variable *Complementary Innovations* as he argues that the importance of adjacent technologies have become more apparent since the introduction of the PFI framework. In the following, the above identified decision factors will be classified alongside the extended PFI framework. First, the *Appropriability Regime* is outlined. Second, the *Market Evolution/Dominant Design* stage is be sketched. Next, the *Complementary Assets* and *Complementary Innovations* are displayed. Finally, the framework is extended by additional elements identified throughout this research.

6.2.1. Appropriability

The *Appropriability Regime* refers to the extent to which the innovation can be imitated and therefore sheds light on the nature of the technology and the ability to protect its intellectual property. A tight *Appropriability Regime* indicates an environment in which the innovation is easy to protect, while a weak *Appropriability Regime* represents an environment in which the technology is easy to imitate and therefore difficult to protect (Teece, 1986). As argued by the author, tight *Appropriability Regimes* are the exception rather than the rule. Even though the UAM industry is classified as a high-technology market, it is claimed that the technology of VTOL manufacturers is hard to protect and "*IP protection is not very relevant*" (Interview B). Moreover, "*patenting is getting expensive really quick*" (Interview D) and many patents can be reinvented at modest cost (Mansfield et al., 1981). Therefore, the *Appropriability Regime* for VTOL manufacturers can be classified as weak.

6.2.2. Market Evolution/Dominant Design

As argued by Abernathy and Utterback (1978) and echoed by Teece (1986), product design is oftentimes the basis for competition in the early phases of an industry. Gradually, one dominant design, or a narrow class of designs, asserts itself and begins to command the market. In this stage, uncertainty prevails and innovators must be prepared with considerable financial resources. As outlined in section *3.3.2*, the industry can be either in a preparadigmatic or paradigmatic stage. Innovators in weak *Appropriability Regimes* engaged in the preparadigmatic stage should be tied to the market so that user needs can fully affect the design. The influence of the decision factors on this matter will be elaborated in section *6.3.1*. Nevertheless, an assessment of the stage of the UAM industry can be made based on the interviews. It has been widely argued that no dominant design has yet emerged throughout the UAM industry. In particular, "*there is no dominant design yet and the different vehicles of the different manufacturers look different*" (Interview M). Further, the current design stage "*may be [broken] down to five to six archetypes and it will become apparent which one is the most technically feasible one and will conquer the market*" (Interview G). Moreover, it has been argued that in the current market stage sufficient funding is seen as a vital tool to overcome the prevailing uncertainty. "*Getting capital is critical*" (Interview E) as "*securing funding [is needed] to realize the product*" (Interview G). This is in line with Abernathy and Utterback (1978) as well as Teece (1986) argumentation that in an industry where no dominant design has emerged, considerable financial resources are needed.

6.2.3. Complementarity

As argued by Teece, successful commercialization of an innovation almost always requires that technical knowledge be used in conjunction with other assets or capabilities such as marketing, manufacturing, after-sales service, distribution and software (Teece, 1986). These can be generic, co-specialized or specialized. A detailed description of the different types can be found in section *3.3.2*. *Figure 2* schematically displays the *Complementary Assets* surrounding an innovation. At the center of the innovation lies the core technological know-how. As argued earlier, this research focuses on the VTOL manufacturer itself and the factors that influence successful future use and operation. Therefore, the technology of the vehicle is taken as given. As noted above, Teece (2006) extends the complementarity of the PFI framework by *Complementary Innovations*. *Figure 18* visualizes the extension. As with *Figure 2*, the entries serve as examples and can be removed or extended depending on the firm in question. Here, the complementarity "circle" surrounding the core is split into two parts, namely *Complementary Assets* and *Complementary Innovations*. As argued by the author, adding *Complementary Innovations* were treated as just another *Complementary Asset*. However, it became evident that affiliated technologies and other *Complementary Innovations* play a significant role today and are therefore being extracted from the *Complementary Assets* and presented as a separate element of complementarity.

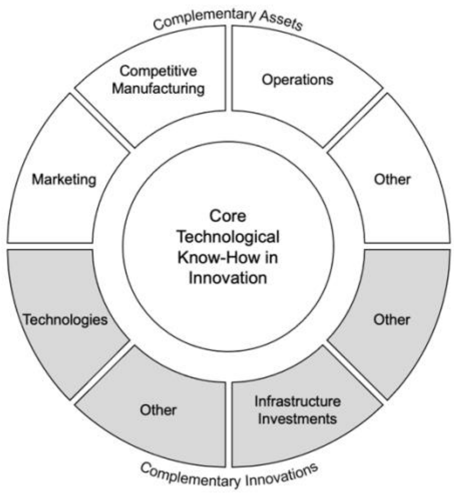

Figure 18: Amended Complementary Asset Framework (Own illustration)

The *Value Chain Factor* and the *Marketing & Research Factor* can be classified as *Complementary Assets* whereas the *Infrastructure Factor* and the *Affiliated Innovations Factor* can be classified as *Complementary Innovations*.

Complementary Assets

The *Value Chain Factor* comprises of the three elements *Sourcing & Manufacturing*, *Service & Operations* and *Partnerships* (*5.1.7*). *Sourcing & Manufacturing* stipulates a classic complementary asset needed to commercialize an innovation. For one, a firm needs to source components for the product/service it is offering. For another, these resources need to be transformed into a finished product/service requiring manufacturing capabilities. Whether these assets are generic, co-specialized or specialized depends on the firm and industry in question. In the case of VTOL manufacturers, it is argued that UAM startups in particular have limited knowledge of manufacturing and mass production and therefore rely on others to execute the assembly of their vehicles. Teece (1986) argues that if the technology is not tightly protected, specialized manufacturing assets are likely to become bottlenecks. For VTOL manufacturers operating in a high-technology market, manufacturing might prove to be more sophisticated and requires deep knowledge. Therefore, *Sourcing & Manufacturing* can be classified as a specialized asset.

Service & Operations display another *Complementary Asset* needed to commercialize a product or service. Having a fully-fledged manufacturing site doesn't help if a firm cannot operate the product or carry out the service. The firm also needs to make sure that their product is being operated or the service is being performed. In the case of VTOL manufacturers, *Service & Operations* refers to the operation of the vehicle as well as the service offering to users. This entails both the physical operations of the vehicles (e.g. flying the vehicle) as well as the service offerings towards customers such as a booking platform or services indirectly connected with the operations (in-flight services, etc.). *Service & Operations* can be classified as specialized as it requires a high level of expertise and technological knowhow to operate VTOL vehicles. *Service & Operations* are argued as crucial for the commercial success of a VTOL manufacturer and can therefore be classified as a *Complementary Asset*.

The third element of the *Value Chain Factor*, namely *Partnerships & Ecosystem*, is not classified as a *Complementary Asset* but is of high importance in accessing the assets. This will be outlined in the subsequent section *6.3.*

Secondly, the *Marketing & Research Factor (5.1.3)* also depicts a *Complementary Asset*. Teece states that "*services such as marketing are almost always needed*" (Teece, 1986, p. 288). Likewise to the above, a well-working manufacturing infrastructure as well as well-designed operations and service offerings do not lead to successful commercialization if the product or service is not marketed towards users and if the demand is not explored. Therefore, marketing and research represent assets which are crucial for commercial success. Within the UAM industry, both, marketing and research, are needed to, for one, market the service and operations of VTOL vehicles, communicate the various aspects and thus creating transparency and for another, to identify passenger movements, travel behaviors, social acceptance which, in turn leads to a better planning horizon for VTOL manufacturers. Therefore, the *Marketing & Research Factor* can be classified as a specialized asset as specific knowledge is needed.

Complementary Innovations

The *Infrastructure Factor* as well as the *Affiliated Innovations Factor* are classified as *Complementary Innovations* according to Teece's (2006) amendment to the framework. This particularly applies for high-technology industries as the R&D activities and requirements for additional technology is comparatively larger in these industries (OECD, 2015). Teece (2006) states that innovations require complementary infrastructure investments such as roads and service stations for cars but also complementary technologies such as better batteries to compete with internal combustion engines. This justifies the classification of the *Infrastructure-* as well as the *Affiliated Innovations Factor* as *Complementary Innovations*.

The *Infrastructure Factor* encompasses *Charging-, Landing-* and *Air Infrastructure* (*5.1.2*). It is claimed that all three are needed for a successful commercialization of a VTOL vehicle. However, VTOL manufacturers have only limited influence on these developments and are somewhat dependent on the development of the required complementary infrastructure. The three types of required infrastructure (*Charging, Landing-* and *Air Infrastructure*) display co-specialized assets: on one hand, VTOL manufacturers require ground- and air infrastructure for their vehicles to operate, on the other hand, the infrastructure needed for VTOL vehicles constitutes a new type of infrastructure which is solely developed for UAM VTOL operations and is therefore reliant on the VTOL manufacturer. In essence, ground and air infrastructure poses a *Complementary Innovation* to VTOL manufacturers.

Another *Complementary Innovation* is portrayed by the *Affiliated Innovations Factor* (*5.1.4*). This factor embodies two elements: the *Energy Supply* as well as *Autonomous Technology*. Both are argued has vital to VTOL manufacturers. Following the definition of Teece (2006), these two can as well be classified as *Complementary Innovations*.

Teece's example of the need for better batteries for carmakers also applies for VTOL manufacturers. The development of better, lighter, denser and more eco-friendly batteries is deemed as a critical part for VTOL manufacturers. Current batteries are claimed as not powerful enough to meet the range expectations of VTOL manufacturers. This can be classified as a specialized asset as the manufacturer is highly reliant on these developments, however, the developer of batteries or other energy sources is not dependent on the VTOL manufacturer. Therefore, innovations in energy supply is needed for successful commercialization displaying a specialized *Complementary Innovation* for VTOL manufacturers.

The second element within the *Affiliated Innovations Factor* is represented by *Autonomous Technology*. Although this is not considered as urgent as better batteries, it is nevertheless an important element that VTOL manufacturers will have to consider in the future to offer a commercially sustainable service. Additionally, it is unlikely that the manufacturers themselves will develop the technology for autonomous flying and are therefore dependent on developers of autonomous technology. Here, the classification into either specialized or co-specialized is hard to conduct as the specifications for autonomous flying technology are not yet established and can therefore not be compared to, i.e. autonomous driving technology. Nevertheless, *Autonomous Technology* further stipulates a *Complementary Innovation* needed by VTOL manufacturers, especially in the long term.

It should be noted that not all of the eight decision factors identified in section *5.1* have been mapped to the PFI framework. Here, this research builds on an extends the PFI framework by an additional outer layer. This can be justified by three findings. For one, three of the remaining decision factors, namely the *Environmental Factor*, the *Regulatory Factor,* and the *Social & User Acceptance Factor* have been perceived as highly important to future commercial success. For another, Teece (2006) emphasizes that future research could extend the framework by a second circle enveloping the first entailing further aspects than complementary assets. Finally, Teece's framework assumes that "*the firm has developed an innovation for which a market exists*" (Teece, 1986, p. 300). Even though the UAM industry can be classified as an extension of the mobility market and niche helicopter services are available, it can still be argued that there is not yet an existing market for the operation of VTOL vehicles necessitating additional considerations. This is also widely confirmed by the interviewees: "*there is no market*" (Interview C); "*the industry is not there yet*" (Interview O); *"[the market is] very much uncertain*" (Interview D); "*[the market] it still needs a lot of time*" (Interview B); "*at the current stage, [the market] doesn't exist yet and it is really only guestimates*" (Interview D); "*[there is] a lot of uncertainty in the market*" (Interview M); "*[the] market [is] at the very beginning of its development*" (Interview K); "*it's a completely new mode of transport*" (Interview N).

The subsequent section adds another layer to the PFI framework that addresses the peripheric sphere entailing external influences and factors.

6.2.4. Peripheric Sphere

The three decision factors *Environmental Factor*, *Regulatory Factor* and the *Social & User Acceptance Factor* are classified as *Peripheric Sphere* elements. *Figure 19* illustrates the extended PFI framework. *Peripheric Sphere* elements are defined as external factors which have a direct influence on the successful commercialization but cannot be acquired or held by the innovator. The impact of the *Peripheric Sphere* elements can be either favorable or unfavorable towards the commercial success of the innovator. This contrasts with the *Complementary Assets* and *Innovations* as *Peripheric Sphere* elements are not tangible assets and are therefore not directly linked to the technological innovation. However, as it emerged throughout the analysis of the UAM industry, these elements play a crucial role in commercializing an innovator's product or service. It should be noted that the *Peripheric Sphere* identified stems from the analysis of the UAM industry and therefore displays considerations for high-technology mobility industries and undefined market environments. Other elements could be added or removed depending on the innovation and industry in question. This is also exemplified by the "Other" element in *Figure 19*. The different elements will be outlined in greater detail in the following.

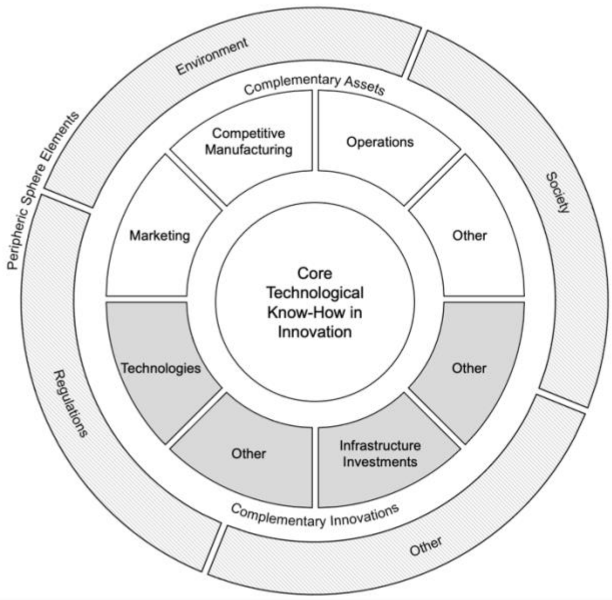

Figure 19: Extended PFI framework (Own illustration)

The *Environmental Factor* is classified as a *Peripheric Sphere* element in that it describes the expectations of social and sustainable impacts associated with the manufacturing and operation of the vehicles and their components. It therefore does not directly influence the innovation but the commercialization of the product or service. Environmental and sustainability aspects are playing an increasingly important role, especially in today's world. Lüdeke-Freund (2020) argues that sustainability-specific barriers can prevent an innovation from being commercially successful. In addition, sustainability is a key factor in the adoption of innovations (Kim & Mauborgne, 2000). In the case of VTOL manufacturers, the general perception of the aviation industry's sustainability is relatively poor, so achieving environmental friendliness in particular has become a strategic issue within the industry (Capgemini, 2020). It is argued that VTOL manufacturers should not just only build their vehicle in a sustainable way but also contribute to solving environmental problems and become part of the solution. The *Environmental Factor* represents an intangible variable which cannot be acquired but is directly influencing future success of the technology that innovators must take into account. The *Environmental Factor* can be seen as favorable towards the innovator as it poses an opportunity for VTOL manufacturers to seize momentum of the sustainability movements and turn it in their favor. Hence, it can be classified as a *Peripheric Sphere* element.

The *Regulatory Factor* can also be qualified as a *Peripheric Sphere* element. The regulatory landscape surrounding an innovation defines how and in what way the product is designed and under what conditions the service can be carried out. As argued by Blind (2012), regulations and regulatory frameworks generate various impacts and have been identified as important factors influencing innovation. Moreover, the authors emphasize the external nature of regulations. The *Regulatory Factor* is of intangible character and cannot be acquired by the innovator. Nevertheless, it ultimately rules over future success as guidelines and regulations define the boundaries of the innovation. Within the UAM industry, regulations are seen as crucial as they define whether a VTOL vehicle is being certified or not. Furthermore, regulatory bodies, policymakers and municipalities set the guidelines for operations, landing- and take off as well as overflight rights and are therefore vital for a successful commercialization of VTOL operations. The *Regulatory Factor* can be classified as unfavorable as there are no regulations for UAM operations at this point in time. Furthermore, the certification processes for aviation vehicles are lengthy and costly. However, regulatory authorities and policymakers are introducing initial regulatory frameworks and municipalities are setting up task forces dealing with UAM initiatives. Hence, movements towards a favorable regulatory landscape can be observed.

Lastly, the *Social & User Acceptance Factor* likewise incorporates the attributes of *Peripheric Sphere* elements. As claimed by Niehaves et al. (2012), the success of new technologies is heavily reliant on social factors. Further, Graf-Vlachy et al. (2018) argue that social influence affects technology acceptance. In general, the social and user acceptance of a technology is seen as an outside factor influencing the commercialization of an innovation. No matter how sophisticated, technologically advanced, sustainable or regulatory-approved an innovation or new technology is, it still requires public acceptance and user adoption to be commercially successful. Social and user acceptance is hard to predict making it one of the most critical factors towards innovators. It cannot be internalized or acquired and requires effort to influence. Nevertheless, social and user acceptance poses a vital element of future success. The *Social & User Acceptance Factor* can be considered as unfavorable due to the prevalence of various issues in the public perception of UAM operation such as noise emissions, safety issues, and privacy concerns. The above justifies classifying the *Social & User Acceptance Factor* as a *Peripheric Sphere* element as it is intangible, external and not directly linked to the technology.

The foregoing exemplifies the extended PFI framework (*Figure 19*) based on VTOL manufacturers and the UAM industry. The *Peripheric Sphere* displays an extension to the Teece's PFI framework adding an "outside layer" which takes external factors influencing commercial success into account. These can be either favorable or unfavorable to the innovator and hence towards the commercial success of the innovation. The extension is based on three pillars. For one, this research identified a research gap in the prevailing innovation strategy literature which is filled by combining the PFI framework with external factors. For another, current innovation strategy literature focuses on existing markets while this research addresses an undefined market. Lastly, the findings gathered throughout this research strengthen the assumption that the PFI framework needs to be extended by an outside layer, especially for high-technology industries. In the case of the UAM industry, the *Environmental*- the *Regulatory*- and the *Social & User Acceptance Factor* were identified as *Peripheric* elements.

6.3. Implications for Strategy

In the following, implications for both innovation strategy as well as UAM strategy are derived. It should be noted that the implications for strategy are derived from the analysis of a high-technology mobility industry with an undefined market environment. Therefore, the generalizability of the identified *Peripheric Sphere* is in need of additional validation and should be tested for robustness and therefore requires further research.

6.3.1. Implications for Innovation Strategy

Teece (1986) argues that the combination of the *Appropriability Regime*, the *Dominant Design* stage as well as the *Complementarity* define an innovator's strategy. Depending on the composition, an innovator can engage in integration, contracting or a mixed modes approach to access *Complementary Assets* or *Innovations* (Teece, 2006). The author argues that in reality the extremes, i.e. full integration or outsourcing, are unlikely and that the latter (mixed modes) seem to be the most common. This assumption is also echoed by Rothaermel et al. (2006). As already discussed in section *3.3.3*, various scholars refined the Teecian elucidation on strategy implications. Here, influences such high-technological change and uncertainty (Afuah, 2001) are introduced as elements affecting the strategic orientation. Afuah (2001) argues that in environments with high technological change, companies are better off without vertical integration. However, when there is high uncertainty, vertical integration can be beneficial. Rothaermel et al. (2006) claim that a simultaneous pursuit of vertical integration and strategic outsourcing contributes to a firm's competitive advantage and thus to its overall performance. What is more, Gans et al. (2018) argue that the nature of the *Appropriability Regime* can determine whether an innovator should follow a speed-to-market strategy (weak appropriability) or keep control over the technology and move second (tight appropriability). Additionally, Jacobides et al. (2006) claim that establishing industry architectures can further contribute to an innovator's competitive advantage.

In brief, the *Appropriability Regime* can define an innovator's market entry strategy while the nature of complementary assets (hence affected by the *Appropriability Regime* and the *Market Evolution/Dominant Design*) define which assets can be accessed through integration and which assets can be accessed through contracting (outsourcing).

This research adds a new variable to the equation by introducing the *Peripheric Sphere* as a further consideration innovators have to take into account. As a matter of fact, the *Peripheric Sphere* affects both the *Market Evolution/Dominant Design* as well as the decision on whether to integrate or contract for *Complementary Assets* or *Innovations*. Moreover, the nature of the *Peripheric Sphere* can give implications towards the market entry strategy of the innovation.

As articulated in section *6.2.2*, innovators in weak *Appropriability Regimes* that appear to be in the preparadigmatic phase should be closely tied to the market. For one, this is due to the fact that by being close to the market the user needs can be captured and incorporated into the design. For another, proximity to the market can also mean proximity to the legislators, i.e. to those who set the regulatory guidelines for the design. This entails that the innovator can, on the one hand, suggest his design to the policymakers and, on the other hand, is close to the legislation and can thus implement guidelines more quickly. Thereby, this can give the innovator an advantage in the development of the dominant design. Here, the nature of the *Peripheric Sphere* can influence to what degree the innovator can take advantage from being close to the market. If the *Peripheric Sphere* elements, such as the *Regulatory Factor* or the *Social & User Acceptance Factor* are unfavorable, it can be more difficult for the innovator to gain from the closeness to the market which, in turn can influence the outcome of the dominant design.

Furthermore, as outlined in section *5.2*, the identified decision factors show high interrelations. In particular, those classified as *Peripheric Sphere* elements (i.e. the *Environmental-,* the *Regulatory*, and the *Social & User Acceptance Factor*) show particularly high levels of correlation. Hence, by influencing those factors that have been classified as *Complementary Assets/Innovations*, the *Peripheric Sphere* elements indirectly influence the decision which assets should be integrated and for which the innovator should engage in contracting to grant access. Exemplary, the *Social & User Acceptance Factor* (*Peripheric Sphere* element) has an effect on the *Marketing & Research Factor* (*Complementary Asset*) in the way that to overcome trust and safety issues (see *5.1.7*), the innovator can conduct and internalize marketing activities to show and prove that its innovation is trustworthy and safe. Generally speaking, if a *Peripheric Sphere* element is perceived as unfavorable and its nature influences a *Complementary Asset/Innovation*, the innovator can counteract by either integrating or contracting the complementarity in question which, in turn can make the *Peripheric Sphere* element favorable.

What is more, the *Peripheric Sphere* also shows an effect on the market entry strategies an innovator can employ. As stated above, the market entry strategy can be derived from the appropriability regime (Gans et al., 2018). However, as discovered throughout this research, the variables identified as *Peripheric Sphere* elements do also influence an innovator's market entry strategy. Under the assumption that an innovator's *Appropriability Regime* is weak and it has managed to access *Complementary Assets* and *Innovations* by either integrating or contracting, according to Teece (1986) and Gans et al. (2018), he should engage in a speed-to-market strategy. However, if the *Peripheric Sphere* proves to be unfavorable, the innovator would not be commercially successful because, for example, the social acceptance of the technology and/or the regulatory landscape are unfavorable and prevent successful adoption of the innovation. (i.e. the public does not accept the technology/policymakers have not approved the technology).

As already mentioned, the above stems from the analysis of the UAM industry from a VTOL manufacturer's point of view. This displays a narrow industry focus, however, it can be assumed that transferability to other non-existent high-tech markets as well as adjacent markets and industries facing the same challenges as those identified for UAM is possible. Nevertheless, a validation of this assumption is not possible. Here, further research and testing needs to be carried out in order to prove that the above described implications for innovation strategy can be generalized towards other industries.

6.3.2. Implications for UAM Strategy

The subsequent section is intended to apply the aforementioned implications for innovation strategy to the UAM industry, specifically to VTOL manufacturers. To this end, the findings from this research are linked to strategic innovation theory, from which implications for the UAM industry can be derived. Ultimately, recommendations for the strategic orientation for VTOL manufacturers are outlined in section *6.3.3*.

Appropriability

The *Appropriability Regime* of VTOL manufacturers is perceived to be rather weak. Within a weak *Appropriability Regime*, the technology is hard to protect. This is justified by the identified argumentation of interviewees who claim that the technology of VTOL manufacturers is hard to protect and "*IP protection is not very relevant*" (Interview B). Moreover, "*patenting is getting expensive really quick*" (Interview D). This assumption is also backed by theory as weak appropriability regimes are the norm for most industries. Following the argument of Gans et al. (2018), a weak *Appropriability Regime* suggest a speed-to-market strategy. This is where the *Launch Strategy Factor* comes into play. The *Launch Strategy Factor* is the only factor that does not fit into either *Complementary Assets/Innovations* or the *Peripheric Sphere*. However, it implies important concepts and assumptions for the market entry of VTOL manufacturers.

As outlined in section *5.1.8*, the *Launch Strategy Factor* comprises of two potential market entry strategies which are both influenced by the third element of the factor, namely the *Geographical Differences*. The interviewees argue that either a *Speed-to-Market* strategy or a *Second Mover* strategy can prove commercially successful. If one follows the frequency of the statements, the *Speed-to-Market* approach prevails over the *Second Mover* strategy. However, as already mentioned in section *5.1.8*, the *Geographical Differences* shape the choice of strategy. Some regions prove to be more ready towards VTOL operations than others. In these regions, a *Speed-to-Market* strategy can prove prosperous. Here, the factor interrelations outlined in section *5.2* come into effect. As argued, the *Launch Strategy Factor* is interrelated with the *Regulatory Factor* as well as the *Social & User Acceptance Factor*. More precisely, the factors shape the *Geographic Differences* element of the *Launch Strategy Factor*.

As the two factors are classified as *Peripheric Sphere* elements, it can be stated that the market entry strategy of a VTOL manufacturer is influenced by the nature of the *Peripheric Sphere*. In the case of VTOL manufacturers, the *Peripheric Sphere* elements influencing the *Launch Strategy Factor* are perceived as unfavorable for a fast market entry which, in turn results in a contradicting argument. On the one side, the interviewees favor a *Speed-to-Market* strategy, while at the same time the unfavorable *Peripheric Sphere* element contradict this argument as these factors should be favorable before entering into the market.

The nature of the *Appropriability Regime* also affects the *Complementary Assets* and *Complementary Innovations*. Within a weak appropriability regime, access to complements plays a crucial role (Teece, 1986). In the following, the *Market Evolution/Dominant Design* implications followed by the implications on VTOL manufacturer specific *Complementary Assets* and *Innovations* will be discussed.

Market Evolution/Dominant Design

As elaborated in section *6.2.2*, the stage of UAM industry can be classified as preparadigmatic where no dominant design has emerged. This notion has been widely echoed by the interviewees. It has been claimed that both, no market for UAM operations is existent and also that there has not emerged a dominant design yet. In this stage, high uncertainty about the dominant design prevails. As an innovator, proximity to the market can prove useful, as user needs can be more quickly incorporated into an innovator's design, but it can also provide greater influence on regulators and policymakers. However, as noted by Teece (1986), in industries where the technology is fairly easy to imitate as well as where high development and prototyping costs and thus significant irreversibility prevails, the probability that the innovator will succeed after the preparadigmatic stage is expected to be low.

Complementarity

As illustrated in *Figure 18*, *Complementary Assets* and *Complementary Innovations* surround the core technology of an innovation. Both are critical to commercial success and can be classified as either generic, specialized, or co-specialized. The nature of the assets as well as the innovator’s position towards these assets defines whether the innovator should integrate the asset or innovation in question or whether it should outsource it. In the case of the UAM industry, the decision factors *Value Chain* and *Marketing & Research* and their respective elements have been identified as *Complementary Assets*. The elements of the *Infrastructure Factor* as well as of the *Affiliated Innovations Factor* are classified as *Complementary Innovations*.

Within the *Value Chain Factor*, the two elements *Sourcing & Manufacturing* and *Service & Operations* serve as *Complementary Assets*. Both can be classified as specialized assets: the capabilities needed to manufacture a VTOL vehicle are perceived as complex and special knowledge is required. As argued by Teece (1986), in industries with weak appropriability, specialized manufacturing often becomes the bottleneck. Whether the innovator should integrate or outsource *Sourcing & Manufacturing* is also dependent on the innovator itself. It was stated earlier that both established aircraft manufacturers such as Airbus or big car manufacturers such as Hyundai engage in the UAM industry. In terms of manufacturing, these enterprises have a superior position over small VTOL startups. For these firms, integrating manufacturing of VTOL vehicles can prove useful whereas startups are better of engaging in outsourcing and partnering with firms with high manufacturing knowledge.

The element of *Service & Operations* is also classified as a specialized asset. It is argued that operating a VTOL vehicles requires deep knowledge about the technology. Moreover, almost all interviewees claim that *Service & Operations* are of utmost importance for commercial success as they see the highest profit opportunity in the operations of the service. Additionally, it is also argued that the VTOL manufacturer will most likely also be the operator of the service hence implicating that the innovator will integrate this asset. This is also backed by theory as it is stated that specialized assets critical for success where capital expenditures are reasonable should be integrated (Teece, 1986). Furthermore, Teece argues that integrating *Complementary Assets* needed for commercial success can create spillover benefits arising from the increased demand for the *Complementary Asset* which further strengthens the argument that *Service & Operations* should be integrated.

Second, the *Marketing & Research Factor* is also classified as a *Complementary Asset* for VTOL manufacturers. As stated by Teece (1986), marketing is almost always needed for the successful commercialization of an innovation. The *Marketing & Research Factor* comprises of the two elements *Marketing & Communication* and *Research*. Both are classified as specialized assets as they need to be tailored to the innovation. *Marketing & Communication* is needed to position the brand in the market, communicate the advantages of the technology but also address issues such as safety or noise. Research is needed to forecast demand as well as identify social acceptance issues. Whether these elements should be integrated or outsourced is again dependent on the innovator in question. Similar to the above, manufacturers such as Airbus or Hyundai have the capabilities and financial power to enroll large marketing campaigns and also engage in extensive research activities. Smaller VTOL manufacturers might be able to pull of branding and marketing activities, however, research is oftentimes considered to be conducted by a third party. Therefore, integration or outsourcing of these actives is dependent on the innovator.

As within the nature of high-technology markets, the requirements for additional technology within the UAM industry is large. This research identified two critical *Complementary Innovations* for VTOL manufacturers, namely the *Infrastructure Factor* and *Affiliated Innovation Factor.*

With regard to the *Infrastructure Factor,* the three variables *Charging-, Landing-* and *Air Infrastructure* are identified as co-specialized *Complementary Innovations*. All three are deemed essential for the realization of vehicle operations. Here, a bilateral dependence prevails: infrastructure becomes redundant if vehicles are not operated as it is developed exclusively for the operation of UAM vehicles. On the other hand, vehicles cannot be operated without a dedicated infrastructure. Ground infrastructure must be specifically designed to effectively operate and charge multiple types of VTOL vehicles. In addition, UAM infrastructure must be integrated into existing mobility systems. Furthermore, the placement of ground infrastructure in densely populated areas requires both public acceptance and further research on traffic junctions. With regard to air infrastructure, a standardized communication system with established routes needs to be implemented. The standardization and generalizability of the infrastructure for UAM establishes the strong linkage to the *Regulatory Factor*. This is because regulatory standards and certification requirements must be formulated to establish common standards. As the establishment of infrastructure requires high capital expenditures and lies out of the competencies of most VTOL manufacturers, it is argued that VTOL manufacturers should outsource the development and operation of UAM infrastructure and partner with dedicated infrastructure providers to access these facilities and systems. In essence, this research indicates that the general perception prevails that third-party providers will be operators and owners of the ground- as well as the air infrastructure. Due to the bilateral dependence and importance of infrastructure, this research argues that partnerships between VTOL manufacturers and infrastructure providers are of high importance and should be given special attention by manufacturers. This notion is also backed by the identified interrelations in section *5.2.*

The innovations comprising the *Affiliated Innovations Factor*, namely *Energy Supply* and *Autonomous Technology,* are both trending topics in the mobility industry. While *Energy Supply* can be defined as a specialized asset as its relevance and further development does not exclusively concern the UAM industry, the *Autonomous Technology* is still relatively immature. Further, the three-dimensional character of autonomous flight technology differs from autonomous ground technology, thus, the determination of whether the *Autonomous Technology* is specialized or co-specialized is indefinite. The innovation related to *Energy Supply* primarily considers battery technology comprising of longevity, weight, sustainability, density and charge cycles. The development and implementation of *Autonomous Technology* is highly dependent on regulatory approval and public and user trust in the technology. It is claimed that development processes require both advanced knowledge as well as high capital expenditures. The aforementioned already illustrates the interrelations of the *Affiliated Innovations Factor* with the *Infrastructure-*, the *Environmental-*, the *Regulatory,* and the *Social & User Acceptance Factor*. Due to the complexity and required investments, it is argued that a VTOL manufacturer should outsource the development of these *Complementary Innovations*.

The above classifies the UAM industry and the identified decision factors along *Complementary Assets* and *Complementary Innovations*. All assets/innovations were defined as either specialized or co-specialized, which can be explained by the complexity of the UAM industry. Whether to integrate or outsource the asset/innovation in question depends both on the market stage, the nature of the asset/innovation as well as on the innovator itself. In the following, the *Peripheric Sphere* of the UAM industry will be outlined.

Peripheric Sphere

The remaining three factors, namely the *Environmental Factor*, the *Regulatory Factor* and the *Social & User Acceptance Factor* are attributed to the *Peripheric Sphere*. The elements of the *Peripheric Sphere* are of external, intangible nature which cannot be held by the innovator. Notwithstanding, these elements have a strong influence on commercial success of the innovation. Even though these elements cannot be held, acquired or outsourced, the innovator can very well influence their nature. The elements of the *Peripheric Sphere* can be classified as favorable or unfavorable to the innovator.

The *Environmental Factor* states that VTOL manufacturers need to consider sustainability and environmental friendliness throughout their business. It is argued that VTOL manufacturers should incorporate sustainability in their business models and not just only contribute to a more environmental friendly mode of transportation but actually be part of the solution to growing environmental issues. This encompasses, for example, emission free manufacturing or sustainable propulsion and energy storage. Even though these requirements may involve additional costs, the *Environmental Factor* provides an excellent opportunity for VTOL manufacturers and can result in a competitive advantage. As most of the current VTOL manufacturers already heralded that their propulsion will be electric, they hold a good position to make use of the *Environmental Factor*. Therefore, the nature of the *Environmental Factor* is classified as a favorable *Peripheric Sphere* element.

On the contrary, the *Regulatory-* and the *Social & User Acceptance Factor* prove to be unfavorable. As stated above, regulations and certifications are deemed critical for VTOL manufacturers. Flying and operating a VTOL vehicle without regulations and guidelines is not possible. For one, regulations assure the safety of the vehicle and for another, they specify how noisy the vehicle can be, where it can fly, take-off and land, and under what conditions the operations can take place. Certification of the technology and the vehicle as a whole is perceived as long-lasting and cost intensive. However, it is needed for a VTOL manufacturer to be commercially successful. As the current regulatory landscape of the UAM industry is still evolving and policymakers, agencies and governing bodies are still in the early stages of establishing rules and guidelines for this novel service, the *Regulatory Factor* is perceived to be unfavorable to VTOL manufacturers.

As already mentioned, safety and noise issues play an important role in certification and policy setting. However, as identified in section *5.1.7*, they stem from the *Social & User Acceptance Factor*. Moreover, besides safety and noise issues, the *Social & User Acceptance Factor* also identified privacy issues as an important element. The influence of the *Social & User Acceptance* factor should not be neglected: without the acceptance of the public as well as the acceptance by the users, the technology can be as good as it may be and the regulations as advantageous as they may be, the commercial success will fail to materialize. In essence, the *Social & User Acceptance Factor* can be declared as unfavorable as the current public perception of the technology is unknown and issues such as safety, noise and privacy need to be dealt with both for public acceptance and user adoption of the technology.

Even though the *Environmental Factor* is declared as favorable, the remaining two factors, namely the *Regulatory Factor* and the *Social & User Acceptance Factor*, are classified as unfavorable. Since the latter two factors are considered to be more important than the *Environmental Factor* (*Figure 4*), the *Peripheric Sphere* can be characterized as unfavorable overall.

The following section will provide recommendations for VTOL manufacturers on how to cope with the above identified status quo and how this can shape their strategic orientation.

6.3.3. Recommendations for VTOL Manufacturers

The above classifies the UAM industry along the innovation strategy implications established in section *6.3.1*. In the following, recommendations for VTOL manufacturers based on the implications outlined in section *6.3.2* are derived. First, the market environment is mapped. Second, the nature of the *Complementary Assets* and *Innovations* is outlined and recommendations on integration vs. outsourcing are given. Next, the *Peripheric Sphere* of the UAM industry is stated and measures to overcome the identified unfavorable nature are introduced. Lastly, recommendations on the market entry strategy are given.

The current market environment is deemed to be characterized by high uncertainty and an undefined market structure. Furthermore, no dominant design has yet emerged resulting in many innovators competing for the establishment of the dominant design. The appropriability regime is perceived to be weak resulting in the technology to be imitable and, in turn hard to protect.

As elaborated earlier, certain *Complementary Assets* and *Innovations* are needed for the innovation of a VTOL manufacturer. These assets or innovations can either be integrated or outsourced. In the case of VTOL manufacturers, a mixed-mode approach is recommended.

This notion is also supported by Rothaermel et al. (2006) who argue that a simultaneous pursuit of vertical integration and strategic outsourcing can contribute to an innovator's competitive advantage. Furthermore, the mix of integration and outsourcing is also dependent on the innovator. The decision whether to integrate or outsource *Sourcing & Manufacturing* can differ depending on if the innovator is an established firm or a small startup. For established firms such as Airbus or Hyundai, mass manufacturing lies at their core and does not pose any major challenges for the innovator. Startups, on the contrary, are unexperienced in mass production and often face cash constraints. Therefore partnering with a third party (i.e. automotive company), focusing on their core technology and outsourcing manufacturing can be the right strategic decision. The situation is different with *Service & Operations*. Here, the fundamental argument is that the innovator will also be the operator of UAM VTOL services. It is argued that much of the business and revenue is in operations and unlike the aviation industry where the manufacturer does not operate the aircraft, the manufacturer of a VTOL vehicle is also seen as the operator. Here, no difference between established firms and startups was observed. Whether *Marketing & Research* activities are integrated or outsourced depends on the capabilities of the innovator in question and the extent to which it wishes to conduct *Marketing & Research*.

With regard to *Complementary Innovations*, uniformity prevails in terms of the strategic decision on integrating vs. outsourcing. Both established firms and startups are well advised to partner and/or outsource to get access to *Complementary Innovations*. For one, the required infrastructure to operate a VTOL vehicle is perceived to be cost intensive and lies out of the expertise of VTOL manufacturers. Due to the co-specialized nature of this innovation, partnerships with infrastructure providers are recommended. However, as it is claimed that VTOL infrastructure is expected to be standardized, partnerships with just one provider might not be the most useful decision. With respect to the development of advanced energy supply solutions and autonomous flying technology, outsourcing the development and partnering with specialized third party firms are perceived to be valuable to access *Complementary Innovations*. Establishing an ecosystem, or an industry architecture (Jacobides et al., 2006), surrounding the innovator by entering into partnerships can further enhance the competitive advantage of the VTOL manufacturer.

The current *Peripheric Sphere* of the UAM industry is perceived to be unfavorable. The *Environmental Factor* poses an opportunity for VTOL manufacturers, however, the nature of the regulatory landscape and the public perception and user adoption are deemed as unfavorable to VTOL manufacturers. Here, two identified measures can remedy this shortcoming. For one, as outlined in section *5.1.6*, *Lobbying* with governing bodies, policymakers and regulatory bodies can accelerate the certification process of an innovator's technology. Entering into strategic partnerships with large companies who have a strong influence on politics and policymakers as well as engaging in marketing activities can amplify the undertaking. For another, providing *Use Cases* can impact both the regulatory landscape and the public perception and user adoption. As articulated in section *5.3*, *Use Cases* can have a massive impact on the social acceptance of the technology. Showcasing the safety of the vehicle while also diminishing noise and privacy concerns can enhance the public perception of VTOL vehicles. Additionally, proving the added value to potential customers at an early stage can lead to a higher user adoption sooner in the process. Moreover, *Use Cases* also demonstrate the technology to municipalities and other governing institutions which, in turn can lead to a more favorable regulatory landscape.

Lastly, recommendations for a VTOL manufacturer's market entry strategy can be drawn. For this purpose, all the above-mentioned influences must be taken into account. In environments of weak appropriability, a speed-to-market strategy is advocated. However, in markets where no dominant design has emerged, this poses risks as an innovator might bet on the "wrong" design and fall behind its competitors. Especially in high-tech markets where irreversibility prevails, betting on the wrong design might be fatal. Nevertheless, if an innovator manages to establish the dominant design, it finds itself in a superior position compared to its contestants. Engaging in a speed-to-market strategy enables the VTOL manufacturer to capture the early adopter market while, at the same time, enabling the manufacturer to showcase the technology and therefore accelerate certification processes. What is more, access to *Complementary Assets* and *Innovations* is crucial for commercial success of an innovation. Additionally, the nature of the *Peripheric Sphere* further influences the successful commercialization of an innovation. In the case of the UAM industry, innovators are facing a weak appropriability in an undefined market where no dominant design has emerged. If an innovator decides to follow a speed-to-market strategy, it should not disregard the currently unfavorable *Peripheric Sphere*. Two approaches can provide redress. The innovator can counteract the unfavorable environment by engaging in *Lobbying* and/or providing *Use Cases* or it can move to a different geographical region where the *Peripheric Sphere* appears more favorable.

7. Discussion

Urban air mobility displays an emerging phenomenon that has gained increasing media coverage as well as initial attention throughout academic literature. However, focusing on the VTOL manufacturer and its introduction as the key innovation leader has not yet occurred. Moreover, identifying considerations that have to be taken into account by an manufacturer in order to be commercially successful have not been the unit of analysis in prevailing UAM literature.

This research seeks to identify decision factors needed to be considered by key innovation leaders when entering an undefined high-technology market and how these innovators can achieve commercial success. This is outlined on the example of the VTOL manufacturer (key innovation leader) in the undefined high-tech UAM market. With effort to answering the underlying research question, this research deployed grounded theory through systematically analyzing 16 interviews with UAM experts.

In order to identify factors already described in the existing literature, academic UAM literature was screened. It became evident that much research has been conducted, however, focusing on the VTOL manufacturer and outlining considerations for commercial success has not been covered in the prevailing UAM literature (Zhou et al., 2019; Silva et al., 2018; Fredericks et al., 2018; Rothfeld et al., 2018; Shamiyeh et al., 2018; Vascik & Hansman, 2017; Vascik et al., 2018). Kellermann et al. (2020) performed a systemic literature review wherein they identified five problematic aspects within the UAM industry. This research extends the predominant UAM literature by, for one, extending the previously identified problematic aspects and, for another, by adding additional aspects consolidating them into eight distinct factors.

In the course of this study, it was found that a key innovation leader in an undefined high-technology market environment should consider eight decision factors to be commercially successful. Moreover, it was ascertained that the identified decision factors show strong interrelations strengthening the argument that none of the decision factors should be neglected. Additionally, this research detected measures that key innovation leaders can take to counteract challenges posed by the decision factors. In particular, the following decision factors have been identified: the *Value Chain Factor*, the *Infrastructure Factor*, the *Marketing & Research Factor*, the *Affiliated Innovations Factor*, the *Environmental Factor*, the *Regulatory Factor*, the *Social & User Acceptance Factor* and the *Launch Strategy Factor*.

The nature of the identified decision factors as well as the innovator's positioning towards these factors influence how they achieve commercial success. In order to assess the nature of the identified decision factors and derive strategic implications for the innovator, innovation strategy literature, in particular the PFI framework (Teece, 1986) as well as thereon based literature (Afuah, 2001; Rothaermel et al., 2006; Jacobides et al., 2006; Pisano & Teece, 2007; Suarez, 2004; Ching et al., 2014; Gans, 2017; Gans et al., 2018), was consulted. It became apparent that not all identified decision factors can be classified as either *Complementary Assets* or *Complementary Innovations.*

At this juncture, this research identified a research gap in the aforementioned framework as the applicability to undefined high-technology markets is not fully given. Here, this research amplified the PFI framework by introducing the *Peripheric Sphere* as a surrounding layer. This adjunct entails external factors, which, unlike *Complementary Assets* and *Innovations*, can't be held by the innovator and therefore cannot be integrated nor outsourced. The nature of the *Peripheric Sphere* elements can be either favorable or unfavorable to the innovator. Elements of the *Peripheric Sphere* impact the commercial success of an innovator as they influence both the strategic decision on whether an innovator should integrate or contract for a *Complementary Asset* or *Innovation* as well as the innovator's market entry strategy. Henceforth, an innovator's commercial success is not only dependent on the *Appropriability Regime,* the *Market Evolution/Dominant Design* and the access to *Complementary Assets/Innovations* but also on the nature of the *Peripheric Sphere.* Thus, in order to be commercially successful in an undefined high-technology market, a key innovation leader should thoroughly analyze the aforementioned decision factors and apply the newly introduced framework to derive implications for its future strategic orientation.

The unit of analysis of this research is represented by the VTOL manufacturer within the UAM industry. The UAM industry is classified as an undefined high-tech market where many innovators compete for the dominant design and the ascendance in the emerging UAM market. It is articulated that the degree to which a VTOL manufacturer can protect its core technological innovation is low, depicting a first variable the manufacturer needs to consider. Second, the undefined market stage and the non-existence of a dominant design further define a VTOL manufacturer's strategy formation. Moreover, the accessibility of assets and innovations needed for the commercial success of the innovation is an additional consideration that in turn defines how the mix of integration and outsourcing is composed among VTOL manufacturers. This is, for one, dependent on the asset/innovation and, for another, on the innovator itself. Finally, a VTOL manufacturer must also consider the *Peripheric Sphere*, which is comprised of external influencing factors that ultimately determine the strategic direction of the innovator.

8. Limitations & Future Research

In order to derive a more comprehensive picture of the industry, a prolonged observation time would have been beneficial to encounter the dynamic nature of the UAM industry as a more extensive time span could have allowed to observe the market maturation, potential product launches and dominant design emergence. Increasing the number of interview partners and expanding the background diversity (e.g. potential users) could have accelerated data triangulation as well as adding additional viewpoints and validity to the research. Additionally, the geographic focus of this research depicts a further limitation. Both the interview partners as well as the researchers focus their argumentations on the applicability of UAM on western countries with a special focus on Europe. Therefore, the argumentation that an innovator can move to a different geographical region where the environment proves to be more favorable needs additional validation.

In addition, the ongoing COVID-19 pandemic has not only resulted in interviews being conducted online but has likewise limited the ability to respond to nonverbal cues, emotions, and behaviors. Additionally, the societal implications on travel behavior and urbanization caused by the pandemic cannot be foreseen. As the UAM industry is a comparatively young academic field, the availability of secondary data is limited and is thus not incorporated in the research. Furthermore, this thesis only addressed a limited spectrum of the innovation strategy literature with a focus on the Teecian approach. However, extending the theoretical backbone by a more broad innovation strategy literature base can provide additional value. In addition, assumptions, such as the premise that the specific technological composition of the vehicle is given, were made.

The identified decision factors constitute an interpretation of the interviews conducted as well as the coding process, which depicts an unavoidable limitation. Moreover, this research identified measures which can be taken to counteract challenges posed by the factors. As this was not the main goal of this study, further research can examine these measures in greater detail. This research exhibits a narrow industry focus, however, it can be anticipated that transferability to other non-existent high-tech markets, as well as adjacent markets and industries facing the same challenges as those identified for UAM, is viable. The fields on which future research can build are twofold. First, the significance of the identified decision factors should be further explored as well as tested for rigor. Second, the validity of the established framework and its applicability towards other industries should be challenged. Examining decision factors as well as the established framework in light of other industries and market stages can bring greater meaning to the latter as well as advance robustness and generalizability. Here, conducting a second round of interviews and providing the experts the identified decision factors and the thereof derived framework can add additional value to this research.

9. Concluding Remarks

This research has shown that both the current academic UAM literature as well as the utilized innovation strategy literature show deficiencies. For one, the UAM literature misses a thorough analysis of the business perspective on key innovators within the industry. For another, innovation strategy literature reveals gaps when analyzing undefined high-tech markets such as the UAM industry. This research seeks to fill the identified research gaps as it identifies eight decision factors needed to be considered by the key innovator (e.g. the VTOL manufacturer) to achieve commercial success while, at the same time, extending innovation strategy literature, in particular the PFI framework, by an additional layer incorporating external factors which influence the commercial success of the innovator. The extended framework can be deployed by innovators in undefined high-tech market environments to shape their strategic orientation. However, these serendipities where identified within a narrow industry and its generalizability and applicability towards other industry is subject to further research.

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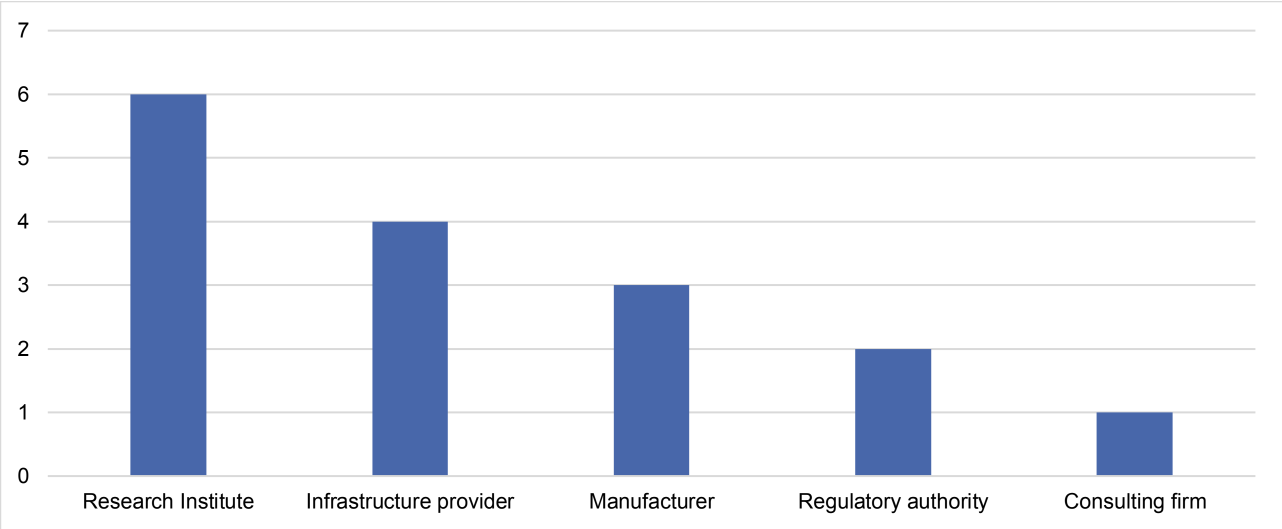
11. Appendices

***Appendix A**: Interview Partner Industry Distribution*



***Appendix B:** Data Collection and Data Processing Form*

Consent to the collection and scientific processing of my interview data

Elaboration on data protection and confidentiality of your information during the interview on the topic of Urban Air Mobility VTOL vehicle manufacturers undertaken by Paul Horlacher and Nick Ehrhardt. This encompasses in particular the recording of the interview with a voice recorder.

I was told that my interview statements in the expert interview series on Urban Air Mobility VTOL vehicle manufacturers will be recorded with a recording device (only with my explicit consent) and put into text by Mr. Paul Horlacher and Mr. Nick Ehrhardt (creation of an interview transcript or memorial protocol). The results of the interviews are only used and displayed anonymously. For the further scientific evaluation of the interview text, all information that could lead to **my identification will be changed or removed from the text**. I am assured that my interview statements are only quoted in extracts in scientific publications.

My data will be stored safe and confidential. The access to my data will not be public and only accessible with explicit permission.

By signing this form, I grant my approval for processing my personal data for the above-mentioned purposes.

( ) Yes
( ) No

I am aware that I am giving my consent to participate in the interview and for processing of my personal data on a voluntary basis and that I can withdraw the effects of this consent at any given time without disadvantages. A withdraw of my consent can happen without form in contacting Paul Horlacher and Nick Ehrhardt under the given contact data.

(Date, location | first name, last name)

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Appendix C: *Interview Guideline*

Interview Guideline Master Thesis: Urban Air Mobility

Interviewers: Ehrhardt, Nick; Horlacher, Paul

Interviewee: ***[OPEN]***

First of all, thank you very much for taking the time to support us in the preparation of the master's thesis. In the following, we would like to further clarify our approach and provide you with some information before our interview.

Our theoretical starting point is the Profiting from Innovation (PFI) framework, commonly used in strategic management theory, which we are applying to innovation leaders in an uncertain and undefined market. Through that, we would like to stress the PFI framework on its applicability to the UAM industry. By doing so, we aim at mapping the current status quo and outline potential pathways on how to maximize profit from the innovation by tackling the identified challenges and utilizing opportunities.

Thus, our goal is to **identify factors that UAM VTOL manufacturers** (Key Innovation Leader/Dominant Player) **have to consider to be successful in the emerging UAM market**. These can be both internal and external in nature.

In the following you will find the structure of the interview as well as our key questions:

Questions	**Time**
- How do you assess the current UAM passenger market?	10-12 min
- Which **factors** do you consider important for an UAM VTOL manufacturer to be long term successful in the emerging UAM market?	10-12 min
- [Potential follow-up questions]	10-12 min