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A Process Data Analysis of The Evtol Case Study

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The sky is not the limit anymore.

(Globalvia)

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

IE	Innovation Ecosystems
VP	Value Proposition
EVTOL	Electric Vertical Takeoff and Landing Vehicle
AAM	Advanced Air Mobility
UAM	Urban Air Mobility
ATC	Air Traffic Control
AAM	Advanced Air Mobility
ANSP	Air Navigation Service Provider
ATM	Air Trafic Management
CONOPS	Concept of Operation
UATM	Urban Air Traffic Management
UASP	Urban Airspace Services Provider

SUMMARY

ABSTRACT

Innovation ecosystem (IE) literature is undergoing vigorous growth (Shiplov and Gawer, 2020). IE literature is vast and portrays recent new structures of economic relations. Literature has matured in recent years and considers ecosystems an actionable new structure of economic relationships that requires specific management. IE is a fertile field for the emergence of uncertainties of different natures and different levels because they grow in a non-linear way, with the development trajectories being emergent rather than strictly controlled. The literature has already shown the source of several different types of uncertainty at the project and organizational level (Pich et al., 2002; Rice et al., 2008; Huchzermeier & Loch, 2001; Huber et al., 1975), but studies of uncertainty management at the ecosystem level are relatively scarce. We know much less about how emerging ecosystems deal with uncertainty. Based on this research gap, this research presents an analytical framework of uncertainties that affect innovation ecosystems' emergence. To do that, we conducted a qualitative multiple case studies methodological approach in one aircraft-related global IE. Based on 164 interviews and 506 technical reports and white papers, we identified an emerging ecosystem based on multiple criteria and mapped and explained all its components according to ecosystem theory. We found 262 main events in a 7-year global trajectory evolution of the ecosystem and grouped them into 6 phases of the ecosystem. We inductively identified, named, and ranked 45 uncertainties and 50 strategies that emerged from the data. Finally, we analyzed the relationship between uncertainties and strategies employed by decision-makers, identifying patterns of uncertainty management and showing a visual map explaining the coevolution during the IE growth trajectory. We finish this study by presenting a set of propositions. This study contributes to the emergence of the IE as a structured research field. This study also contributes to public policymakers by depicting elements that inhibit innovation ecosystem emergence. Based on these findings, practitioners may strategize paths for better dealing with situations of different natures in these contexts.

Keywords: Innovation Ecosystems; Uncertainty Management; Emergence; Study Case; Strategies.

RESUMEN

La literatura sobre ecosistemas de innovación (EI) está experimentando un crecimiento vigoroso (Shiplov y Gawer, 2020). La literatura de EI es vasta y retrata nuevas estructuras económicas de relaciones. La literatura ha madurado en los últimos años y considera que los ecosistemas son una nueva estructura de relaciones económicas procesable que requiere una gestión específica. Los EI son un campo fértil para la aparición de incertidumbres de diferentes naturalezas y diferentes niveles, ya que crecen de forma no lineal, con trayectorias de desarrollo más emergentes que estrictamente controladas. La literatura ya ha mostrado el origen de varios tipos diferentes de incertidumbre a nivel de proyecto y organizacional (Pich et al., 2002; Rice et al., 2008; Huchzermeier & Loch, 2001; Huber et al., 1975), pero los estudios sobre gestión de la incertidumbre a nivel de ecosistema son relativamente escasos. Sabemos mucho menos sobre cómo los ecosistemas emergentes lidian con la incertidumbre. Basándonos en esta laguna de investigación, esta investigación presenta un marco analítico de incertidumbres que afectan la aparición de ecosistemas de innovación. Llevamos a cabo un enfoque metodológico de estudios de casos múltiples cualitativos en un EI global relacionado con la aeronáutica. En base a 164 entrevistas y 506 informes técnicos y documentos, identificamos un ecosistema emergente según múltiples criterios, mapeamos y explicamos todos sus componentes de acuerdo con la teoría del ecosistema. Encontramos 262 eventos principales en una trayectoria evolutiva global de 7 años del ecosistema y los agrupamos en 6 fases del ecosistema. Inductivamente identificamos, denominamos y clasificamos 45 incertidumbres y 50 estrategias que surgieron de los datos. Finalmente, analizamos la relación entre las incertidumbres y las estrategias empleadas por los responsables de la toma de decisiones, identificando patrones de gestión de la incertidumbre y mostrando un mapa visual que explica la coevolución durante la trayectoria de crecimiento del EI. Terminamos este estudio presentando una serie de proposiciones. Este estudio contribuye a la aparición del EI como un campo de investigación estructurado. Este estudio también contribuye a los legisladores públicos al representar elementos que inhiben la aparición de ecosistemas de innovación. En base a estos hallazgos, los profesionales pueden trazar estrategias para lidiar mejor con situaciones de diferentes naturalezas en estos contextos.

Palabras clave: Ecosistemas de Innovación; Gestión de la Incertidumbre; Emergencia; Estudio de Caso; Estrategias.

RESUM

La literatura sobre ecosistemes d'innovació (EI) està experimentant un creixement vigorós (Shiplov i Gawer, 2020). La literatura d'EI és vasta i retrata noves estructures econòmiques de relacions. La literatura ha madurat en els últims anys i considera que els ecosistemes són una nova estructura de relacions econòmiques aprofitable que requereix una gestió específica. Els EI són un camp fèrtil per a l'aparició d'incerteses de diferents naturaleses i diferents nivells, ja que creixen de forma no lineal, amb trajectòries de desenvolupament més emergents que estrictament controlades. La literatura ja ha mostrat l'origen de diversos tipus diferents d'incertesa a nivell de projecte i organitzacional (Pich et al., 2002; Rice et al., 2008; Huchzermeier & Loch, 2001; Huber et al., 1975), però els estudis sobre gestió de la incertesa a nivell d'ecosistema són relativament escassos. Sabem molt menys sobre com els ecosistemes emergents tracten la incertesa. Basant-nos en aquest buit d'investigació, aquesta investigació presenta un marc analític d'incerteses que afecten l'aparició d'ecosistemes d'innovació. Per fer-ho, vam dur a terme un enfocament metodològic d'estudis de casos múltiples qualitatius en un EI global relacionat amb l'aeronàutica. Basant-nos en 164 entrevistes i 506 informes tècnics i documents blancs, vam identificar un ecosistema emergent segons múltiples criteris, vam mapar i vam explicar tots els seus components d'acord amb la teoria de l'ecosistema. Vam trobar 262 esdeveniments principals en una trajectòria evolutiva global de 7 anys de l'ecosistema i els vam agrupar en 6 fases de l'ecosistema. Inductivament vam identificar, vam anomenar i vam classificar 45 incerteses i 50 estratègies que van sorgir de les dades. Finalment, vam analitzar la relació entre les incerteses i les estratègies emprades pels responsables de la presa de decisions, identificant patrons de gestió de la incertesa i mostrant un mapa visual que explica la coevolució durant la trajectòria de creixement de l'EI. Acabem aquest estudi presentant una sèrie de proposicions. Aquest estudi contribueix a l'aparició de EI com un camp d'investigació estructurat. Aquest estudi també contribueix als legisladors públics en representar elements que inhibeixen l'aparició d'ecosistemes d'innovació. Basant-nos en aquestes troballes, els professionals poden traçar estratègies per tractar millor situacions de diferents naturaleses en aquests contextos.

Paraules clau: Ecosistemes d'innovació; Gestió de la incertesa; Emergència; Estudi de cas; Estratègies.

1 INTRODUCTION

Joining forces — especially in the form of R&D alliances, collaborative projects, and open innovation initiatives (Chesbrough, 2003; Shipilov & Gawer, 2020; Kapoor & Klueter, 2021; Gomes et al., 2021; Gawer and Cusumano, 2014; Granstrand & Holgersson, 2020) — has become ever more vital for firms aiming to develop breakthrough ideas and new business opportunities. It's not financially worth addressing alone all uncertainties related to the innovation process because generic technologies can lead to very different market paths/applications. Also, the cost of entering each of these technological niches is very expensive. Even in the cases of some market segments, such as gene therapies in the health area, it is very difficult for firms to master the entire development process. It is very difficult for firms to address the complexity of the technology alone.

In this sense, open innovation (Chesbrough, 2003) comes as a possibility of innovation and sharing risks and uncertainties at the same time. Even though open innovation is not a synonym for maintaining the technology in the market because technology can be born and be shelved, as we can see in the high failure rates of market technology entrance indexes. Even innovations created from collaborative processes often fail due to a low level of market development and network effect challenge (i.e., it's hard to generate a network effect to drive the growth of technologies in the market) (Thomas & Autio, 2014). There are also problems related to the low level of resources available, and the low institutional and financial support that firms might receive.

So, firms exploring new technologies must establish a structure of interdependence to give regularity to the value creation/ coproduction/co-sale process (Kapoor & Klueter, 2021; Gomes et al. 2021c; Gomes et al., 2021b; Adner, 2017). Decision-makers inside these firms need to evolve their capabilities and learn how to establish these structures of interdependence with regular flows of knowledge and resources. They need to learn to manage not a firm or a portfolio of innovation projects but an entire innovation ecosystem.

In this sense, this thesis builds on the idea that innovation ecosystems are new structures of economic relations (Jacobides et al., 2018). This structure breaks the pillars based on individuality or punctual collaborative project-based approaches towards a systemic, dynamic, integrated, long-term term, and distributive vision (Datté et al., 2018; Sultana et al., 2023) of collaboration. The main idea underlies the logic that actors are not fully hierarchically controlled, that they are independent, and heterogeneous with varying degrees of multilateral and non-generic complementarities. The literature has matured in recent years and preconizes those ecosystems require specific management (Adner, 2017). They interact to collectively generate a coherent, ecosystem-level output to a defined user audience (Thomas & Autio, 2020; Adner, 2017).

In this sense, the IE *as strategy* literature (Adner, 2017) proposes that ecosystem boundaries are not geographically delimited, so organizations inside ecosystems may relate to other actors sometimes located even in other countries (Ferasso et al., 2018; Hakala et al., 2020; Aarikka-Stenroos & Ritala, 2017; Adner & Kapoor, 2010).

Innovation ecosystems (IE) are a fertile field for the emergence of uncertainties of different natures (Thomas & Ritala, 2021) and different levels (Gomes et al., 2019) because they grow in a non-linear way, with the development trajectories being emergent rather than strictly controlled (Ritala & Almpanopoulou, 2017). Uncertainties at the ecosystem level are the loss of predictability such that the future of the IE is unpredictable, and information about the IE emergence process is incomplete, unknown, or unavailable (Furr and Eggers, 2021). Uncertainties are even more pronounced in nascent ecosystems (NE) (Shi et al., 2021). NE are ecosystems in formation (Thomas & Autio, 2014; Shi et al., 2021).

The literature shows us that uncertainty is a perceptual phenomenon (Milliken, 1987), meaning that each decision-maker (IE actors who play particular roles in an ecosystem (i.e., orchestrators, complementors, etc) (Adner, 2017) perceives them differently (Pich et al., 2002). So, individual decision-makers face ecosystem-level uncertainty (Gomes et al., 2018; Packard et al., 2017).

Previous literature explained aggregative typologies for unknowns at the IE as the lack of knowledge about environmental changes (Milliken, 1987) boundaries of the ecosystem (Gomes et al., 2021), IE structure (Gomes and da Silva Barros, 2022; Adner & Feiler, 2019), design of IE structures (Datté et al., 2018). Uncertainties related to the new actor's engagement and commitment to the delivery value proposition (Gomes et al., 2021a), the "chicken-and-egg" problem of launch and adoption (Thomas & Ritala, 2021), possible asymmetric resource dependencies uncertainties (Shipilov & Gawer, 2020), lack of knowledge about resources and activities-related risks (Talmar et al.,

2020) and how to establish IE legitimacy (Thomas & Ritala, 2021). Other works disclose the effects of the propagation of uncertainties in IE (Gomes et al., 2018), specifically in the development, performance, and adoption of new technologies (Rice et al., 2008; Kapoor and Klueter, 2021).

In this sense, there is an extensive debate in the entrepreneurship literature about the best way to act in the face of uncertainties to "control" them, and different schools of strategic management will address this issue (Townsend et al., 2018). Strategic literature shows four macro approaches decision-makers might adopt to manage uncertainty (Wiltbank et al., 2006). For example, while some authors posed planning (Porter, 1985; Schoemaker, 1995; Schwartz, 1997; Godet, 1997) and experimenting (Mintzberg, 1990) to reduce uncertainty as the best path to predict the future, other authors posed that improvising (Hamel & Prahalad, 1991, Courtney et al., 1997; Sarasvathy, 2001) and shaping (Furr & Eisenhardt, 2021) to recognize uncertainty are the best path to build the future.

Ecosystems, by their nature, are surrounded by uncertainties; therefore, managing uncertainties is crucial for technological evolution (Gomes et al., 2019). The unmanagement of uncertainty in nascent IE settings brings negative impacts on IE's long-term sustainability (Thomas & Ritala, 2021) undermining ecosystems, interfering with their growth, leading to ruin, business bankruptcy, partnership disintegration, and people's deprivation to access technologies that positively impact their lives. The lack of awareness of the IE uncertainties can obscure visibility into ecosystem interdependencies and member roles. For example, the nascent smart glass ecosystem (Klein et al., 2020; Canal Tech, 2021) struggled to move toward growth due to uncertainties regarding new consumer habits, information security, and institutional and cultural barriers. Moreover, uncertainty about 3D technology has undermined the augmented virtual reality TV ecosystem (Techmundo, 2021). Limited knowledge about levels of production scale undermined this ecosystem and decoupled its members. Many uncertainties about the impact of this technology on the film industry and users' health (motion sickness) caused by virtual reality contributed to IE destruction. That ecosystem has deteriorated, causing ecosystem complementors and components (e.g., Blu-ray and videogames film producers, 3D content-generation producers, 3D content converters producers, and filming device production companies) to disinvest.

In this sense, a poor knowledge base about the uncertainties surrounding an ecosystem harms actors to make informed decisions, seize opportunities, manage interdependencies, coordinating efforts, and develop collective resilience, decreasing the chances of growth and overall success of the ecosystem. This is critical since, when an ecosystem is emerging, like other new organizational forms, it often strives to gain resources and institutional support, leading to high failure rates in the early phases (Thomas & Ritala, 2021).

A smaller number of studies approach uncertainties in nascent ecosystems. In the very first phases of the ecosystem emergence process (proto-vision phase) (Datté et al., 2018), the lack of knowledge demands more experimentation-oriented strategies than strategies based on resource planning (Thomas & Autio, 2014). However, few studies explored uncertainty management in IE settings. H**ow do uncertainties shape entrepreneurial behavior in nascent ecosystems?** More precisely, how do actors playing the same roles in the ecosystem react to each family of uncertainties? Is entrepreneurial action manifested by implementing more reactive mindsets (adapting, learning groups of strategies) or proactive mindsets (shaping and effectuation groups of strategies)?

This research looks at the IE through a configurational lens (Gomes et al., 2021b) and uncertainty management theory (Packard et al., 2017; Townsend et al., 2018; Foss et al., 2019) to explain entrepreneur behavior shaped by uncertainties over time. In order to reach this goal, we intend to:

a) Identify types of exogenous and endogenous uncertainties perceived by decision makers (innovation ecosystem actors) in the formation of an ecosystem over time;
b) To group these uncertainties into families and understand how they evolved along their growth trajectory;
c) To analyze how decision-makers (IE actors) frame the uncertainties (i.e., perceive them as opportunity vs. threat);
d) To analyze through what strategies, decision-makers (IE actors) respond to the uncertainties when managing their implications to the IE management;
e) To analyze what response patterns, exist for uncertainty management in a nascent ecosystem.

To reach these goals, we follow the tradition of studies on entrepreneurship and innovation research fields and choose an inductive process-based qualitative approach (Langley, 1999) to develop a deeper understanding of the role of uncertainty in these settings (Sydow et al., 2012). The process thinking approach is widely used in the field of strategy and innovation studies (Ott et al., 2017; March, 1994; Pettigrew, 1985; 1990; Faccin et al., 2020) and has proven to be appropriate for understanding the changes that occur over time at an ecosystem level (Shi et al., 2021).

We investigated one case study (Langley, 1999) facing the emergence phase and yet did not overcome the liability of the newness barrier to growth. We study one nascent IEs called the Electric Vertical Take-off and Land (EVTOL) ecosystem - the ecosystem of an aircraft that can take off, hover, and land vertically. This new type of vehicle demands specific training and knowledge requirements for pilots and operators, airworthiness certification, international processes, and service characteristics. These vehicles have different levels of aircraft automation and might be based on piloted or remotely piloted/operated. Inside this EVTOL IE, multiple actors perform different roles (Adner, 2017) as complementors, suppliers, and orchestrators, among other roles. This thesis is structured as follows: section 2 presents the theoretical foundation of the study. Section 3 the methodology section followed by section 4 analysis of the data) and 5 (discussion of the results).

This thesis considers the ecosystem-as-a-structure (Adner, 2017; Thomas & Autio, 2020) by focusing on what uncertainty management strategies can provide superior growth (Talmar et al., 2020; Xu et al., 2018; Adner, 2006; 2017; Adner & Kapoor, 2010; Rice et al., 2008; Gomes et al., 2018; Loch et al., 2008; Kapoor & Klueter, 2021). We finish with conclusions and contributions in chapter 6.

2 THEORETICAL FOUNDATIONS

The theoretical foundation of this thesis shows how entrepreneurial action as a possible analysis lens to analyze the phenomenon of uncertainties in IEs, more precisely, nascent ecosystems. To do that, we first present the phenomenon itself (what is a nascent ecosystem) in section 2.1. Then, we present the second subsection (2.2) and third (2.3) subsections showing the reader how the literature on entrepreneurial action understands uncertainty and the management of uncertainty construct, respectively. The fourth subsection (2.4) explains why these explanations are not sufficient to answer our problem. Our focus here is on the theory elaboration to explain what the analytical perspective of ecosystems doesn't say about uncertainties and why we need more study in this research field.

Table 1 presents a summary of terminologies that are addressed in this theoretical foundation. As posed by Rivard (2021), clear conceptual construct definitions are very important when building theory, so authors should state their construct definitions in a concise, clear verbal expression of a unique concept.

Table 1 - Thesis' Concepts

Concept	**Definition**	**Author**
Innovation Ecosystem	A community of a not fully hierarchically controlled and independent, heterogeneous set of actors with varying degrees of multilateral and non-generic complementarities that collectively generates a coherent, ecosystem-level output and related value offering targeted at a defined user audience.	Adner (2017); Autio (2021); Jacobides et al. (2018)
IE Emergence	Emergence is an "incipient" evolution stage of IE development situated after birth and before its growth/expansion.	Rabelo and Bernus (2015); Talmar et al. (2020); Dedehayir et al. (2018)
Nascent ecosystem	An incipient stage of a collective emergence process of an IE in formation that starts with a Proto vision subphase and finishes with enacted resonance subphase (when the ecosystem starts to grow)	Dedehayir et al. (2018), Kapoor and Klueter (2021); Shi et al. (2021)
Global Innovation ecosystem	International alignment structure of interdependent actors cooperating to materialize a global value proposition under conditions of global uncertainty.	Gomes et al. (2022)
Orchestrator	A single key actor, which is often a large leading firm R&D consortium, platform owner, or a government-sponsored industrial program.	Hakala et al. (2020); Nambisan and Sawhney (2011); Sydow et al. (2012); Paquin

		and Howard-Grenville (2013)
IE Internal Actors	IE members interact to generate systemic innovation, a specific type of ecosystem-level output (the orchestrator, the complementors, and the components).	Adner (2017); Thomas and Ritala (2021)
Uncertainty	Loss of predictability such that the future is unpredictably different from the past, and information about the future is incomplete, unknown, or unavailable	Furr and Eggers (2021)
Uncertainty Mitigation	Strategies to reduce or deal with the uncertainties in a given context	Gomes et al. (2021c)
New Technology	Disruptive technologies can be either a new combination of existing technologies or new technologies whose application to problem areas or new commercialization challenges (e.g., systems or operations) can cause major technology product paradigm shifts or create entirely new ones.	Kostoff et al. (2004)
Entrepeneurial action	Specific, discrete decisions that make up the entrepreneurial process.	Packard et al., (2017)
Strategy	Conscious adaptation is utilized by firms facing uncertainty.	Alchian (1950)

Source: Author's Elaboration

2.1 INNOVATION ECOSYSTEMS

Since the view of the interrelationship between biology and administration began to be explored, ecosystems have been studied through the lens of different theories and theoretical perspectives, such as the institutional theory (DiMaggio and Powell, 1983), value networks (Normann and Ramirez, 1993). More recently, authors started to bring elements from open innovation (Chesbrough et al., 2014), dynamic capabilities (Farago et al., 2020), and exchange theory (Benitez et al., 2020) to understand the dynamics of the ecosystem.

Ecosystems are a new type of hybrid value-system model different from hierarchy-based value-system and market-based value systems. Ecosystems are a new form of organization that has a structure much more fluid and difficult to define.

Some papers help the researcher differentiate ecosystems from other inter-organizational coalitions and system approaches (Gomes et al., 2021b; Borges et al., 2019; Shipilov & Gawer, 2020). IE has a clear supply-side emphasis, although it differs from conventional supply chains once the value proposition depends on the availability of complementary products and services (Autio & Thomas, 2021). Unlike the supply chain literature, the IE does not focus on exchanging information and the flow of materials along the production chain (Gomes et al., 2018; Autio, 2021; Bogers et al., 2019).

Moreover, IE is not the same as a value chain because it is not formatted in a specific industry and involves more than a buyer-supplier's relationship bargaining power and yet across industry boundaries (Adner, 2017). Ecosystems are also not networks, although they both share a similar tension between competition and cooperation (Shipilov & Gawer, 2020). The IE literature looks much more at the co-evolutionary processes that occur as various organizations interact, often in symbiosis, and the significant complementarities/ interdependencies/ modularities among actors. On the other hand, the network literature will look much more at the structure of transactions, the structure of relationships, the positions of actors, the flows of information, and exchanges of specific assets that occur in both vertical and horizontal inter-organizational networks (Shipilov & Gawer, 2020). Table 2 shows how the ecosystem literature differs from other coalition forms of organizations.

Table 2 - Ecosystems as a New Research Stream

Literature	**Authors**	**Related Literature**	**Why it's NOT an Innovation Ecosystem**
Strategic Alliances and Networks	Shipilov and Gawer (2020)	Network literature will look much more at the structure of transactions, the structure of relationships, the positions of actors, the flows of information, and exchanges of specific assets that occur in both vertical and horizontal inter-organizational networks.	The IE literature looks at the co-evolutionary processes that occur as various organizations interact, often in symbiosis, and the significant complementarities/ interdependencies/ modularity among actors.
Open innovation	Kapoor and Klueter, (2021); Gomes et al. (2021)	Open innovation literature tends to focus on sources of innovation and knowledge transfer mechanisms inside punctual interactions among firms (specific projects) to co-create solutions for the market.	Open innovation tends to ignore how companies work together to *maintain* the technology in the market. The main focus is not on how to establish a structure of interdependence with regular flows of knowledge and resources to give regularity to the value creation/ coproduction/ co-sale process.
Clusters	Porter (1998)	Clusters have been more defining frontiers.	IE boundaries are expanded and opaque and might permeate more than one cluster.

Supply Chain	Gomes et al. (2021b)	Supply chain literature tens to focus on Make or buy decision flows of information and resources, Contract flows of materials and the role of managers to enable transactions. SCM does not include the management of complementors.	IE focuses on the interactions that are more complex in terms of cognitive, technological, and financial interdependencies within a group of actors that might be related to more than one supply chain.
Digital Platforms	Bogers et al, 2019; Dattée et al., 2018; Gawer and Cusumano, 2014.	Platform research speaks to the importance of interfaces in modularity, the control of interfaces, and the role these interfaces play in structuring relationships between platform members.	The interactions within an IE are generally organized around a technology platform consisting of shared assets, standards, and interfaces. The presence of a technology platform allows actors to combine their individual offerings to provide a complete value proposition to customers. However, some scholars have also studied IE without a technology platform at the core.
Innovation Systems	Granstrand and Holgersson, (2020)	Innovation systems are often based on geographical boundaries, labeled using constructs such as national or regional innovation systems	IEs allow for cross-sectoral and cross-regional examination of innovation activities.

Source: Author's Elaboration

Some author explains how the ecosystem concept has evolved in a fragmented way over the last 25 years (Oh et al., 2016; Dedehayir et al., 2018, Bogers et al., 2019). The construct evolved from concept construction to experimentation (that is, its proliferation) and understanding (management definitions) (Gomes et al., 2021b). IE is a strategy and is rooted in strategy theories grounded in the 1980s and 1990s (Hedley, 1977; Porter, 1985; Andrews, 1976; Mintzberg, 1973; Barney, 1991). Moore (1993) pioneered in introducing the ecosystem definition metaphorically in the management literature to understand how firms compete and collaborate to create value jointly. The focus underlies negotiating with communities and accessing new sources of information.

This first strategy stream considers the ecosystem as an affiliation (entities tied to a focal actor) (Adner, 2017). More recently, despite some controversial ideas (Oh et al., 2016), a recent view comprises IE as more than a simple metaphor. Ecosystems as a structure, namely, are a system of activities organized around a multilateral set of partners, technologies, and platforms that need to interact to deliver a market-and-profit-driven focal value proposition (Adner, 2006; Adner & Kapoor, 2010). This view considers activities as complementary actions and interactions undertaken by ecosystem members to create and capture value (Bassis and Armellini, 2018).

An ecosystem is an actionable structure that calls for specific management approaches and strategies (Gomes et al., 2021b) to gain competitive advantages. Ecosystems can be organized around a solution, a transaction, or a systemic innovation (Adner et al.,2019; Adner and Kapoor, 2016; Aarikka-Sternoos and Ritala, 2017). The ecosystem facilitates the collective generation of results, which can be products (usually with modular architecture) and services, innovative business models (Snihur et al., 2018), or the production of knowledge (Järvi & Ritala, 2018).

All ecosystem elements (such as information, knowledge, resources, inputs/outputs, or activities) flow within the ecosystem's structure (Adner & Kapoor, 2010).). The way these elements move from one place to another may enable value creation (Shipilov & Gawer, 2020). The need for co-creation reduces as value capture becomes clearer for ecosystem members. Value capture "refers to the individual firm-level actualized profit-taking; that is, how firms eventually pursue to reach their own competitive advantages and to reap related profit" (Ritala et al., 2013, p. 5). Talmar et al. (2020) understand that value capture is an ecosystem-level capability (Teece, 1986) that represents how what kind, and how much value created by the ecosystem is captured by a particular actor (i.e., direct financial gains, reputation increment, higher efficiency, knowledge) (Lepak et al., 2007).

While all ecosystems will need to have a configuration, these will be unique to each one. For example, Siemens' ecosystem configuration will be different from SAP's. The ecosystem literature has paid attention to the role of these actors in IE. Participant heterogeneity is a central feature in ecosystems (Thomas & Autio, 2020). Ecosystems are composed of a "multilateral set of partners" (Adner, 2017), usually understood as the orchestrator, the complementors, or components of the focal innovation. These actors are economically, technologically, and cognitively interdependent (Thomas and Autio, 2020) and share complementarities (Teece, 2018).

Technological interdependence means that actors are co-specialized around "a unique resource, shared platform, or a common modular architecture' (Autio and Thomas, 2021, p.4). Some actors in an ecosystem may share cognitive interdependencies. That means they believe in the same rules and share the same beliefs and values (Thomas & Autio, 2020). This type of interdependence can be found in other types of ecosystems, although other models are not analyzed in this research. Last but not least, another possible type of interdependency is economic interdependency. Economic interdependence means that, in an ecosystem, individual value capture is influenced by collective value capture. In the case of emerging ecosystems, there is still little economic interdependence as the ecosystem may still be starting to gain scale and scope.

The coordination of complementarities occurs nonhierarchically and in the absence of formal contracts (Shipilov & Gawer, 2020). Complementors develop innovations that complement the value proposition by providing services or products that, together with the components, add value for customers (Jacobides et al., 2018). What allows these organizations to produce components of a system independently is modularity (Jacobides et al., 2018).

The actors inside the ecosystem may collaborate and compete (Hannah & Eisenhardt, 2018) to create and capture value (Ritala et al., 2013) from the ecosystem structure (Bogers et al., 2019). When looking at the ecosystem from a co-evolutionary perspective, there may be a change in these actors' names and positions as the ecosystem evolves and goes through different evolution stages. Adner and Kapoor (2010) discuss how the different location of innovation (i.e., upstream vs. downstream) and its content (i.e., component innovation vs. complementary innovation) affects the focal firm's competitive position in the ecosystem. Thus, different ecosystems may exhibit varied innovation dynamism and evolutionary prospects (Gomes et al., 2018)

In this sense, from a conceptual point of view, the Adner concept understands the ecosystem as an expanded value chain (Gomes et al., 2018). This project considers IE from a structure perspective standpoint (Adner, 2017). More specifically, we follow Adner (2017), Autio (2021), and Jacobides et al. (2018) and consider an IE as a community of a not fully hierarchically controlled and independent, heterogeneous set of actors with varying degrees of multilateral and non-generic complementarities who collectively generate a coherent, ecosystem-level output and corresponding value offering targeted at a defined user audience. Besides this definition, we still want to add a complementary definition of IE: a network of individual and collective uncertainties.

One cannot ignore that IE is treated as something complex and multi-layered (Xu et al., 2018). Depending on the study area, other types of actors may be considered ecosystem members, such as clients, competitors, universities, research institutes, and regulatory authorities (Thomas & Autio, 2020). This project considers that internal ecosystem actors are the orchestrators, the complementors, and the components because this is the primary source of actors that interact to generate systemic innovation, a specific type of ecosystem-level output. These are the main actors because they are the ones who directly work on different parts of systemic innovation, regardless of how those parts make up a focal innovation (Gomes et al., 2021b).

System-level output (Autio & Thomas, 2021) may take the form of products and services that are compatible with one another, often adhering to a modular product architecture that allows the user to assemble a customized composition of modules to suit individual preferences."

2.1.1 Nascent Innovation Ecosystems

An ecosystem can go through pre-initiation, birth/formation, growth/ expansion, maturity/ leadership, and reconfiguration/ self-renewal phases (Moore, 1996; Dedehayir et al., 2018; Rabelo & Bernus, 2015; Dattée et al., 2018). The emergence of ecosystems has been discussed in the literature (Thomas, 2013; Thomas and Autio, 2014; Dattée et al., 2018; Dedehayir et al., 2018; Sultana et al., 2023). Emergence is an "incipient" stage (Dedehayir et al., 2018) of IE development because the growth occurs in a non-linear fashion, and the development trajectories are emergent rather than strictly controlled (Ritala & Almpanopoulous, 2017). The IE progresses from a random collection of elements to a more structured community (Moore, 1993).

In a recent literature review (Autio and Thomas, 2021), the authors referred to Dattée, Alexy, and Autio (2018), Hannah and Eisenhardt (2018), Snihur et al. (2018) explained the research field of the emergent ecosystem. The authors split this research field into two research streams. The fourth research streams consider IE emergence as a collective emergence process (Dattée et al. 2018). Thomas and Autio (2014) analyzed five high-technology emerging ecosystems (Amazon, eBay, Facebook, Google, and Salesforce) and commented that it took around five years for the ecosystem to begin effectively capturing value (time to profitability). Dattée et al. (2018) analyzed two ecosystems (world leaders in the IT and telecommunication industries) and identified that the emergence took between five to ten years to occur. Shi et al.

(2021) investigated the tele rehabilitation through the games ecosystem and presented a nascent ecosystem that took three years to develop.

Planning IE for emergence is not an easy task, mainly if the value proposition is tightly coupled with a nascent industry. Although IEs consist of interdependent firms from multiple industries with some degree of inter-industry interdependencies (Thomas and Autio, 2014), there will always be a specific technology-based industry that will be nascent to start the ecosystem, as we can observe in the nanomaterials ecosystem, with antibacterial property and was capable of eliminating anaerobic organisms (Gomes et al., 2021c), telerehabilitation through gaming industry (Shi et al., 2021), blockchain industry (Kapoor & Klueter, 2021). Thus, some emerging ecosystems can be born in the heart of a nascent industry.

The ecosystem emergence phase has already been studied in light of industry lifecycle literature (Thomas & Autio, 2014). The new technology provides dramatic improvements to current product market paradigms or creates entirely new industries (Kostoff et al., 2004). These technologies, like air taxis (Zuzul & Tripsas, 2020) are born in the science IE layer, reaching their technical feasibility in the technology ecosystem layer and the economic viability in the business ecosystem layer (Xu et al., 2018). The interplay among these layers will make feasible the nascent IE (Xu et al., 2018). The IE begins when the technology is ready to apply to products and services. As an interviewee from Dattée et al. paper (2018, p.23) commented: “The objective is not to discuss the technology because the technology is there, but to imagine and design what the business model can be, what is the value proposition and who pays for what.”

The literature describes processes that underlie the emergence phase of an IE. In some works, this process seems sequential (i.e., Rabelo & Bernus, 2015; Dattée et al., 2018; Dedehayir et al., 2018), while others do not (i.e., Talmar et al., 2020). Mapping is a process that defines the value proposition and niche strategy to be targeted (Rabelo & Bernus, 2015; Talmar et al., 2020). Dattée et al. (2018) even call this process "Narrowing the Future". A general analysis of existing and desired future technological scenarios (Rabelo & Bernus, 2015) and envisioned sets of interdependencies (Dattée et al., 2018).

Figure 1 shows the main phases of ecosystem emergence based on the literature review. Design is another essential process during IE emergence. This process consists of organizing IE requirements, components, actors' roles, resources, value addition, and degree of dependence on the success of ecosystems (Rabelo & Bernus, 2015; Talmar et al., 2020) into a tangible architecture. Building an IE involves considering numerous and evolving elements required for creating the conditions to nourish, flourish, and sustain innovation (Rabelo & Bernus, 2015). This phase is crucial because it deals with planning the initial actions that trigger subsequent actions in a larger group of actors.

Figure 1 - Elements Related to the Ecosystem Emergence Process

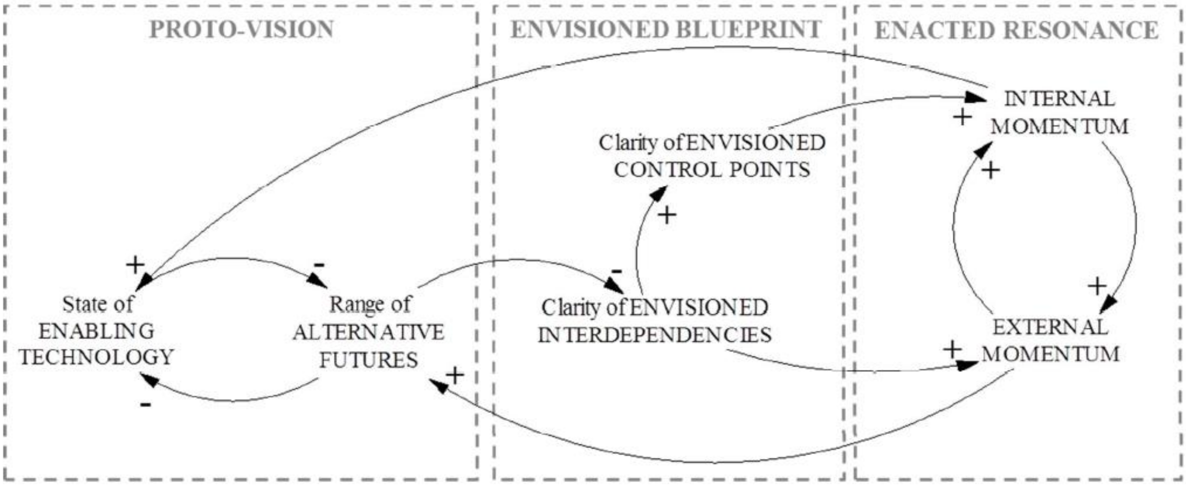
Source: Author's elaboration.

Thomas and Autio (2014) analyze the emergence process of six ecosystems. The authors propose three phases of emergence: The Initiation phase consists of the initial idea and technological development, resource gathering, and early operation. In the second phase, which we call Momentum, the ecosystem begins to grow rapidly, with competitor entry, increasing numbers of participants (driven by positive network effects), aggressive marketing, much press, and societal interest, as well as investment. In the Control phase, the focus moves from growth to control and value capture, as the ecosystem is established as the undisputed leader.

Dattée et al. (2018) investigated four IE created by leading companies in the technology and communication market to understand how these orchestrators simultaneously conducted a collective process to discover and implement a complex VP through an IE, while guaranteed they would benefit from the fruits of the collective effort. As a result, the authors present a model that portrays ecosystem strategy as a closed-loop process. The orchestrator controls this closed system to ensure that it maintains its position in the ecosystem over the long term. We think this work is interesting because it shows that the creation of an ecosystem is an ongoing process of a man aging coupled feedback loops. Some feedback loops consolidate the ecosystem's trajectory, narrowing the range of alternative futures and forcing the focal company to keep up with the ecosystem's dynamics.

According to Dattée et al. (2018), the ecosystem emergence process comprises three major phases. The first one, “Proto-Vision,” happens when the orchestrator gives a clearer direction for developing the technology in a way to arrive, potentially, at an even narrower range of future applications. During this phase, they are learning about intended as well as unforeseen areas of the application, allowing the firms to better understand what each enabling technology could be about, as well as how to potentially develop it further to discover new, more refined applications. The second phase, “Envisioned Blueprint,” is about designing a tangible architecture to convince/ engage actors to join the IE and also to identify and capture control points. The third one is “To enact resonance” and is a reinforcing feedback loop leading to the amplification of reciprocal resource commitments between external and internal actors. This resonance loop creates an increasing actor’s path dependency, which reduces uncertainty and entrenches the ecosystem's trajectory toward one clarified and shared vision. The escalating internal and external resource commitments directed by the orchestrators led to ecosystems emerging. To move toward actual future value creation (in which this value capture could happen). Figure 2 shows how IE emerges.

Figure 2 - A Revised Process Model for Innovation Ecosystem Creation



Source: Dattée et al. (2018).

As noted above, many authors define different phases of the ecosystem's lifecycle. Some authors focus on understanding the pre-initiation planning for emergence phases (see Souza-Luz et al., 2024). Other researchers try to explain the ecosystem after birth. Looking mainly at the work of Dattée et al. (2018) defined the beginning of the ecosystem emergence process as the “Proto-vision” and the end of the ecosystem emergence process as the “enacted resonance” when the ecosystem starts to grow (Enacted Resonance).

2.1.1.1 Proto-Vision

During the emergence of the ecosystem, the first versions of the technology are enabled and ready to be commercialized. Requirements and initial architecture for the technology have already been developed (Thomas & Autio, 2014). Dattée et al. 2018 portray those stakeholders may want to design some alternative futures to visualize the future of newly emerging technology. Some ideas about how the ecosystem "should be" developed emerge from the very first actors who co-produced the technologies (Thomas & Autio, 2014). This exchange of ideas about developments is a regular and collaborative process (Thomas & Autio, 2014).

These actors cooperatively worked together to co-opt key customers. Some users have already started to test the value proposition (Shi et al., 2021; Thomas & Autio, 2014). In the case of telerehabilitation through the gaming industry, Shi, Li, and Chumnumpan (2020) comment on the initial strangeness that can occur, in the users' view, when having contact with something very new. There is already an idea of who is the user of the ecosystem as a function of initial sales tests for these users (Thomas & Autio, 2014).

In this phase, the orchestrator provides greater influence and directs the ecosystem. Some control points have already been mapped by the orchestrator (Dattée et al., 2018; Thomas and Autio, 2014). Some orchestrators may even perform actions to discourage troll behavior (actors who disagree by starting arguments or upsetting people), as Thomas and Autio (2014) identified in the case of this first phase of the emergence of Wikipedia’s ecosystem.

The building of ecosystem collective identity (i.e., the set of mutual understandings among ecosystem participants regarding the IE VP's central, enduring, and distinctive characteristics) is very important in the ecosystem emergence stage. Taking an institutional view, Sweden, Lindgren et al. (2015) show that an IE collective identity needs to be aligned with the emerging ecosystem VP, or conflict occurs. Thomas and Ritala (2021) showed that identity is a process that starts when the ecosystem first begins to attract participants encompassing both the cognitive and social aspects of identity. The identity of an ecosystem is built as the Internal IE members are convinced about the ecosystem proposal (Dattée et al., 2018; Thomas & Ritala, 2021). When studying the Digital Photography Company, Zuzul and Tripsas (2020) showed that firms in emerging industries can create identities that are intertwined with the identity of the industry as a whole and, thus, shape key aspects of the industry. This study, among others, shows how firm-level identity can be interrelated with collective-level identity.

An ecosystem identity facilitates the mutual understanding of the IE VP, that is, what the ecosystem is about, what it seeks to achieve, and how it seeks to do this (Thomas & Ritala, 2021). Similar affirmation takes place via visible identity signals across user communities (Hakala et al., 2017). Through ecosystem identity, it's possible to reach coalignment through a mutual sense of “who we are” and “what we do” (Thomas & Ritala, 2021). During this Proto-vision phase, the nascent ecosystem is just starting to build its identity. The collective identity is not yet consolidated

(Thomas & Ritala, 2021). Some ecosystem participants may come to manifest this identity through symbols (e.g., corporate brand) (Cornelissen et al., 2007; Thomas & Ritala, 2021; Hakala et al., 2017).

2.1.1.2 Enacted Resonance

Ecosystem growth is an ongoing process. The growth phase is associated in the literature with the word Momentum (Thomas & Autio, 2014; Dattée et al., 2018). This phase begins when the ecosystem starts to leverage its operations and expand in a sharp curve. The beginning of the ascent closes the cycle of ecosystem emergence. It is not the aim of this research to describe the accelerated growth phase, although Thomas and Autio (2014) understand that it still belongs to the emergency stage. We are more interested in understanding the emergence in its essence, the most embryonic phase, before the formal structuring of governance processes takes place.

If we associate the emergence of the IE with the emergence of the nascent industries, as proposed by Furr and Eisenhardt (2021), we could say that companies are becoming “adolescents” (Furr & Eisenhardt, 2021) along with the IE. The beginning of the accelerated growth follows an IE uncertainty reduction curve and an increase of IE resources (Furr & Eisenhard, 2021), an increase in the sense of collective identity and legitimacy among members (Thomas & Ritala, 2021), and an increase in the number of actors (Thomas & Autio, 2014; Dattée et al., 2018).

One important element to evaluate if ecosystems are entering into the enacted resonance is external legitimacy. The process of building legitimacy takes place along the ecosystem's trajectory and depends not only on the goodwill of the orchestrator and complementors but also on the end users and actions outside the ecosystem, such as media reports (Thomas & Ritala, 2021). During the enacted resonance phase, the ecosystem already has a designed identity and an existing degree of legitimacy.

The processes of cognitive legitimacy drive the emerging ecosystem meaning (Thomas & Ritala, 2021). The construction of cognitive legitimacy takes place through discursive processes that drive the compressibility of the IE value proposition. This construction takes place through activities that motivate and convince others to accept and participate in the IE, as well as build a shared understanding of its purpose with the broader economic and social environment (Thomas & Ritala, 2021).

The processes of cognitive legitimacy drive the meaning and compressibility of the IE value proposition (Thomas & Ritala, 2021) through discursive processes (i.e., activities that motivate and convince others to accept and participate in the IE, as well as build a shared understanding of its purpose with the broader economic and social environment) (Thomas & Ritala, 2021). Moreover, the processes of normative legitimacy drive the viability of the ecosystem (Thomas & Ritala, 2021) through performative processes (i.e., processes of strategic action, value realization, adoption, and external intervention) (Thomas & Ritala, 2021). Thomas & Ritala (2021) and Thomas and Autio (2014) comment on the role of orchestrators in increasing normative legitimacy by investing resources (i.e., infrastructure, methodology, controls, governance) in the ecosystem. Investments in aggressive marketing are also important to increase the interest of the media and society as well (Thomas & Autio, 2014).

We also see if the ecosystem is evolving from the increase in the number of users and increasing IE members' number (i.e., new companies interested in joining the ecosystem) (Dattée et al., 2018, Thomas & Autio, 2014). The increasing number of participants is due to positive IE network effects (Thomas & Autio, 2014). In this sense, as IE begins to grow rapidly, with competitor entry, orchestrators will also need to use resources to retaliate against other competing IEs, as in the case of Facebook (during its early growth phase in 2004, it took some steps to recapture other ecosystems through of the surround' strategy) (Thomas & Autio, 2014). In this sense, value capture is also an important driver of the Enacted Resonance phase. The orchestrator may encourage the IE value capture by establishing rules for fair and equitable distribution of rights associated with actors' intellectual property assets.

Below we present Table 3. The main focus of this table is to show the reader what is the focus of the analysis of this thesis.

Table 3 - Innovation Ecosystem Main Elements

IE Components	Design	The particular set of activities and resources that interrelate firms and shape the value proposition	Ganco et al. (2020); Gomes et al., (2021a); Luo (2018); Shipilov and Gawer (2020)
	Systemic innovation	The “conducting wire” for the companies in the ecosystem, the main innovative ideas that shape the ecosystem itself.	Dosi (1982); Fine (2010); Lim et al (2010);
	Complementarities	The unique, generic, and supermodular complementarities that are important to deliver the value proposition to the market.	Jacobides et al. (2018); Shipilov and Gawer (2020)
	Competition outside IE	Other ecosystems compete to deliver the same focal value proposition to the market.	Pombo-Juárez et al. (2017); Xu et al. (2018)
	Value System	Actor’s knowledge of how to create and capture value from the ecosystem.	Talmar et al. (2020); Gomes et al. (2018); Pellikka and Ali-Vehmas (2016); Teece (1986)
	Actors	The human and non-human representatives that establish some relationships among themselves. Some companies assume the roles of orchestrators, while others might assume the roles of complements, providers, or even clients of the value proposition.	Talmar et al. (2020); Thomas and Autio (2020)
	Interdependence	The links that “glue” firms together (usually by the degree of technological, economic, and cognitive interdependencies). Changes in this interrelatedness process and activities might impact the ecosystem.	Shipilov and Gawer (2020); Gomes et al., (2021b)
	Structure	The collective arrangements among the interconnected members of the ecosystem.	Shipilov and Gawer (2020)
	Collaboration	The combined efforts between companies to achieve common goals and benefits.	Adner (2017)
	Competition level	The degree of competition that companies in the ecosystem have among themselves.	Adner (2017); Talmar et al. (2020)
	Activities	Routines that take place between ecosystem members to create and capture value.	Talmar et al. (2020)
	IE Configuration	The essential flows of information, knowledge, resources, and activities flow within the ecosystem structure.	Shipilov and Gawer (2020), Talmar et al. (2020); Gomes et al. (2021b)

	IE Identity	The shared meaning of the ecosystem that arises from the consciousness of its members.	Gomes et al. (2021b); Thomas and Autio (2020)
IE nascent Stages	Proto-Vision	-First versions of the technology are enabled; - Requirements and initial architecture for the technology developed; - Alternative ecosystem futures designed; - Ideas of how the ecosystem "should be" developed; - The idea of who is the user of the ecosystem has already been imagined; -Some asset complementarities and interdependencies are already known; -Some control points have already been mapped; - Some users starting to test the value proposition; - Cooperative work to co-opt key customers and partners;	Dattée et al. (2018); Thomas and Autio (2014)
	Enacted Resonance	- Actor's expectations aligned; -New actors interested in joining the ecosystem; - Actors convinced about the ecosystem proposal; -Actors with formatted sales volume potential ideas; - Actors found ways to access users; - Increasing numbers of participants (driven by positive network effects) - Aggressive marketing, much press, and societal interest;	

Source: Author's Elaboration.

2.2 THE UNCERTAINTY

Before we describe the IE construct. We start by describing the historical evolution of uncertainty studies. Then, we present how this research field evolved into entrepreneurship studies. We then present the different facets of the uncertainty construct in terms of ontologies, approaches, sources, and types. We finish the section by showing uncertainties in nascent IEs.

2.2.1 Historical Evolution of Uncertainty Studies

The entrepreneur's uncertainty-bearing role may be traced back to Richard Cantillon, an eighteenth-century French economist. Cantillon suggested that entrepreneurs performed the vital economic function of committing to buy inputs without knowing how much customers would pay for their end products (Bhidé, 1999). For example, a shoe manufacturer paid fixed prices for their footwear components, with the hope of selling the shoes at a price that could exceed its costs to the wholesaler. The wholesaler paid a fixed price for the shoes, with the hope they could see it to the retailer at a price superior to the costs he had. The same happens with the retailer when selling to the final client. Bhidé (1999) explained that this chain of "speculation" and risk bearing (rather than arbitrage) was the key to the market system. Frank Knight refined the risk-bearing idea from an economic point of view to argue that profit represents the entrepreneur's reward for assuming responsibility for unmeasurable and unquantifiable risk, which he called "uncertainty" (Knight, 1921).

Knight (1921) is credited with being the first writer to make a clear distinction between risk and uncertainty. For Knight, the generation of economic profit takes place under fundamental or true. His ideas decoupled him from the dominant economic theory of the time (Mousavi & Gigerenzeret, 2014). Knight (1921) described three types of uncertainty and showed how we could understand and deal with each of them.

Table 4 - Decisions Under Risk vs. Uncertainty

Nature of unknown	Knight probability	Decision process	Simple Example	Application to managerial research	Method	Generated knowledge
Risk ("weak uncertainty", "Foreseeable Uncertainty")	A priori probability (design; propensity)	Deductive (Know distributions and unknown draws)	In a box that you can open, there is the exact number of green and red balls. If you know the exact number of balls on a box and the fact that there are only two colors, you know that we have a 50-50 chance of drawing a green ball. So, you can calculate the distribution of balls inside a box.	Repeatable instances from the past help decision-makers predict the future. If the analyst can identify a set of similar previous events, the analyst can calculate the probability of the expected occurrence of similar events in the future.	Use probability theory to model the underlying structure; optimization	Deterministic knowledge (as in lotteries); e.g., objective odds
Risk	Statistical probability (frequencies in the long run)	Inductive (statistical inference) (Know distributions and unknown draws)	You don't know how many balls are in the box or how many colors. The only way to calculate the chances is to open the box and count. You cannot open the box to count. So, you cannot calculate the distribution of balls inside a box. If you are not allowed to do that, you will simply be guessing. You will keep trying to create an exhaustive mental map of the numbers and colors using trial and error, experimentation, and lots of calculations over time before you can calculate the odds of drawing a green ball.		Use statistical inference; optimization	Stochastic knowledge, e.g., estimates of correlations
Uncertainty (or "true", "strong," or "unforeseeable" uncertainty)	Estimate; conduct based on opinion; not fully reasoned	Heuristic (Unknown distributions and unknown draws)	You don't know what is inside the box at all. And you cannot open the box. So can build your own box and put inside them whatever you want.	There are no repeatable instances from the past that help decision-makers to predict the future.	Select a heuristic that is ecologically rational for a task; exploratory data analysis	Satisficing solutions when optimizing is not feasible; intuition (as in entrepreneurship)

Source: adapted from Mousavi & Gigerenzeret (2014).

Table 4 shows a typology of how the unknown feature of a situation can be formally characterized and assessed. We can depict from the table the three types of uncertainty described by Knight (1921). The first type, “weak uncertainty”, “risk”, “Knightian a priori probability,” or “Foreseeable Uncertainty,” is a measurable uncertainty. The first type consists of a situation where available information is used to form a deductive knowledge of a situation, departing from general truths and objective odds already known and existing. The mindset behind this idea is to use the information to form a deductive knowledge of the situation (Mousavi & Gigerenzeret, 2014). Risk is an a priori probability known by the design of a die or slot machine, not by observation. Risks are a weak uncertainty because they can be hedged, pooled, or otherwise neutralized.

The second type (Knightian statistical probability) consists of collecting empirical and experimental evidence/data from repeated observations and aggregating these observations to infer the properties of the true statistical probability distributions (Mousavi & Gigerenzeret, 2014). Although the mathematics of probability applies basically to risk calculations, these proxies may lose relevance for “uncertainty” or “true uncertainty” calculations. We will discuss a little bit about these objectives (predictive)-and and-subjective (control) calculations in subsection 2.2.4).

The third model of uncertainty or “true”, “strong,” or “unforeseeable” uncertainty consists of situations in which information about the future is incomplete, unknown, or unavailable (Furr & Eggers, 2021), so the probabilities cannot be reliably estimated or where the set of alternatives and their consequences are not known in the first place. In this situation, probability theory/statistics can no longer find the best solution, and other inductive tools are needed, such as heuristics (e.g., search rules, aspiration levels, lexicographic rules, and other heuristic principles, intuition, gut feelings) (Mousavi & Gigerenzeret, 2014).

Following Knight (1921), other decision theorists before the fifties (see, for example, game theorists such as Luce and Raiffa, 1957; Taussig, 1921) understand uncertainty as a situation where the individual cannot assign probabilities to the outcome of events. Other conceptualizations for different knowledge gaps emerged[1].

[1] There is an extensive literature on ambiguity, equivocality, and complexity (for a revision on the application of this terminologies in entrepreneurship research, see Townsend, 2020 and Rindova & Courtney 2020). Some authors consider ambiguity as a particular type of uncertainty (Amoroso et al.,

After the fifties, uncertainty evolved from an exogenous anomaly to a foundation of analysis. This construct has undergone many refinements throughout the past few decades (Chawla et al., 2012). Duncan (1972), for example, criticized previous approaches to uncertainty because, in his vision, it was “too restricted” to a “narrower mathematical definition”. This author added to the theory by posing that if we apply the uncertainty construct to the managerial theories, it’s important to consider that managers can interpret the situations affecting the organization (Duncan (1972, p.318).

Contingency theorists assumed uncertainty as an objective phenomenon too, and the key issue thus became how this “objective” uncertainty impacts decision-making flexibility. Thompson (2003) defined what is a complex environment, while Lawrence and Lorsch (1967) elaborated on the link between these complex environment characteristics as precursors for different organizational structures.

So, these later authors created the idea of “perceptual uncertainty” and broadened proposing a subjective approach to uncertainty showing that managers have different perceptions and tolerance for ambiguity or uncertainty when dealing with organization issues. Milliken (1987) advanced these perceptual ideas by proposing three types of uncertainty (state, response, and effect); meanwhile, Daft and Weick (1984) proposed that uncertainty might be a subjective process by which individuals interpret ambiguous information and construct plausible accounts that allow them to act. sensemaking process.

A wide number of other authors from management schools started to investigate uncertainty. Resource-based theorists discussed uncertainty management. Penrose (1959) commented on ideas of uncertain activities leading to complex managerial tasks. More recently, Barney (1991) understood uncertainty as an overcoming information gap. These previous authors see uncertainty from a more positivist point of view, arguing that uncertainty can be mitigated if we properly allocate resources to solve that. Resource dependence theorists evolved on these ideas showing that organizations structure their external relationships in response to the uncertainty resulting from dependence on elements of the environment (Furr & Eisenhardt, 2021).

2017). These other terminologies are not part of this study, although we recognize the importance of the study mainly on ambiguity for management research field. Ambiguity refers to the collapse of sensemaking (Weick, 1995), when it is impossible to discern what is important or even what is going to happen. Lack of clarity/ awareness regarding the interpretation of a particular event or situation, the possible effects of this on. Complexity is the lack of understanding.

[2] https://aruanars2.wixsite.com/innovationeco

On the other theoretical spectrum, psychology theory, and self-organizing systems, we see uncertainty associated with the experience of anxiety and is linked to the activation of anxiety-related brain circuits (Hirsh et al. 2012). Simon (1979) brought psychological ideas to the managerial research field and created the "bounded rationality" construct, which shows that humans have a limited understanding of the world.

This idea of bounded rationality is also discussed by Dosi and Egidi (1991). This previous author pointed out the "procedural uncertainty" idea, which is the computational and cognitive limitations of agents in pursuing their goals arising from human cognitive limitations. These studies also favor quantitative-static research designs where knowledge is reduced to a measurable variable regardless of the research context. If we look at procedural uncertainty in transaction costs literature, we can associate these ideas with the bounded rationality of the firm's administrators. They have limited cognitive skills to cope with uncertainty, so studies in this arena try to depict the influence of procedural uncertainty on decisions concerning the scope of the firm, specifically the decision to vertically integrate.

More recently, we see alliances and networks theorists trying to understand how uncertainties affect and are affected by alliances and networks. For example, Sydow, et al. (2012) strongly encourage alliance and network scholars "to study uncertainty practices more deeply, focusing on how managers actually and recurrently make sense of and cope with uncertainty in inter-organizational collaborations". Even though these authors asked their community to embrace this challenge, we see that the entrepreneurship and innovation community delivered some answers to their questions recently (see Gomes et al. 2018, 2019, 2020).

2.2.2 Uncertainty Applied to Entrepreneurship Studies

Entrepreneurship theory is a way to understand how to respond to uncertainty, to situations in which there is no correct procedure for deciding what to do because this theory investigates human intelligence (what Knight calls the "cephalization" process, it means an ability to seize the situations and learn with them to solve problems creatively).

The entrepreneurship research field is the scholarly examination of the processes of discovery, evaluation, and exploitation of opportunities; and the set of individuals who discover, evaluate, and exploit them (Shane & Venkataraman, 2000, p. 218). We see that entrepreneurial function can be manifested in large and small firms, in old and new firms, by individuals or teams, across a variety of occupational categories, and so on (Klein, 2008).

Langlois (2007) fragmented this definition into three entrepreneurial “parts” or “functions”. The first one consists of what Kirzner defines as discovery and alertness to new opportunities. The second part consists of what Knight defines as evaluation or judgment in economic organization. The third part consists of what Schumpeter defines as exploitation the carrying out of new combinations and the creative destruction that often results therefrom. Klein one year later (2008), added other dimensions to Langlois's (2007) theory fragmentation ideas and showed that besides discovery, evaluation, and exploitation, the theory also pays attention to coordination and adaptation.

We think this “repartition” of entrepreneurial functions is important because it can help us understand why uncertainty is a topic so strongly related to entrepreneurial studies. We see that Knight’s work is focused on answering the evaluation or judgment aspect of the previously mentioned entrepreneurial function. (Knightian) uncertainty enables entrepreneurs to act autonomously and creatively, and these actions, at the same time, endogenously lead entrepreneurial actions to be almost arbitrary (aleatory, subjective) rather than deliberate (reflexive, farseeing).

Recently Kano (2021) discussed how the concept of Knightian uncertainties could be embraced into the entrepreneurial field of studies, showing the two main research streams that applied Knight's ideas on entrepreneurial research: Kirzner (1973) and Lachmann (1976) entrepreneurial schools. According to Kano (2021), both opposite researchers were born in Austrian economics and are well known for their contribution to the analysis of entrepreneurial processes. Both agree that entrepreneurs cannot avoid error or loss in a world of uncertainty. However, while Kirznersians believe that the market tends toward equilibration because entrepreneurs are always “alert” to unnoticed opportunities, so they engage in arbitrage, consequently tending toward equilibrium, Lachmannerians think that the market tends toward divergence because entrepreneurs are always formulating their plan based on radical subjectivism (imagination or subjective expectations).

In this thesis, we follow Lachmann (1976) who states that the future is to all of us unknowable, though not unimaginable, but the human mind is capable of imagining possibilities and, from them, forming expectations, even for and within indeterminate circumstances.

Considering the great relevance that uncertainty has in entrepreneurship studies, we dedicated the next subchapters to explaining what uncertainty is, what types and areas of uncertainty might affect entrepreneurial activity, and what its sources originate from this construct.

2.2.3 Managerial Ontology

The managerial literature shows that uncertainty is a multifaceted construct because it involves different dimensions. Distinct organizational theories have emerged to incorporate uncertainty as an analytical construct. One important dimension that we have is managerial ontology. Put in other words, it is how managers see uncertainty (the way they interpret uncertainty as something that is a “good influence” or “bad influence” on their firms).

Managerial studies approached both ontologies. If we look inside the “good influence” literature, authors believe that uncertainty is essential to make room for freedom of creative and bold entrepreneurial actions (Lachmann, 1976).

At the startup- level of analysis, previous studies show that highly uncertain contexts create a favorable context that helps startup entrepreneurs with limited endowments (Bhidé, 1999). So, startups should create, maintain, and amplify uncertainty (Bhidé, 1999) to enable the existence of opportunities in the market (Mcgrath & Macmillan, 2000; Shane & Venkataraman, 2000).

At the project level of analysis, uncertainty has been proven to be something positive to exert positive effects of uncertainty on R&D investment too (Ross et al., 2018). This influence has also been considered a positive source of value for projects (Huchzermeier & Loch, 2001).

At the value-chain level of analysis, we see that volume and behavioral uncertainty also have a positive relationship with forward integration into distribution (John & Weitz, 1988). Moreover, supplier uncertainty is positively associated with decisions to vertically integrate. The association between supplier uncertainty and the decision to vertically integrate, moderated by the extent to which decision-makers take supplier uncertainty information into account proven to also be positive (Sutcliffe & Zaheer, 1998).

On the other hand, if we look inside the “bad influence” literature, the authors believe that uncertainty should be avoided, mitigated, or reduced. This literature seems to be broader than the previous one and shows the negative effects of uncertainty on SMEs’ employment growth (Ghosal & Ye, 2015) and entrepreneurs’ ability to exploit opportunities successfully (Miller, 2012).

Psychologically, uncertainty is experienced subjectively as anxiety and is associated with activity in the anterior cingulate cortex and tended noradrenaline release (Hirsh et al., 2012). Hirsh et al. (2012) pose that (a) uncertainty is a critical adaptative challenge for any organism, so individuals are motivated to keep it at a manageable level; (b) uncertainty emerges as a function of the conflict between competing perceptual and behavioral affordances; (c) adopting clear goals and belief structures helps to constrain the experience of uncertainty by reducing the spread of competing affordances, and (d) uncertainty is experienced subjectively as anxiety and is associated with activity in the anterior cingulate cortex and with heightened noradrenaline release.

Financially speaking, uncertainty negatively impacts a firm’s R&D investment decisions (Li et al., 2021). Profit-margin uncertainty significantly reduces firms’ investments (Ghosal, 1996). Uncertainty might also negatively impact key firm-level outcomes such as early-stage capitalization processes (Townsend & Busenitz, 2015).

At the project level, uncertainty might exert other influences on R&D collaboration (Banerjee & Siebert, 2017), processes (Verganti, 1999), and returns (Amoroso et al., 2017). At the organizational level, perceived environmental uncertainty influences organizational structures and processes (Huber et al.,1975).

At the inter-organizational level, technological uncertainty impacts collaborative relationships (Hoetker, 2005), strategic alliances (Martínez-Noya and Narula, 2018), and contract agreements (Carson et al., 2006). Technological uncertainty also discourages vertical integration due to the lowered profits in such industries, so it impacts the industry emergence process (Moeen et al., 2020).

Supply uncertainty (uncertainty regarding the partner’s possible opportunism) affects the governance efficiency of the relationship and lowers incentives to invest in transaction-specific assets that may be committed to the relationship. Uncertainty is also negatively associated with decisions to vertically integrate (Sutcliffe & Zaheer, 1998).

2.2.4 Predicted-objective x Control-subjective Approaches to Uncertainty

Researchers don't agree on the operationalization of the uncertainty construct. If we look at previous works, we will see that some authors try to employ predictive-based objective metrics to uncertainty meanwhile others employ control-based subjective metrics.

Objective metrics as, for example, statistical modeling of the process that determines the conditional variance of an aggregate indicator at the industry level, such as price level or industry output (Ross et al., 2018; Dixit & Pindyck, 2012), and regression-based forecasting models (Banerjee & Siebert, 2017).

Researchers usually employ objective metrics by analyzing dispersions of expert opinions (Zhang, 2006; Anderson et al., 2009). Another way to operationalize uncertainty is by analyzing secondary data by using a seven-point Likert-type scale to evaluate the degrees of uncertainty avoidance (Young et al., 2018). They also analyze uncertainty through secondary data volatility index from the options market. For example, Bird and colleagues (2012) evaluated uncertainty daily by calculating the implied volatility of the call and sell options contracts.

On the other hand, other authors like Milliken (1987, p.135) understand that externally measurable constructs are problematic because there is 'no clear evidence of a relationship between objective characteristics of the environment and perceptions of uncertainty'. Some examples of studies that adopt this type of measure are Gomes et al., 2019; 2022).

Duncan (1972) was one of the first authors to introduce subjective metrics in the uncertainty management research field. The author developed a Likert system to subjectively capture uncertainty. The first operationalization dimension was the lack of information regarding the environmental factors associated with a given decision-making situation (i.e., by asking, "How often do you believe that the information you have about this factor is adequate for decision-making?"). The second dimension did not know the outcome of a specified decision in terms of how much the organization would lose if the decision were incorrect (i.e., by asking, "How often do you feel you are unable to predict how this factor is going to react to or be affected by decisions made in this group" and ranking the answers in (1) never, (2) seldom, (3) occasionally, (4) often and (5) always). The third dimension was the ability to assign probabilities as to the effect of a given factor on the success or failure of a decision (i.e., by asking, “How sure on a scale from 0,1 to 1,0 you think each of these factors is going to affect the success or failure of your workgroup in carrying out its function?” and “how confident in a scale from 0,1 to 1,0 you are In his estimate?")

Examples of subjective metrics are dummy variables that reflect the experimental levels of primary, competitive, and supplier uncertainty (1 = low, 2 = high) (Sutcliffe & Zaheer, 1998; Milliken, 1987). Another example is the Pich, Loch, and Meyer (2002) study, where the authors rated four factors at the firm level: (a) whether economic risks in innovation are too big; (b) whether the investment required by technology innovation is too much; (c) whether the firm lacks sufficient accumulated technology; and (d) whether the firm lacks relevant technological information for innovation. In this same direction, perceived environmental uncertainty has been measured directly by asking managers about the market or partner-specific, or other dimensions of network uncertainty.

Duncan (1972) developed a Matrix showing different states of perceived uncertainty decision-makers might face when they face simple or complex perceived uncertainty in the environmental state dimension. Accordingly, to the author, there are different environmental state dimensions and predicted perceived uncertainty experienced by individuals in decision units. In simple and static environments, there is a small number of factors and components in the environment. These factors are somewhat similar to one another, remain basically the same, and don’t change. At the opposite dimension, in complex and dynamic environments, the ones Duncan understands as environments with “high perceived uncertainty”, the number of factors interfering in the decision-making process is high, as the number and heterogeneity of components in the environment. Table 5 shows a matrix that splits the perceived uncertainty concept into two Maxis (simple – complex and static- dynamic environments).

Table 5 - Degree of Perceived Uncertainty

		Simple	Complex
		"Low perceived uncertainty"	***"Moderately Low perceived uncertainty"***
Number of factors and components	Static environmen	Small	Large
Similarity between Factors and components	Static environmen	Factors and components similar to one another	Factors and components not similar to one another
Degree of change in Factors and components	Static environmen	Factors and components remain basically the same and are not changing	Factors and components remain basically the same
		"Moderately high perceived uncertainty"	***"High perceived uncertainty"***
Number of factors and components	Dynamic enviro	Small	Large
Similarity between Factors and components	Dynamic enviro	Factors and components similar to one another	Factors and components not similar to one another
Degree of change in Factors and components	Dynamic enviro	Factors and components are in a continuous process of change	Factors and components are in a continuous process of change

Source: Author's Elaboration

For this study, we follow the entrepreneurship research field tradition and employ subjective metrics to uncertainty. The next subsection is dedicated to presenting to the reader the Areas where uncertainty might impact.

2.2.5 Endogenous versus Exogenous Sources of Uncertainty

Areas of uncertainty manifestation mean where it shows, is revealed, and is firstly evidenced. The uncertainty construct also has a dimension related to its origin ("birthplace"). The origin of uncertainty means where decision-makers can see uncertainty emerge. Uncertainty might emerge at the individual level or collective individual level.

A Collective of individuals means that uncertainty emerges inside an organization or a specific project. An uncertainty can emerge at the network level or ecosystem level. At the network level, Sydow, et al. (2012) approach the uncertainty at the alliances and networks. At the ecosystem level, Gomes et al. (2018; 2019) showed the heart of uncertainty emergence in ecosystems. Internal boundaries (born within the ecosystem) or external boundaries (Dixit et al., 1994). Each level of aggregation can include different sources of uncertainty, presented in the next subsection.

What is the best way to manage and structure organizations to enable them to respond to and survive in an environment with sometimes high levels of uncertainty? Packard et al. (2017) discussed this question and showed that endogenous uncertainties could be influenced meanwhile exogenous uncertainties cannot. Entrepreneurs cannot influence exogenous sources of uncertainty because they are uncontrollable factors that interfere with the decision-making process. On the other hand, entrepreneurs can influence endogenous sources of uncertainty because these are controllable factors that interfere with the decision-making process (Packard et al., 2017), so they might use standard operating procedures that serve to reduce uncertainty (Duncan, 1972).

So, if uncertainty emerges endogenously or exogenously, it means inside or outside an organization's boundary. Examples of uncertainties that are born inside organizational boundaries (endogenous uncertainties) are the human imperfect cognitive ability to solve complex multivariable problems (Alchian, 1950), lack of absorptive capability (Chawa et al., 2012), the human, imperfect predictive ability to maximize profit even if we assume that optimum levels are known. At the project -level, the inability to map all the variables relevant to project performance (Gomes et al., 2013). Unforeseen influences might have an impact, for example, on new product innovation, as we can see in Unilever’s detergent project case (Keizera et al. 2002) and Webcam’s failure case of miscalculated customer acceptance website and system of computerized warehouses (Loch et al., 2008).

At the organizational- level, uncertainties are political and power structures of the organization, among other organizational issues related to the development and commercialization of the technology (Rice et al., 2008).

Organizations might face uncertainty regarding their resources, like, for example, talent attraction and funding and company necessary resources (i.e., financial skills, among others) to develop and commercialize technologies (Rice et al., 2008)

Examples of uncertainties that are born outside organizational boundaries (exogenous uncertainties) are many. Some authors call this “primary uncertainty” because it is a lack of knowledge about states of nature, such as natural events, that affect a firm’s investment decisions. Uncertainty arising from exogenous sources might be related to the market. For example, changes in preferences, uncertainties about customer needs, and market size. Uncertainty might also emerge from the partial knowledge about customers' explicit and latent functional and price preferences. Customers themselves may be unaware of their preferences (Moeen et al., 2020).

Sydow et al., (2012) performed a systematic literature review on uncertainty, risk, and ambiguity and reviewed 49 articles (most of them from the innovation and technology management research area) that dealt with uncertainty and risk at the network level and showed that uncertainty is usually a construct that is simply assumed or inferred from the variation of some other exogenous variable (e.g., the volatility of an industry in terms of financial performance, sales and profits in the industry in which an alliance participates.)

At the competition level, uncertainty sources are born on competitors because we don't know their actions which may be either 'innocent' or 'strategic'. For example, a source of uncertainty might be related to the lack of competitor intelligence or awareness about the prospective actions of competitor firms (Wernerfelt and Karnani, 1987).

At the inter-organizational level, relationships and partnerships are a source of uncertainty characterized by information asymmetries between market participants (Sydow et al., 2012).

At the supply level, Wernerfelt and Karnani (1987) commented on the lack of knowledge about the behaviors of the vertical partner in the transaction (i.e., possible behavior of strategic non-disclosure/disguise/distortion of information).

At the technology level, the literature describes sources of uncertainty as partial knowledge about technical components design and architectures (e.g., What existing technical components to rely on? What new components to develop? How to combine components within an architecture?) (Rice et al., 2008; Moeen et al., 2020). Uncertainty regarding technology performance and accurate assessment of the effort and time necessary to achieve a technological advance (Rice et al., 2008). Moreover, uncertainty about possible applications where the new technology can be successfully deployed, and difficult to determine which application technology will create the most value (Rice et al., 2008).

At the institutional level, partial knowledge about institutions (Moeen et al., 2020), policy interventions (Dixit and Pindyck, 2012), changes in regulations (Ghosal & Ye, 2015), such as those involving standards or tariffs (Sutcliffe & Zaheer, 1998).

Unexpected shocks and disruptive events might be a source of uncertainty, too (Li et al., 2021), as well as the normal fluctuation in market conditions (Saghaei et al., 2020) and industry revenues volatility.

2.2.6 Uncertainty Aggregative Typologies

Some researchers have advanced in trying to create typologies of uncertainties. Below we present some literature tentative to categorize uncertainties into abstractive theoretical typologies. Uncertainty is a multidimensional construct. Some authors tried to group sources of uncertainty into macro typologies. The idea here is to review how the literature has grouped these sources until now.

Milliken (1987) suggests that uncertainty is multidimensional and develops a typology disclosing uncertainty in three parts. According to a view, the first part, state uncertainty (or perceived environmental uncertainty), is an inability to assign probabilities to states of nature. The difficulty of predicting how an environment is changing (Milliken, 1987). The second part, effect uncertainty, is an inability to predict outcomes of managerial action. Lack of knowledge about cause-effect relationships, in particular, how states of nature will affect the organization (how these changes will impact the individual or firm). The third part, response uncertainty or “procedural uncertainty”, is the doubt about the “how to react” question. It means the inability to predict the outcomes of decisions and predicting what the consequences of each choice will be (Milliken, 1987). This typology deals with the computational and cognitive limitations of agents in pursuing their goals, even if the information is available. Arising from human cognitive limitations, i.e., bounded rationality (Dosi and Egidi, 1991).

Gomes et al. (2019) analyzed the phenomenon from a multilevel perspective (e.g., project, portfolio, organization, and network) and proposed three aggregative typologies of uncertainties: primitive uncertainty (related to how far the exploration is from the core—the exploration tolerance), structural uncertainty (related to the exploration breadth), and elementary uncertainty (related to the exploration depth).

Helfat and Teece (1987) and Williamson (1985) propose an aggregate typology using opportunistic relational logic. For these previous authors, behavioral uncertainty (also known as secondary uncertainty) means the difficulty in predicting the actions of other relevant actors, particularly given the potential for opportunistic behavior because actors might act with ‘self-interest seeking with guile’. The lack of knowledge about the actions of other economic actors might affect a firm's investment decisions because of the possibility of ex-ante or ex-post opportunism on the part of the exchange partner firm (for example, actors may use self-disbelieved statements and misinformation to profit at the expense of the exchange partner.

More recently, Gomes and da Silva Barros (2022) approached ecosystem-level uncertainty, more specifically, how the government deals with uncertainties concerning market formation in sustainability transitions, and identified three types of uncertainty aggregative typologies: configurational uncertainty (difficulty in predicting what the boundaries of the ecosystem in terms of structure/actors/activities exchanged among them are), affiliation uncertainty (difficulty in predicting whether the right actors would engage in a particular ecosystem to produce a coherent focal sustainability value proposition) and interdependence uncertainty (difficulties in predicting whether and how mutual dependencies would emerge and strengthen a new market).

Gomes et al. (2018) defined collective uncertainty, which refers to uncertainties that "affect a group of actors in an IE, affecting the performance of a group of actors and, in some cases, the performance of the whole IE.

2.2.7 Uncertainty in Nascent Innovation Ecosystems

Now we go deep into the ecosystem-level sources of uncertainty. During IE emergence, the perimeter of the overall value proposition is not established, the actors are not all identified, and the rules are still not entirely defined. There also may be difficulty in specifying the ex-ante value proposition. Mahmoud-Jouini and colleagues (2017) described a series of uncertainties related to this phase.

During IE emergence, the information is incomplete, unpredictable, or even unknowable (Furr & Eisenhardt, 2021). An ecosystem may struggle with "unclear or contested product definitions, ambiguous demand, and lack of a dominant design or legitimated category" (Furr & Eisenhardt, 2021, p.7). Resources may not yet exist or may have either indeterminate or changing value. When ecosystems are nascent, their architecture (e.g., roles, the system of activities, value creation, value distribution, and technical standards) is often unclear and contested. During IE emergence, actors may lack the coalignment structures that shape governance, institutional support, information, and evidence about IE viability (Thomas & Ritala, 2021). Also, it is not clear what the value proposition is (Thomas & Ritala, 2021).

In the IE emergence game, uncertainties, and doubts about the long-term sustainability of the ecosystem (Thomas & Ritala, 2021) play a significant role. Safeguarding the actors' particular views, which sources of uncertainty may be more critical in enabling IE progress?

Uncertainty can be considered a perceptual phenomenon. One may not deny that different individuals will perceive uncertainty differently. An ecosystem may face uncertainties regarding the intensity of competition (Adner, 2017). During this phase, it is difficult to predict the value structure before having the ecosystem up and running (Adner, 2006; 2012) and defining the ecosystem boundaries (Gomes et al., 2021a). Difficulty mapping and understanding the technological architecture underlying the value proposition (Kapoor & Klueter, 2021) and composition of focal innovations (Gomes et al., 2021a) and how the innovation development process is going to be (Adner, 2006; 2012). It is difficult to foresee all the necessary structures (often, new elements appear along the way) (Dattée et al., 2018).

An ecosystem may face uncertainties concerning recruiting ecosystem member candidates (Gomes et al., 2021a), and after recruiting, initial value realization suffers from a "chicken-and-egg" problem of launch and adoption (Dattée et al., 2018; Thomas & Ritala, 2021) that may cause disinterest and voluntary disconnection of these candidates. There may be uncertainties about really delivering benefits valued by the customers (Mahmoud-Jouini et al., 2017), guaranteeing that there would be an achieve mainstream adoption process across the value chain.

Actors may have a limited understanding of interdependence-related risks (Adner & Feiler, 2019). For example, whether and how the set of actors and their associated activities can contribute to the technology's value proposition. In a relationship of interdependence, if one actor depends on a specific complementarity more than another one, then the costs (and risks) of holdup for him will go up (Shipilov & Gawer, 2020).

Complementarities may have substantial costs in the presence of asymmetric dependencies (Shipilov & Gawer, 2020). That's why it is important to coordinate complementarities (Talmar et al., 2020) to avoid costs and asymmetries.

The coordination of the complementarities relies primarily on role definitions, complementarity, and technological, economic, and cognitive alignment structures that strike a balance between change and stability (Autio & Thomas, 2021, p.4). In a world in which market participants may not even share the same conceptual categories or interpret ‘information’ in the same way, problems of coordination are even more evident.

In this sense, there may be divergence in perspectives (expectations of value creation and value distribution) and interests across actors regarding values capture (Adner, 2017; Talmar et al., 2020), causing discontent and conflict between ecosystem participants (Thomas & Ritala, 2021). Actors may lack knowledge about resources and activities-related risks (Talmar et al., 2020). There may be uncertainty about how to establish legitimacy across these actors (Thomas & Ritala, 2021).

During ecosystem emergence, there are plenty of uncertainties regarding what new technological advances will be invented because there may exist a lack of knowledge about the foundations of the IE base technology (Kapoor & Klueter, 2021). There are also uncertainties if the technology will be standardized and commercialized, allowing for a migration from one value proposition to another (Kapoor & Klueter, 2021). Potential resistors might emerge and undermine the ecosystem's emergence.

If product delivery technical viability matters, as Adner and Kapoor (2016) explained when studying the micro-foundations of technological substitution in ecosystems, what would be the IE operational costs (Mahmoud-Jouini et al., 2017)? The is uncertainty about that too.

Figure 3 shows the different sources of uncertainty. This figure shows the uncertainties at the ecosystem level of analysis grouped in key ecosystem elements and based on our interpretation after analyzing the literature review. The figure has three parts.

The first part, the center, is the target of the ecosystem. When we talk about the ecosystem, the final target is always related to the collaborative generation of a concept, a product planning with the “value proposition”. So, we follow Talmar’s (2020) ideas and include this target at the center of the figure.

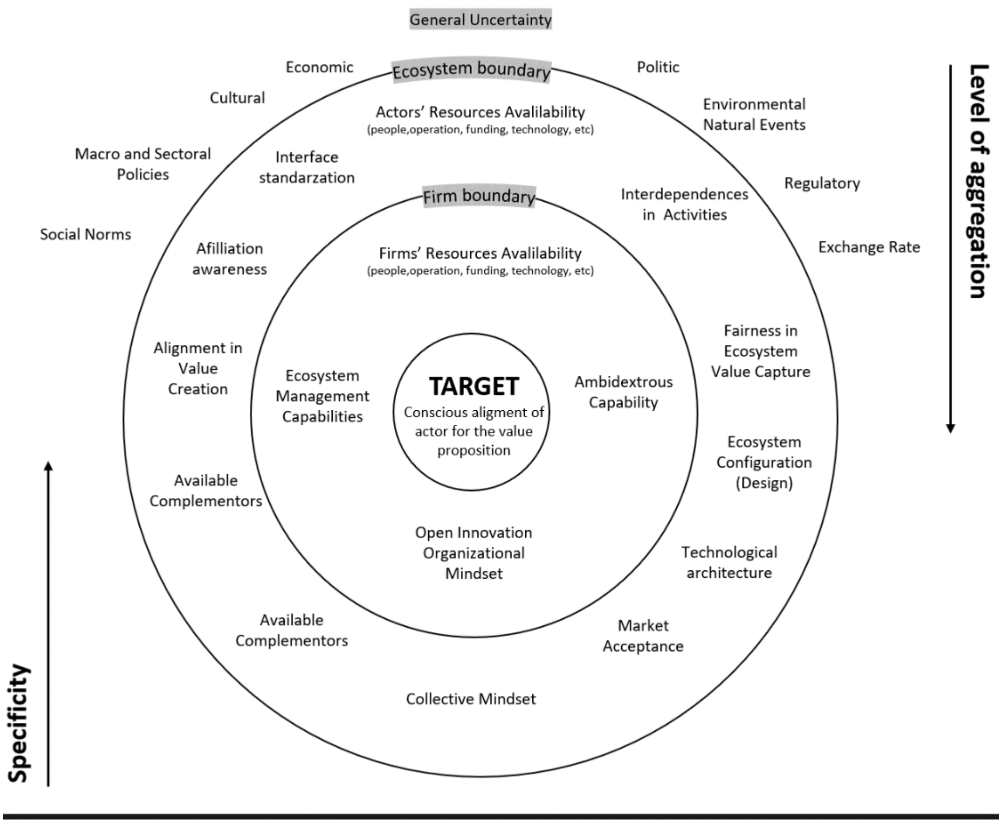
The second part, the first level, is the individual ecosystem actors' (firms) interaction with the value proposition and some examples of sources of uncertainties they deal with inside the firm’s boundaries. The third part, the ecosystem level, is the collective of actors (orchestrators, complementors, components) and the sources of uncertainty they usually deal with inside their boundaries.

The main point of this figure is to show the reader examples of uncertainty sources and how different they are if we take into perspective the different levels of analysis. That’s important because, during the data gathering of the thesis, we will probably face situations Where respondents are talking about firm-level uncertainties, and we must differentiate them from ecosystem uncertainties.

Another important point to highlight is that the lower the level of aggregation of risk, the more it's possible to be controlled by the firm. It means that uncertainty at the ecosystem level, which is a broader level of aggregation, will be almost impossible to be controlled by an individual actor (firm) (Vaaler et al., 2008; Müllner, 2016).

Finally, it's important to note that the relationship between different sources of uncertainty is not always significant. Sutcliffe and Zaheer (1998) evaluated the different sources of uncertainty and their simultaneous effects on decisions regarding vertical scope, showing that each source can generate different and independent impacts on a firm.

Figure 3 - Uncertainty Sources



Source: Adapted from Vaaler et al. (2008) and Müllner (2016).

Table 6 shows a summary of the main elements of the uncertainty construct summarizing its main dimensions described in the previous sections.

Table 6 - Uncertainty Construct

Construct Dimensions		**Name**	**Authors**
Theories that analyze uncertainty		Real options theory	Ghosal and Ye (2015)
		Resource dependence theory	Penrose (1959); Barney (1991); Furr and Eisenhardt (2021)
		Psychology and theory and self-organizing systems	Hirsh et al. (2012); Simon (1979); Dosi and Egidi (1991)
		Entrepreneurship	Shane and Venkataraman (2000); Packard et al. (2017); Lachmann (1976); Kirzner (1973)
		Transaction Costs (TCT)	Williamson (1985); Chawla et al. (2012)
		Contingency theory	Thompson (2003)
		Systems theories	Ashby (1958)
Managerial ontology		Positive	Mcgrath and Macmillan (2000); Adner (2012); Lachmann (1976); Bhidé (1999); Huchzermeier and Loch (2001); John and Weitz (1988); Sutcliffe and Zaheer (1998)
		Negative	Li et al. (2021); Ghosal and Ye (2015); Miller (2012); Hirsh et al. (2012); Sutcliffe and Zaheer (1998); Banerjee and Siebert (2017); Amoroso et al. (2017); Verganti (1999); Huber et al. (1975); Martínez-Noya and Narula (2018); Carson et al. (2006); Moeen et al. (2020); Hoetker (2005)
Approach (how to "measure") metrics		Predicted- objective	Zhang (2006); Anderson et al. (2009); Young et al. (2018); Bird et al. (2012); Dixit and Pindyck (2012)
		Control-subjective	Sutcliffe and Zaheer (1998); Milliken (1987); Pich et al. (2002); Duncan (1972)
Areas of uncertainty manifestation (origin, “birthplace”)		Organizational	Loch et al. (2008)
		Project	Rice et al. (2008)
		Network	Sydow et al. (2012)
		Ecosystem	Gomes et al. (2022)
Sources of uncertainty	Endogenous Uncertainty	Human inability	Alchian (1950)
		Lack of absorptive capability	Chawaal (2012)
		Project Portfolio	Gomes et al. (2013)
		Organizational	Chawa et al. (2012)
	Exogenous Uncertainty	Relationships among Market Actors	Sydow et al. (2012)
		Supply Uncertainty	Wernerfelt and Karnani (1987)

		Institution	Moeen et al. (2020)
		Unexpected/disruptive events	Saghaei et al. (2020); Li et al. (2021)
		Technological	Kapoor and Klueter (2021); Rice et al. (2008)
		Demand	Moeen et al. (2020)
		Competidors	Wernerfelt and Karnani (1987)
Aggregative typologies		Response (Procedural) Uncertainty	Gomes (2013); Dosi and Egidi (1991)
		Primitive Uncertainty	Gomes et al. (2019)
		Structural Uncertainty	
		Elementary Uncertainty	
		Configurational Uncertainty	Gomes and da Silva Barros (2022)
		Affiliation Uncertainty	
		Interdependence Uncertainty	
		State (perceived) Uncertainty	Milliken (1987)
		Effect Uncertainty	
		Response (Procedural) Uncertainty	
		Behavioral Uncertainty	Helfat and Teece (1987); Williamson (1985)
		Collective Uncertainty	Gomes et al. (2018)

Source: Author's Elaboration.

The main epistemological idea we pose here is that uncertainty is a primary determinant of strategy (Chawla et al., 2012). Managing uncertainties is fundamentally different from managing risks (Kapoor & Klueter, 2021; Knight, 1921). Traditionally, the greater the degree of uncertainty, the lesser the degree of prediction. Managing risks assumes that managers know about the alternatives and the probabilities associated with their respective outcomes (Knight, 1921). These situations in which the probability distributions of the outcomes of a given event are known are more probably to happen when the environment is more stable. On the other hand, managing uncertainties assumes a lack of factual knowledge about something because little information is available regarding alternatives and outcomes. Situations of uncertainty refer to situations in which it is impossible to quantify such probabilities.

In this sense, after presenting the uncertainty construct, the next section focuses on presenting the management of the uncertainty construct. We present four strategic formation logics that summarize how decision-makers act to manage uncertainty in entrepreneurial settings.

2.3 STRATEGIC MAKING UNDER UNCERTAINTY

Strategic formation is "the process by which executives create a unique set of interdependent activities to create and capture value (Ott et al., 2017, p. 1). This idea is central to understanding why some firms in entrepreneurial settings create competitive advantage and succeed when dealing with uncertainty while others do not (Ott et al., 2017). Four strategic schools evaluate the strategy creation process.

Many uncertainties can arise during the strategy creation process. Even in very uncertain contexts, entrepreneurs can try to increase control over the results of their actions and over the means necessary to transform current realities into new ones. There is an extensive debate in the literature about the best way to act in the face of uncertainties to "control" them, and different schools of strategic management will address this issue.

Prediction and control to deal with strategy is not a recent discussion in the literature. The idea of prediction and control is explored in a very paradoxical way. The logic behind managerial ideas was that the more you can predict, the more you can control. But how can someone control a future you cannot predict? When dealing with this paradoxical ontological question, Wiltbank et al. (2006) separated these two ideas into different axes and created a theoretical model that served as the basis for our explanation below. These ideas are the roots of strategic thinking, and we need to understand this "logic" behind the strategy that managers adopt when facing uncertainty. In other words, the idea of this matrix is to clarify how different strategic schools see the environment and deal with uncertainty.

According to this author (Wiltbank et al., 2006), theorists on strategy might choose to develop their theories using non-predictive (effectual) or predictive (causal) logic and high-low logic. The main Wiltbank's idea is that when the strategist's foresight horizon appears relatively certain, prediction and control appear to have a co-extensive relationship. As this horizon becomes more uncertain, the relationship between prediction and control changes. The main point theorists argue is that it is not a paradox of prediction and control but a relationship between prediction and control that defines what theories we must use to understand how to deal with uncertainty.

Wiltbank et al. (2006) showed that the relationship between prediction and control changes as the degree of uncertainty in the environment also changes. The prediction and control as distinct dimensions are grounded in Frank Knight's (1921) seminal work on the relationship between unpredictability and profit.

Figure 4 shows a summary of Strategic Schools. Visionary school logic presents management strategies for managers who believe they have high prediction and high control over uncertain situations. Adaptative school logic presents management strategies for managers who believe they don't have any control over the future and that they also don't know how to predict it. So, the mentality here is, "Let's try to adapt as soon as we can. We are fast learners, and then we will survive."

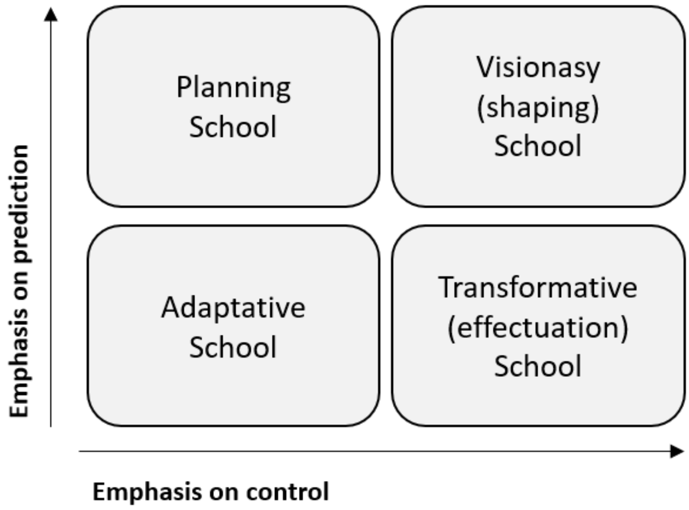
Transformative school logic follows an "effectual logic" and presents management strategies for managers who believe they have control over the future, so they don't need to predict it. So, the mentality here is "control itself becomes our strategy. If we focus on the means, we will arrive at whatever we want. So how can we cocreate a future, shape, change, and transform the world?"

Last but not least, planning school logic follows a "causation logic" and presents management strategies for managers who believe they have any control over the future, so they need to plan a lot to anticipate what is going to happen. So, the mentality here is, "We know we cannot control the future, but we will use every resource to develop techniques that will teach what will happen in the future." This mentality is the ground base of the strategic field itself.

Planning and visionary schools consider the environment as given (something companies cannot change), whereas transformative and visionary schools consider that companies can build or influence the construction of the environment (something companies can change). The top-right box of the figure presents a most recent vision of a new theoretical perspective that intends to deal with uncertainty problems in nascent ecosystems. This perspective understands the strategic action that takes place in high-uncertainty environments (Furr & Eisenhardt, 2021).

The chapter that follows below starts from the epistemological idea that entrepreneurs facing aleatory uncertainty will tend toward non-predictive (effectual) logic (Packard et al., 2017). On the other hand, entrepreneurs facing epistemic uncertainty will tend to have more predictive (causal) logic. The literature has barely explored strategies to deal with uncertainties in ecosystems, and even less the relationship between these strategies and ecosystem development.

Figure 4 - A summary of Strategic Schools used in Strategy Formation Process Studies



Source: Adapted from Wiltbank et al. (2006).

Below we present these four strategic schools that approach uncertainty management (planning, adapting, transforming, and shaping schools), beginning with a brief historical description of each school followed by the uncertain managerial “logic” behind the curtains.

2.3.1 Planning School: high prediction and low environment control

When scholars first discussed risk and uncertainty management in the literature, we saw that the approach was more objective and has roots in economics from rational choice theory (Ramsey, 1931) and behavioral sciences theory (Schwartz, 1997). Researchers in this arena tend to see uncertainty as a product of industrial structures that could be resolved by information gathered from analytical frameworks. The focus of this study is on risky and ambiguous scenarios (which are potentially measurable).

In management research, this topic was discussed by the planning school (between 1960 and 1970), and the focus of the strategy was directed toward the external environment. This stream analyzed the external environment of organizations based on their market power, arguing that the structure of an industrial company is a determining factor in its competitive performance.

Authors from this stream assume the environment is beyond their control and that decision-makers know the set of options they have in their hands, so they can foresee the outcomes of some considered course of action (Packard et al., 2017).

Several authors have shown planning as a weapon for managing uncertainty, as can be seen in the works of Porter (5 Porter's Forces, 1985 and later Porter's Value Chain, 1985), Portfolio Planning Matrix (Hedley, 1977), Product Lifecycle (Levitt, 1965) Strategic Environment Matrix (Henderson, 1979). This stream of strategy theory argues that industry determines company profits and that planning is a deliberate, rational, and conscious analysis. (Hedley, 1977; Porter, 1985; Andrews, 1976). This stream argues that entrepreneurs must act in these environments to better deal with uncertainties through structured planning.

Different foresight techniques are used during strategic planning to create shared visions, consolidate participant opinions, elaborate strategic guidance, and analyze competitors' concepts, customer needs, and the political and regulatory environment. In a cluster context, managers use foresight to identify technology priorities, open up new market needs, reveal breakthrough technologies, to foster the development of perspective product lines (Carayannis et al., 2017).

These authors understand that researchers in this line assume that the environment is not under their control but is predictable, emphasizing planning. They argue that forecasting increases the chances of success of an enterprise exposed to uncertain environments, as it contributes to the identification of resources that will be valuable in the future. Porter (1980) is one important author from this school and views uncertainty as a byproduct of structural complexities that could be resolved if the right information could be "plugged" into analytical frameworks (Chawla et al., 2012). Some examples of foresight frameworks are planning and positioning (Ansoff, 1979), competitive analysis (Porter, 1980), real options (Mc Grath, 1999), and scenario planning (Schoemaker, 1995; Schwartz, 1997; Godet, 1997).

2.3.2 Adaptative School: low prediction and low environment control

Several thinkers contributed to the formation of the adaptative school: Fast decision-making (Eisenhardt, 1989), incrementalism (Quinn, 1980), emergent strategy (Mintzberg, 1994), and more recently, dynamic capabilities (Teece et al., 1997).

Authors from this stream “assume the environment is unpredictable, shorten their planning horizons, and invest in flexible strategies that effectively respond to changes in the environment” (Wiltbank et al., 2006).

This school began to question planning as a weapon for managing uncertainty. The Mintzberian theoretical perspective, for example, understands strategy formulation as a weed in the garden of change. They assume that the environment is unpredictable and that the planning horizon is short. It understands that the external environment contributes to strategy formulation, but it is not an intrinsic part of the strategic process. It understands that strategy formation is an incremental process that involves managers’ cognition and learning. Mintzberg argues that we cannot promote thinking (strategic formulation) independent of action (strategic implementation) and that mistakes and successes feed the incremental process of formulating and executing a company’s strategy.

These authors criticize the objective planning school because they believe that while convenient for modeling purposes, objective probability theories are perhaps not descriptively accurate and are ill-equipped to deal with judgments (decision-makers cannot foresee possible courses of their action) (Packard et al., 2017). They also argue that strategy-making under uncertainty cannot be subsumed within the economic theory of rational choice because this is a positivist managerial approach and is dependent on historical data that is bound to fail in many cases, as statistical data about economic events are historical. They can tell us what happened, not what will happen, i.e., case, not class probabilities (Chawa et al., 2012).

This theoretical perspective criticizes the previous one because it understands that Andrews’ and Porter’s school of design and planning emphasizes too much strategy and capability and too little on the learning process that arises from the company’s interaction with the strategy. This author adopts an accepting attitude towards risk and uncertainty, as he understands that the unknown brings fear and risk but also learning (Mintzberg, 1990).

This perspective argues that entrepreneurs must act in these environments to better deal with uncertainties through learning and action. For Mintzberg (1994), firms should rely on learning processes (often guided by mental models) and put their efforts into adapting to emerging events, avoiding spending their scarce resources on trying to predict the future. The ability to adapt to flexibility is the best way to deal with uncertainties (Wiltbank et al., 2006).

Another theoretical perspective derived is the dynamic capability view, which is, in fact, an evolution of RBV's ideas. In this sense, a dynamic capability focuses on a company's proactive ability to adapt to generate and explore specific internal and external competencies (Augier and Teece, 2007). The term "dynamics" refers to how companies dynamically create, expand, modify, and structure their resource base (Helfat et al., 2007) and orchestrate, adapt, integrate, and reconfigure their internal and external skills. It is also understood as an ability to renew skills and achieve congruence with the changing business environment. This stream argues that entrepreneurs must act in these environments to better deal with uncertainties through the allocation of resources and capabilities to deal with uncertainty.

When thinking about low control and low prediction environments, Furr and Eisenhardt (2021) suggested a repertoire of learning strategies to clarify uncertainties and to learn about a high-uncertainty market. Some examples of these strategies are trial-and-error learning, experimentation, passive learning, and learning by borrowing. In other words, we see that learning is the main weapon to fight against the presence of unknown unknowns (Pich et al., 2002).

Furr and Eisenhardt (2021) also emphasize the use of cognitive structures — holistic representations like mental models and analogies — to frame the understanding of highly uncertain markets (Helfat et al, 2007) and drive the strategy creation process (Furr & Eisenhardt, 2021).

The logic behind all of these ideas from adaptative and planning schools is that entrepreneurs must resolve uncertainty as much as possible before a judgment is made. If we pay attention to Table 7 (Strategy Making Under Uncertainty), we see that qualitative studies that go deep into one organization mostly use adaptative strategies when dealing with uncertainty in different levels of analysis (ecosystem, firm, individual, inter-organizational, new markets) (Alchian, 1950; Berger & Bradac, 1982; Furr & Eisenhardt, 2021; Gigerenzer, 2007; Grabowski & Roberts, 1999; Mousavi & Gigerenzer, 2014; Moynihan, 2008; Pich, Loch & Meyer, 2008; Simon 1979).

Now let's move the focus to the transformative school and visionary schools. In the next two subsections, discuss the schools that believe in the power of a creative entrepreneurial mind that can support the proactive generation of possibilities, new evidence, and unique insights (Rindova & Courtney, 2020).

2.3.3 Transformative School: low prediction and high environment control

Transformative school researchers defend that traditional planning and adaptative approaches tend to fail. They believe that the environment is unpredictable and, consequently, companies should try to control the variables of change. There is a high lack of information about the future state of the environment, the strategic-and-action-planning process is much less reliable (Kapoor & Klueter, 2021), and plans are always incomplete.

For them, agents should seek to control the components of change without necessarily making use of forecasting. Authors from this stream assume that environmental factors may not exist a priori and seek, through cooperation and the creation of goals, to imagine the future, expanding existing realities (Wiltbank et al., 2006).

Several thinkers contribute to the formation of the transformative school: Value curve creation (Kim & Maubourgne, 1997), backing into the future (Hayes, 1985) effectuation (Sarasvathy, 2001). Authors from this stream “assume future environmental factors are largely non-existent and seek to create them through cooperation and goal creation with others to imagine possible futures extending from current means” (Wiltbank, 2006).

Saravasthy (2001) built on the ideas of March (1978; 1982) created the effectuation research stream and elucidated how non-predictive and non-visionary strategies could work inside the entrepreneurial research field. The entrepreneurial action under effectuation logic relies on first recognizing uncertainty. They won’t commit to the formulation of ex-ante plans to resolve uncertainties because they believe that things will change and there will be so many costs for altering those plans as new information is obtained. As Packard et al. (2017, p.21) said: “Loss aversion biases are thus averted (…) effectuation attempts to maximize the effectiveness of dynamic judgment”.

Sarasvatski suggested that controlling the future is unfeasible, but controlling the present is doable. For this, the author proposes that entrepreneurs adopt effectuation strategies to deal with uncertain environments. Effectuation strategies are a more flexible way because they allow us to accept that decision-makers don’t have control over variables. It allows us to accept that highly uncertain environments, as is the case of nascent ecosystems, won’t have a structured view of possibilities and trends. Besides trying to anticipate the future and investing resources in tools for anticipating the future, we should try to react to present situations better.

Table 7 shows Fuzzy front-end and Bricolage as some examples of effectual strategies (Kim & Wilemon, 2002; Furr & Eisenhardt, 2021). The next subsection also believes that entrepreneurs should recognize uncertainty and proactively deal with that.

2.3.4 Visionary School: high prediction and high environment control

Several thinkers contributed to the formation of the visionary school: Corporate imagination (Hamel & Prahalad, 1991), will and vision (Telis & Golder, 2002), shaping strategies (Courtney et al., 1997), strategic projection (Rindova & Fombrun, 1999). Authors from this stream "assume the environment is predictable but malleable and impose their vision of the future, shaping the environment to achieve their desired outcomes" (Wiltbank et al., 2006).

This school focuses on building an organization and its environment, imagining future possibilities, and acting proactively to realize those possibilities. An unwavering commitment to a vision guides the prediction and evaluation of alternatives to achieve the vision. Researchers believe that companies can predict and control the deployment of a vision. In this sense, managers should put all efforts into making this vision turn real. In uncertain environments, with little data and a lack of historical information, managers can use visions to guide the organization and facilitate the resource commitment process.

The idea of high prediction and high control is very intriguing here. Of course, few companies might get to perform a shaping strategy. Here we are talking about a theoretical scenario where its hard-to-find empirical cases to analyze.

Eisenhardt usually shows in her studies some interesting cases of companies that used shaping strategies in new market formation. She believes that superior strategists in these entrepreneurial settings have a broad view of their nascent market formation (what she calls "strategic playing field"), and this holistic view helps them to actively shape that field to their advantage. Some examples of shaping elements she inductively found in her case studies are the deep understanding of the economics and bottlenecks of the game, as well as the learning process and experimentation to resolve uncertainties faced during the nascent market emergence (Ott et al, 2017).

This literature talks about the importance of “joint action” due to the ambitious idea of changing the payoff structure of an entire market. Changing the payoff structure goes far beyond estimating supply and demand curves. For example, when there is a new product category (see Gavetti et al., 2017 and their explanation about the case of the iPhone 7 market entrance) or a fundamental new input (such as the Dynamic Random-Access Memory Semiconductors- DRAMs) or a major change in process technology in an existing industry.

When talking about shaping strategies, the goal here is to rely on imagination, framing, and structuring a new market. A market shaping process is driven by a focal market actor or a group of aligned market actors with the intent to perform a market change. This literature usually focuses on firm-level changes in firm-market interfaces, based on the recent meta-synthesis performed by Flaig et al. (2021).

This strategy focuses on a proactive mindset to cope with the loss of prediction and even interpretability that occurs in highly uncertain markets (Rindova & Courtney, 2020). Flaig et al. (2021) reviewed 79 qualitative articles on market shaping using a process perspective to group the main topics approached inside this literature. They showed shaping as a set of activities of infusing a new market change (by enticing the actors and creating a shared vision), forming a new market (by building market identity and network, lobbying for changes in regulations, and influencing institutions), and retention of changes for newly shaped market stabilization (by increasing the resilience and restricting actions from other unaligned market actors).

At the individual level, Furr and Eisenhardt (2021) show that shaping is something that actors can perform by imagining strategists to invent a new and favorable market order and imagining processes like storytelling and wielding soft power (e.g., cooptation, diplomacy) to achieve these changes.

Table 7 (The main ideas Behind the Four Schools) shows that planning and adaptative schools have reactive mindsets usually related to avoiding or reducing uncertainty; meanwhile, transformative and visionary schools have proactive mindsets thinking of not looking inside uncertainty but at how the opportunities generated by uncertainty can open the path from the proactive market transformation.

Table 7 - The Main Ideas Behind the Four Schools

	Reactive Mindset	**Proactive Mindset**

Entrepreneurial Thinking	Adapter	Shaper
Schools	Planning and Adaptative Logic	Transformative and Visionary logic
Strategy Theories	Real options theory (Mc Grath, 1999)	Entrepreneurship and technology management theory (Courtney et al., 1997)
Epistemologies	Scientific (Discovery-oriented)	Design (Possibility-centered)
Knowledge Intensity	Best applied when the markets are stable	Best applied when the markets change fast
Actors	Truth-seekers	Truth-makers
Mindset	Uncertainty is a bad thing	Uncertainty is a good thing
Entrepreneurial Behaviour	responding rapidly to the changes (REACTION)	Possibility creation (PROACTIVE)
Attitude Toward Uncertainty	We should defend ourselves from uncertainty by avoiding, reducing, or transferring to another one because it is a threat to our survival.	Uncertainty is our secret weapon to shape the market, so we should embrace empowerment because it is an opportunity for our partners and us.
Management Tools	Decision-making based on learning experiences	Employ creative cognition and design like Mental time travel, counterfactual reasoning, storytelling
Enactment Strategies	To develop products and services that respond to emerging patterns of demand	Develop novel value propositions. Design new business models. Create your own game. Mental time travel, comparability, Counterfactual reasoning and stories.
Firms' Knowledge Management	To address the incomplete knowledge problem by modifying the firm's knowledge base. To generate additional knowledge. To expand the firm's partial knowledge	Take advantage of incomplete knowledge problems by modifying the firm's knowledge base. To create new knowledge. To steer market interactions toward an envisioned new market order
Complementary assets and resources	Incremental resource allocation to explore multiple emergent directions and opportunities	the functioning of the future market is dependent on complementary assets and resources that are not available at all. "big bets" resource commitment to create and enact a new market order
Level of Prediction	Low	High
Control Logics	Low	High
Human influence over outcomes	Week	Strong
Market	Are a given and deterministic context, exogenous to the firm to which firms and other market actors must adapt.	It is a malleable or plastic complex adaptative system, which is essential to the outcome of agent-driven efforts.

Source: Author's Elaboration.

As we showed in Table 7 ("The Main Ideas Behind the Four Schools"), the process of creating strategies has two contrasting viewpoints. Although the literature argues that there is a certain rivalry between these two reaction-production logics (Rindova & Courtney, 2020), we believe they can indeed be complementary and situational.

Take, for example, the idea that “Too much competition during the emergent stages of an ecosystem may be detrimental”. If we look at a reactive mindset, we see that competence is something bad, so we should run and create mechanisms to prevent other ecosystems from growing. On the other hand, if we look at this phrase from a proactive mindset perspective, we could say that nascent ecosystems may have a better chance of thriving in these early stages, considering the low competition level of these markets (Shiplov & Gawer, 2020) or that ecosystems can shape the development of their own advantage (Adner, 2006; 2017).

When formatting strategies to unlock ecosystem growth, decision-makers face uncertainties. We believe that ecosystem decision-makers will employ proactive and reactive mindsets when strategizing in the ecosystem emergence process to face these uncertainties. This logic will “switch” when the ecosystem enacts its resonance. So, proactive strategies are suitable for dealing with uncertainties affecting ecosystem emergence -because here are the critical moments of turmoil, institutional conflict, or undergoing disruptive/discontinuous change- while reactive mindsets will be more used during evolutionary periods of stabilization.

Table 8 presents insightful strategies that we found in uncertainty management literature. The focus of this table is on the “means” to practically operationalize uncertainty management. After performing two literature reviews and snowball techniques, we used these managerial strategies and related them with the planning/adapting/shaping/transforming strategic schools we described before. It’s important to note that we don’t think that crisis-driven strategies, for example, could apply to other network organizational forms. The goal of this table is just to present to the reader how different schools, with different mindsets, see uncertainty management and apply strategies to reduce or recognize them.

Table 8 - Strategy Making Under Uncertainty

**	Level of analysis	*	Strategy	Description	Authors
U	New markets	A	Trial-and-error Learning	Taking action and observing what happens. Executives persist in their behaviors when outcomes are positive but adjust their behaviors in response to negative outcomes. Attempt to form their strategies incrementally based on the consequences of their actions	Furr and Eisenhardt (2021); Alchian (1950)
U	New markets	A	Experimentation	Deliberate actions to produce knowledge (learn about) thought controlling variation of activities and context to produce knowledge possibly mitigating specific uncertainties.	Furr and Eisenhardt (2021)
U	New markets	A	Bricolage	“Making do” with existing resources by reimagining their uses and recombining them in novel ways	Furr and Eisenhardt (2021)
U	New markets	A	Passive Learning	Stopping to observe generates the counterintuitive insight that learning can occur while doing nothing.	Furr and Eisenhardt (2021)
U	New markets	A	Learning by Borrowing	Copying others to accelerate strategy formation.	Furr and Eisenhardt (2021)
U	New markets	A	Problem-Solving	Focus sequentially on successive strategic domains, pause at a learning plateau to consolidate insights, and then move to the next domain.	Furr and Eisenhardt (2021)
U	New markets	A	Mental models	Simplified cognitive structures (blueprints or *visions* of the future)	Furr and Eisenhardt (2021)
U	New markets	A	Analogies	Cognitive structures (mental representations of previous situations based on own experience, personal values, knowledge of exemplar firms) that guide understanding the current situation	Furr and Eisenhardt (2021)
U	New markets	S	Wielding soft power	Using cooptation, diplomacy, and framing to reach the goals.	Furr and Eisenhardt (2021)
U	New markets	S	Storytelling	Shaping stakeholders to understand the meaning of something.	Furr and Eisenhardt (2021)
U	New markets	S	Improvisation	The deliberate fusing of the design and execution of a novel production	Furr and Eisenhardt (2021)
R	Interorganizational	A	Development of trust and control	Building techniques and governance (equity, contract length, motivation, role of board, formalization, change management, optimization control) depend on the type of risk the alliance faces.	Man and Roijakkers (2009)
R	Interorganizational	A	Decisions to transfer to another actor	Transfer it to another organization (using, for example, contracts by agreeing on the terms of transactions ex-ante and off-take agreements). They do not	Müllner (2016)

				provide ex-post compensation for a potentially hazardous source of risk but rather fixed terms that compensate for ongoing outcome variations.	
U	Interorganizational	A	tit-for-tat	Cooperate first and then imitate the other person.	Mousavi and Gigerenzer (2014)
U	Interorganizational (for crisis response)	A	Learning strategies	Members tried to help each other by developing joint standard operating procedures.	Moynihan (2008)
U	Interorganizational (for crisis response)	A	Learning strategies	Members collectively cope with uncertainty by creating a reflexively agreed-upon inter-organizational division of labor	Moynihan (2008)
U	Interorganizational (for crisis response)	A	Learning strategies	Members collectively cope with uncertainty by pursuing joint objectives.	Moynihan (2008)
U	Ecosystem	A	Conducting collective experiments	Projects, fairs, and exhibitions to share experiences and articulate dispersed learning.	Gomes (2013)
U	Ecosystem	A	Blocking paths	Prevent or delay competitors from obtaining a technology or entering the market (e.g., patenting technologies, actions to obtain patent use and exclusivity, establishing formal partnerships with key actors)	Gomes (2013)
U	Ecosystem	S	Connecting uncertainties	Entrepreneurs connect individual and collective uncertainties to reduce or create value from the solution of such uncertainties.	Gomes 2016 (thesis)
U	Ecosystem	S	Internal Uncertainty management	Focal Firms may also partner with external actors to manage global and local uncertainties while giving them greater autonomy.	Gomes et al., 2022
U	Ecosystem	S	Cooperative Uncertainty management	Focal firms often engage with external partners to manage uncertainties.	Gomes et al. (2022)
U	Ecosystem	S	Autonomous uncertainty management	Focal firms face the dilemma of addressing uncertainties internally or using partnerships before engaging with external partners.	Gomes et al. (2022)
U	Firm	A	Imitation	Imitation of successful firms concerning internal postures (i.e., "conventional" markup, price "fellowship," "orthodox" accounting and operating ratios, "proper" advertising policy, etc.)	Alchian (1950)
U	Firm	A	Controlling resources	Collecting and controlling resources, such as knowledge, information	Packard et al. (2017); Jauch and Kraft (1986)

R	Firm	P	Risk Management Practices	Systemic risk identification probabilistic analysis of risk levels, detailed plans for uncertainty reduction, methodic tradeoffs, and appointing a risk manager.	Raz et al. (2002)
U	Firm	A	Reduction	Reducing the payback time and discount rates or raising the required rate of return	Chittenden and Derregia, 2015
U	Firm	A	Reduction	Reduce the projects' cash flow forecasts.	Chittenden and Derregia, 2015
U	Firm	A	Focus on Safety and reliability	Prioritization of safety and reliability as goals considering that such practices enhance a milieu of safe operations	Grabowski and Roberts (1999)
U	Firm	A	One-bounce rule	Continue searching (e.g., for prices) as long as options improve; at the first downturn, stop searching and take the previous best option.	Mousavi and Gigerenzer (2014)
U	Firm	A	Default heuristic	If there is a default, follow it.	Mousavi and Gigerenzer (2014)
U	Firm	A	1/N rule	Allocate resources equally to each of N alternatives.	Mousavi and Gigerenzer (2014)
U	Firm	A	Communication at the interfaces	People communicate to reduce uncertainty, thereby making their environments more predictable. Communication at interfaces is where the values, norms, and tacit assumptions are communicated.	Berger and Bradac (1982); Weick (1979)
U	Firm	A	Culture	Development of a decentralized yet shared and trusted culture of reliability.	Grabowski and Roberts (1999)
UT	Firm	P	Balanced scorecard	The use of these integrated performance measurement systems helps managers to the device where to allocate resources to ace uncertainty and reach strategic outcomes.	Bremser and Barsky (2004)
U	Ecosystem	S	Bottleneck strategy	Understanding ecosystem bottleneck components (when they emerge, adjust cooperation - competition balance to fit bottleneck crowdedness).	Hannah and Eisenhardt (2018)
U	New Markets	S	Superior, transformative, expansive double-loop learning, the higher-level learning process	Learning beyond adaptation and beyond the extant learning, boundaries requires proactive unlearning of organizational processes and assumptions.	Hannah and Eisenhardt (2018)
U	Firm	S	Infusing, formation, and retention to the newly shaped market	Proactive actions promote changes in markets and avoid uncertainties by enticing actors and creating a shared vision among them, building market identity and network, lobbying for changes in regulations and influencing institutions, increasing resilience, and restricting actions from other unaligned market actors.	Flaig et al. (2021)

U	Project	A	Instructionism	Restricting oneself to ecological niches that are simple and change very slowly (slowly changing natural environment, absence of competition). However, this strategy can be devastating if there are sudden changes to the environment. In cases of foreseeable uncertainty, contingent policies apply.	Pich et al. (2008)
U	Project	A	learning.	The capacity to conduct new and original planning in the middle of the project	Pich et al. (2008)
U	Project	A	Selecionism	The pursuit of multiple candidate solutions until the best can be identified	Pich et al. (2008)
UT	Project	A	(Reactive) Feedback planning	Any initially unforeseen event should be handled later by reacting at a low cost and time.	Verganti (1999)
UT	Project	E	Fuzzy front-end	Identifying opportunities and preparing a clear product concept, developing relationships internally and/or externally, and speeding the process	Kim and Wilemon (2002)
U	Project	A	Naivety	Naive portfolio selection strategy.	Mousavi and Gigerenzer (2014)
U	Individual	A	Decisions of avoidance	Keep it at a manageable level and should be constrained by reducing the spread of competing affordances.	McMullen and Shepherd (2006)
U	Individual	A	Fragment decision-making tasks	Fragment decision-making tasks amongst multiple specialists and coordinating their work using communications and authority.	Simon (1979); Chawla et al (2012)
U	Individual	A	Objective-goal focusing	Replace abstract, global goals with observable and measurable subgoals.	Simon (1979); Chawla et al (2012)
U	Individual	A	Focus on satisficing decisions	Transform intractable decision problems where choices by focusing on satisficing decisions, where choices are satisfactory and not optimal.	Simon (1979); Chawla et al (2012)
U	Individual	A	Collective mechanisms	Technology standard setting, quality control committees, coordinated narratives, or lobbying across a large group of actors.	Lee et al. (2017)
U	Individual	A	Building a common template	Guide the mental model of ecosystem actors and, consequently, influence the decision-making process through the collective construction of a narrative about the future. The message is conveyed through business plans, technology maps, presentations, and workshops.	Gomes (2013); Gomes et al. (2022)
U	Individual	A	Communication platform	Creating a platform for sharing and integrating knowledge evolution to improve the ability of actors to assess the effects of their decisions on the performance of the ecosystem as a whole.	Gomes (2013)
U	Individual	A	Good Feeling	Gut feelings as an important or very important factor in making capital allocation decisions based on their experience after having considered all the data available.	Gigerenzer (2007)

U	Individual	A	Intuition (unconscious heuristics)	When one senses what to do without being able to explain why (feeling related to the personal choice situation, a business problem, a managerial judgment, or a market condition.).	Gigerenzer (2007)
U	Individual	A	Recognition heuristic	If one of two alternatives is recognized, infer that it has a higher value on the criterion. Winning strategy when the agent has partial knowledge. This doesn't apply to the agent who is highly knowledgeable or does not know anything about the task.	Mousavi and Gigerenzer (2014)
U	Individual	A	Fluency heuristic	If both alternatives are recognized, but one is recognized faster, infer that it has the higher value on the criterion.	Mousavi and Gigerenzer (2014)
U	Individual	A	Take-the-best	To infer which of two alternatives has the higher value, (a) search through cues in order of validity; (b) stop the search as soon as a cue discriminates; (c) choose the alternative this cue favors.	Mousavi and Gigerenzer (2014)
U	Individual	A	Tallying	To estimate a criterion, do not estimate weights but simply count the number of positive cues.	Mousavi and Gigerenzer (2014)
U	Individual	A	Imitate the majority	Determine the behavior followed by the majority of people in your group and imitate it.	Mousavi and Gigerenzer (2014)
U	Individual	A	Imitate the successful	Determine the most successful person and imitate his or her behavior.	Mousavi and Gigerenzer (2014)

Source: Author's Elaboration.

*Strategic Orientation Adaptative = adaptative. E= effectual. P=Planning. S= Shaping. **Dimension R= Risk U= Uncertainty UT= Technological Uncertainty

2.4 HIGHLIGHTS

So far, we have tried to make the case that:

-Ecosystems are an expanded value chain, a cross-sectoral phenomenon, and a new way of looking at how value is created, shared, and captured by firms embedded in inter-organizational relationships; Ecosystems are formed by organizations that jointly create a value proposition that a single firm could not create in isolation;

- IEs are different from other forms of strategic coalitions like strategic alliances, entrepreneurial ecosystems, clusters, etc.;

-For an IE to be considered as such, some prerequisites need to be considered. These attributes are what define the ecosystem as something unique, different from horizontal strategic networks, supply chains, and other strategic coalitions;

-Ecosystems have actors who play different roles, and an actor can play more than one role in the ecosystem. This study is more interested in the flows and roles of the actors that play these roles (Adner, 2017);

- IE's attributes necessary to be considered as such are: design, actors assigned with roles, coordination of modularities, complementarities, and interdependencies, set of norms and rules, value creation, capture and delivery system, shared identity and value proposition, rules of collaboration and competition among others;

-The emergence of an ecosystem comprises different evolutionary phases, and this study is focused on the very beginning (before the ecosystem speeds up the network effects) because this emergence is a fertile field to analyze the uncertainties;

-The elements of an ecosystem are consolidated as the strategic alignment between the actors becomes clearer (Walrave et al., 2018);

-Because the firms are very connected to one another due to the same shared goals, nascent ecosystems are built collectively. So, entrepreneurs act collectively to control the means necessary for the construction of a nascent ecosystem;

-Uncertainty is a multifaceted construct. Uncertainty at the ecosystem level is mainly related to a knowledge gap about the nature and structure (configuration) of the ecosystem, relations, resources, and interdependences among actors, and delivery of the value system (Moeen et al., 2020; Gomes et al., 2022);

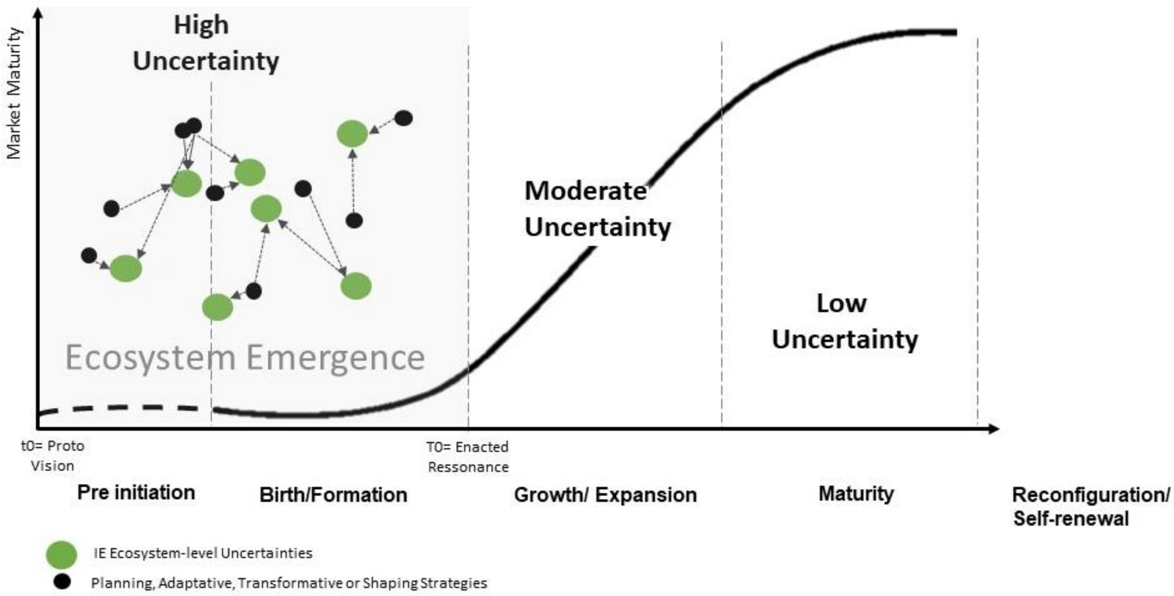
-Different sources of uncertainty permeate the entire emergence phase of the ecosystem and may be related to all the elements that compose it;

-Entrepreneurship researchers embraced Knight's ideas meaning its subjective logic enables entrepreneurs to act autonomously and creatively to deal with uncertainty;

-Four strategic logics behind uncertainty management influence the way entrepreneurs deal with uncertainty. Two of them (planning and adaptative) focus on uncertainty reduction strategies; meanwhile, two of them (transformative and visionary logic) focus on uncertainty recognition strategies.

Figure 5 shows how we see the interactions between uncertainties and strategies in the ecosystem emergence process of an IE. This figure was created based on some relevant papers. The first one is Furr and Eisenhardt (2021) who theorized under the relationship between uncertainty levels and nascentmarkets's evolution stages. The second one is the substages of the ecosystem emergence process, extracted from Dattée et al. (2018) anchored by Thomas and Autio, 2014 and Rabelo and Bernus's (2015) main ideas. Green balls represent the first specific goal of this thesis. Multiple sources of uncertainties might exist, but we focus only on IE-level uncertainties and mainly based on the ideas of Kapoor and Klueter (2021), Furr and Eggers (2021); de Vasconcelos Gomes et al., (2018), Thomas and Ritala (2021); de Vasconcelos Gomes et al. (2021a). We also understand that different types of strategies interact with one another during this first phase of ecosystem evolution. Some uncertainties might need multiple strategies in order to be reduced while others might need only one strategy. Some strategies might be more related to shaping while others might be more related to adaptative postures.

Figure 5 - Theoretical Framework



Source: Author’s Elaboration.

In the next section, the methodology of this study is presented. Following Langley’s ideas (1999; 2017), we started data gathering to see how these constructs might interact with each other during the evolutionary process of the ecosystem we analyzed. The methodology intends to describe how the researcher will collect and analyze the information collected in the field, the criteria for selecting the cases, and what strategies are adopted to avoid research bias and increase the reliability of the study.

3 METHOD

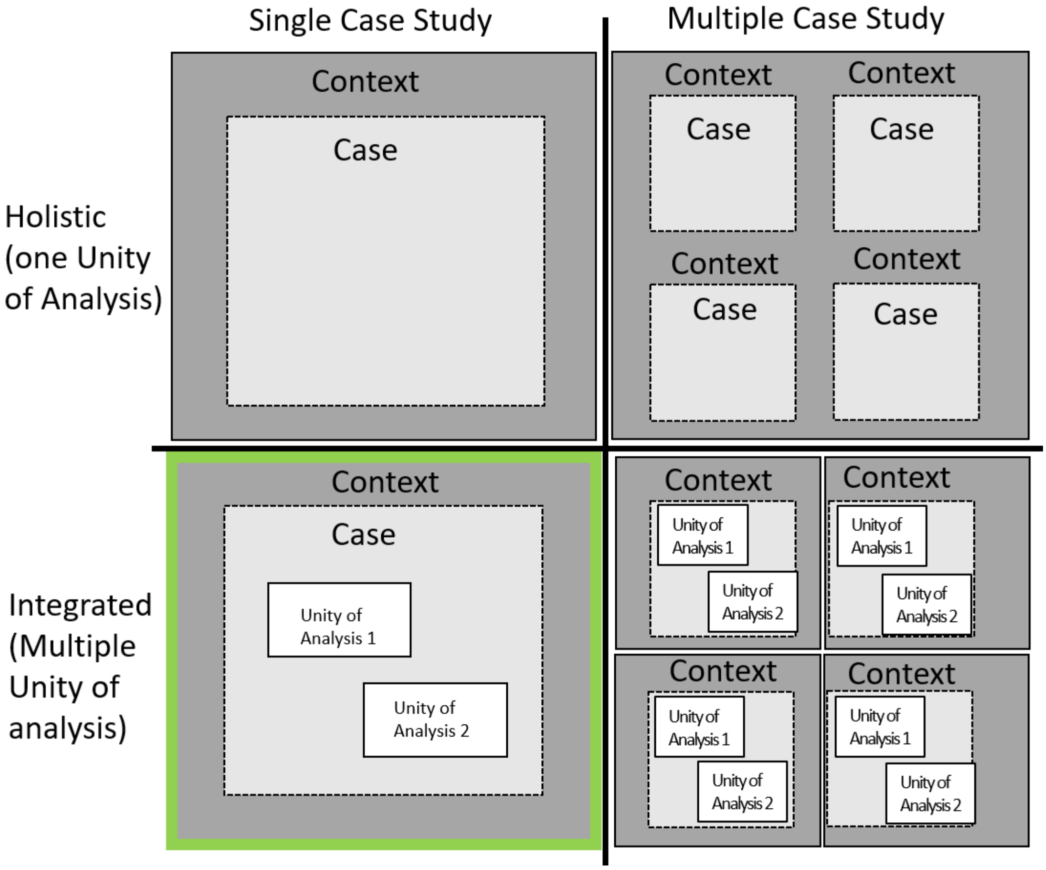
This study's focus is the collective entrepreneurial decision-making process these actors employ under uncertainty. In order to capture *how a process occurs*, we decided to perform a process-based case study (Langley, 1999). The phenomenological notion behind this methodology argues that people and their worlds are inextricably related through the lived experiences of individuals. Thus, the human world is never distinct and separate, but it is an experienced world that is related to a conscious subject (Berger & Luckmann, 2023). We believe that the individual reality is socially constructed through actions, negotiations, and agreement. Human action is based on individual understandings of reality. Therefore, how people act is determined by how they understand their reality.

The study intends to build theory by shedding light on the complex nature of uncertainty management and investigating response patterns for uncertainty management in a nascent IE. In this sense, we adopted an interpretive research paradigm to investigate entrepreneurs' decisions in the context of IE emergence (Yin, 2004).

This study describes how things happened. We investigated one case study (Langley, 1999) that is facing the emergence phase and yet did not overcome the liability of the newness barrier to growth. The processual methodology supports researchers to satiate the desire to capture "the escaped reality" (Pettigrew, 1990, p. 270) or even the desire to express the experience of temporality, flow, activities, and emergence of facts in concrete terms (Langley, 1999). We employed the visual map, quantification, and synthesis strategies along with the data results and discussion section (Langley, 1999). Following the case study methodology (Yin, 2004), we decided to analyze the Global EVTOL technological context.

Figure 6 shows the different types of study cases and shows a bold black contour line on Type 2, the one we chose for this study. We performed a single case with multiple unities of analysis embedded.

Figure 6 - Case Study Methodological Choices



Source: Yin (2004).

We will explain more about this in subsection 3.3.1 (Definition of Unit of Analysis). Open-ended inductive studies are useful for understanding the ecosystem environmental dynamics of emergence (Dattée et al., 2018; Shi et al.,2021; Thomas & Autio, 2014). This approach has proven to be appropriate for understanding the changes that occur over time at the level of an ecosystem (Shi et al., 2021; Hannah & Eisenhardt, 2018).

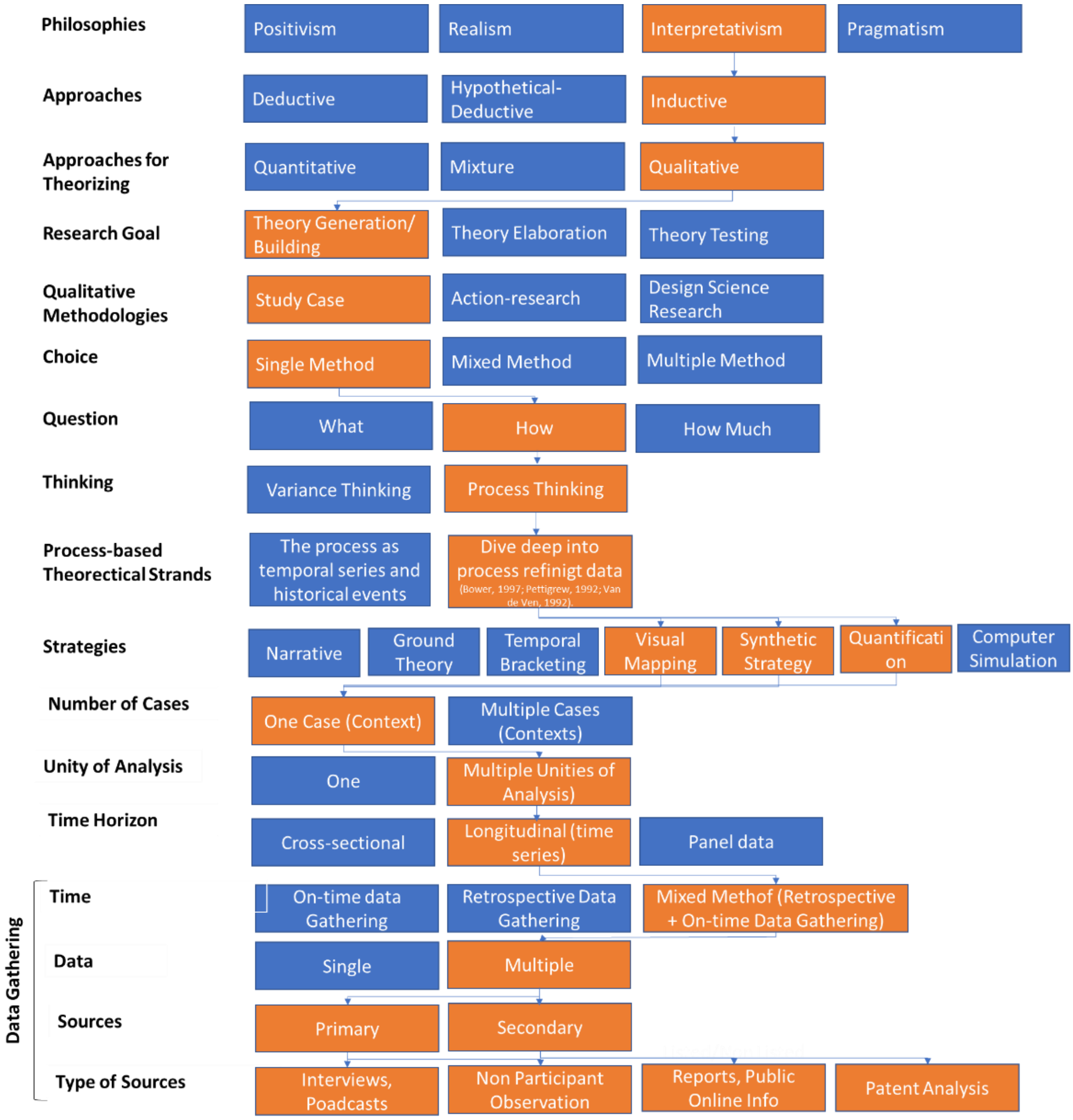
The next challenge was to build the sample. We choose an intentional non-probabilistic sampling. Our idea was not to test a theory but to build a model that could explain one phenomenon that is still incipient in the literature. So, this thesis builds an explanatory model for a phenomenon that has been little studied in the literature. We preliminarily investigated the urban air mobility ecosystem and then focused on the EVTOL IE. Below we present some features that explain the criteria for case selection. Figure 7 shows the choices we made in order to reach the thesis goals.

We choose a process-based qualitative approach (Langley, 1999) to analyze this thesis for a couple of reasons. First, since alliances and networks are likely to be even more complex than single large organizations, qualitative approaches may be especially useful in developing a deeper understanding of the role of uncertainty in these settings (Sydow et al., 2012). Second, the inductive-qualitative approach seems to be the most suitable to answer this study's research question (Gehman et al., 2018).

Third, we follow the tradition of studies on entrepreneurship and innovation research field to understand uncertainty management. The process thinking approach is widely used in the field of strategy and innovation studies to understand strategy formation (Ott et al., 2017), decision-making (March 1994), organizational change (Pettigrew, 1985; 1990), and R&D collaborative practices (Faccin et al., 2020). Process researchers seek to understand and explain the world in terms of interlinked events, activity, temporality, and flow rather than in terms of variance and relationships among independent and dependent variables (Gehman et al., 2018).

Fourth, as we explained in section 2.2.4, we need a flexible approach to investigate how companies deal with uncertainty (Milliken, 1987). Fifth, entrepreneurial judgment is not static or discrete but dynamic and continuous, involving experimentation, learning, and selection (Shepherd, 2015), so we need a dynamic approach to understand decision-making under uncertainty. The process-based case study allows the reader to unfold the events over time.

Figure 7 - Methodological Choices



Source: Author's elaboration based on Saunders et al. (2009, p.108) and Gehman et al. (2018).

3.1 THE EVTOL CASE STUDY

We decided to focus on a market in transition that is experiencing turmoil and institutional conflict. Emerging innovations in electrification, automation, and other technologies are enabling new opportunities for on-demand air mobility, business models, and aircraft design. In recent years, a variety of technological advancements in electrification, and automation is enabling innovations in urban aviation, including new aircraft designs, services, and business models.

The Advanced Air Mobility Markets (AAM) is broadly defined as aviation solutions for urban, suburban, and rural communities. These emerging markets are rooted in new forms of electric air transport in response to the need to change the global energy matrix due to the scarcity of fossil fuels, a rising traffic congestion problem, and a need for smarter transportation systems. Communities are placing pressure to decarbonize all activities and improve resiliency to climate change.

Urban Air Mobility (UAM) is considered a subset of AAM markets and is limited to aviation solutions for air transportation passengers and goods in metropolitan areas. Regarding the value proposition, UAM envisions a safe, sustainable, affordable, and accessible air transportation system for passenger mobility, goods delivery, and emergency services within or traversing metropolitan areas. This is a still nascent stage market and, while although showing increasing momentum, it has not yet manifested. (Andritsos et al., 2022).

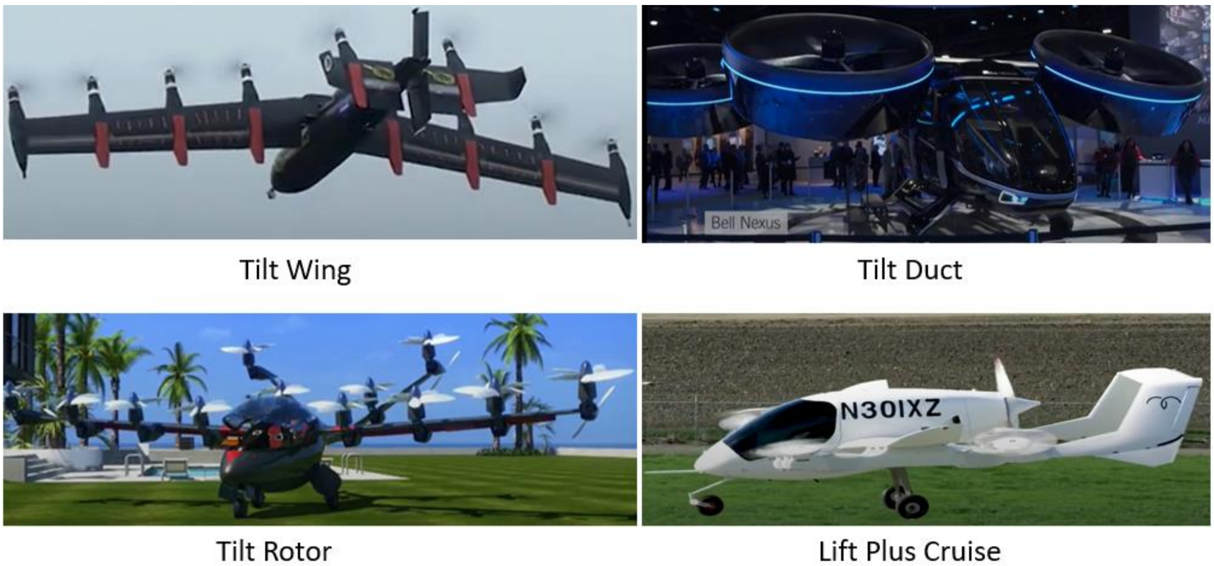
Electric air mobility markets will bring a variety of benefits to society. The city will be able to diversify the local economy with new sources of revenue, attract green infrastructure investment, and accelerate the decarbonization of the transportation system. These new markets will also open the door to new training opportunities and green jobs that support passenger needs, fleet operations, and beyond.

Another important benefit is that AAM technologies have the potential to reduce CO2 emissions by almost 9,000 tons annually – equal to the emissions from driving around Earth over 1,400 times, according to data from technical reports (CONOPS EVE, 2021). By 2035, these new technologies could reduce CO2 Emissions from over 4,000 cars /11,000 tons annually in a city like Rio de Janeiro, for example.

Inside AAM, we study one nascent IE called the Vertical Take-off and Land (VTOL) ecosystem, the ecosystem of an aircraft that can take off, hover, and land vertically. These vehicles refer to an envisioned class of four to nine-seat passenger aircraft operating short flights and providing scheduled and on-demand service between airports and "vertiports" all over towns and cities for passengers and emergency transport. A vertiport might be located in an Airports/Airport terminal (thin-haul commuter concept), on top of parking garages, hotels, existing helipads, and unused land surrounding highway interchanges). These vehicles travel at a speed of up to 100 km/h and an altitude of 1,000 and 5,000 feet, occupying an airspace that is still little explored.

EVTOLs have design characteristics. First is the passenger capacity of four to nine-seat aircraft operating short flights and providing scheduled and on-demand service between smaller airports. Second, specific propulsion and airframe configurations. EVTOL aircraft will make use of electric propulsion, so they have zero operational emissions and will likely be quiet enough to operate in cities without disturbing the neighbors (Uber, 2016). Third, different aircraft types (e.g., wingless designs, electric rotorcraft, aircraft that use any of its thrusters for vertical lift and cruise vs. aircraft that use independent thrusters for vertical lift and cruise). They also have specific operational characteristics, such as VTOL and aircraft that can fly and ride on roads (sometimes referred to as roadable aircraft). Figure 8 presents some examples of EVTOL's aircraft.

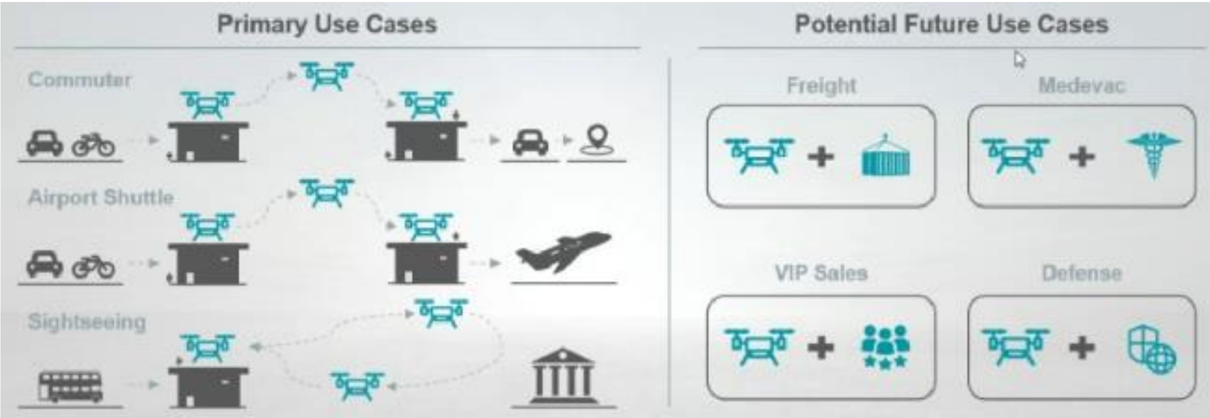
Figure 8 – Examples of EVTOL Designs



Source: Google Images.

There are three main types of travel that these vehicles intend to perform when the ecosystem emerges. The first one is focused on commuter's public (people traveling from/to remote areas to urban centers to work). The second public is the Airport Shuttle public (people traveling from/to urban home to the airport. The third one is the Sightseeing public (tourists on city tours, using EVTOLs to have a panoramic view of the city). Figure 9 shows these different approaches. In the future, a completely autonomous technology might be available and potential future cases might be in freight, medevac, VIP, good delivery, and defense sectors.

Figure 9 - EVTOL Technology

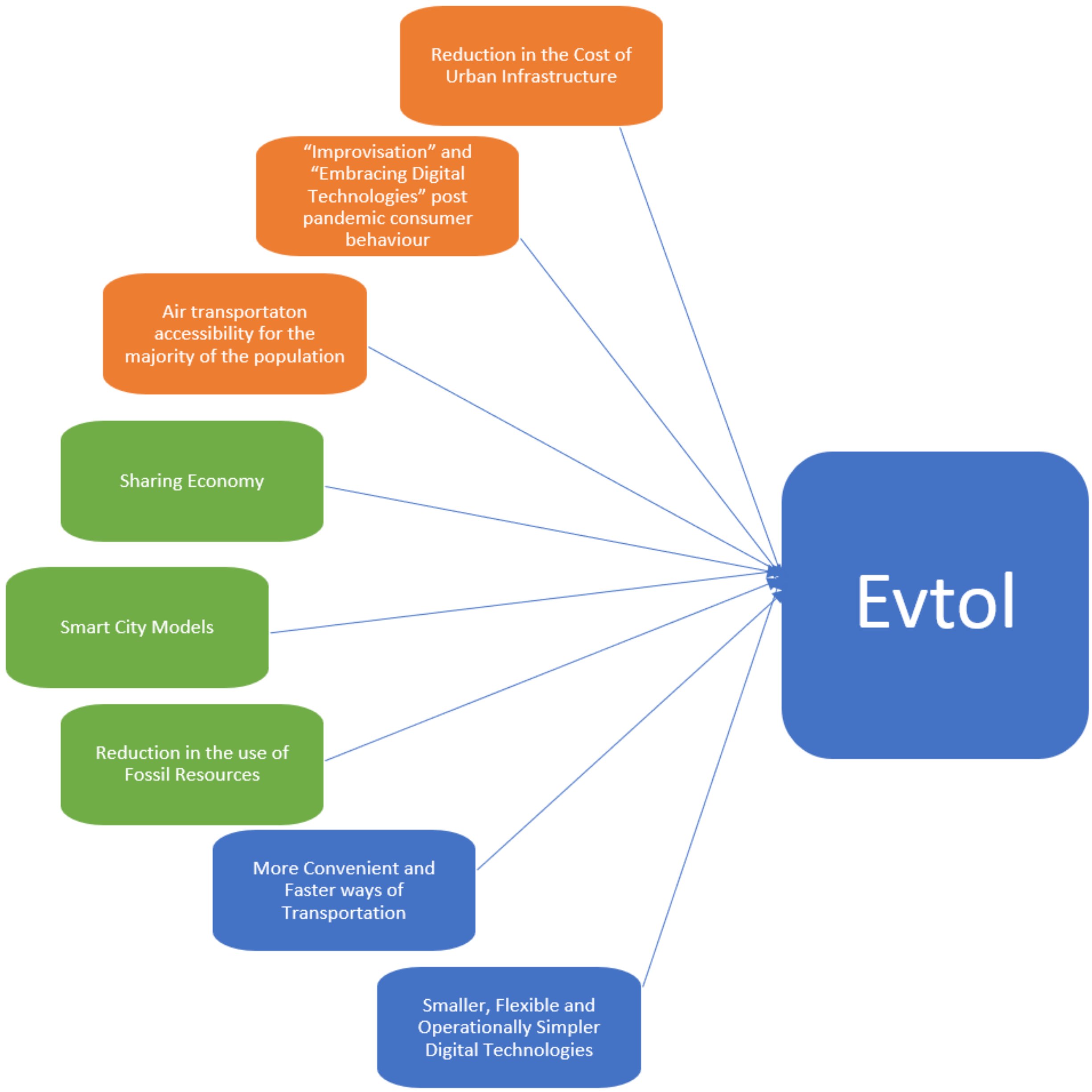


Source: EVE's presentation.

We chose this empirical field for a couple of reasons. First, this context meets Adner's (2017) ideas and is defined as a nascent IE. EVTOL is facing the emergence phase and yet has not overcome the liability of the newness barrier to growth. The EVTOL Air Mobility Market is undergoing disruption towards sustainable models. New forms of electric air transport arise in response to the need to change the global energy matrix due to the scarcity of fossil fuels and in response to a latent need to connect people and places in a second and quick way to places. Figure 10 shows the multilevel factors driving the emergence of the EVTOL ecosystem. We see advances in technologies - high-specific energy batteries, high-specific power motors and controllers, low-cost sensors driven by consumer electronics, and new composite automotive manufacturing techniques. According to one interviewee:

"Over the last four years from a very nascent idea of what's to come the technology scale of hobbyist drone to something that actually is a meaningful and viable transportation solution." (Head of Certification, OEM Manufacturer, 2022)

Figure 10 - Multilevel factors driving the emergence of the EVTOL ecosystem



Source: Author's Elaboration.

Second, we understand that this **market** (the Brazilian market) is a very interesting market to explore and implement EVTOL's IE. Brazil has the highest number of private turboprop aircraft in the world and the highest number of helicopter concentrations across its coastal cities. São Paulo has the most helicopters in the world, with 574 heliports. Third, we see that EVTOL is an **innovative product** more than a new type of Aircraft, but a new way of traveling around cities. This innovation affects other related markets, as we can depict from Table 9. Fourth, the **way traditional aviation deals with risk** is by using Comprehensive Safety Management Systems (SMS) to identify, analyze, and mitigate risks. However, these traditional risk assessment approaches are problematic when applied to high-volume, highly automated unmanned operations. In the case of EVTOL, which faces high uncertainties, they are no longer a solution (Airbus Report, 2018).

Table 9 - Cross-sectoral-related Changes Pushed by the EVTOL IE Emergence

Sector	**What Changes**	**Why EVTOL Changes**
Wheather	Weather forecasting	Predictive systems for forecasting weather by blocks (neighborhoods) instead of cities
Civil Construction	Urban spaces	Use of vacant spaces, construction of new building models like tops of parking garages, existing helipads, unused land surrounding highway interchanges
Transportation System	Traffic	Changing routes, reducing traffic jams, congestion fees, lack of parking, changing bottlenecks and land mobility policies
Hospital	Patient service management for Road Traffic Accident	Significant reduction in the number of calls for traffic accidents
Aviation	Long Flights	Use of airplanes for long distances
Aviation	Rotors	High performance and low noise
Aviation	Battery	Designed around cells and fossil fuel-dependence reduction and insecurity related to this commodity market prices
Helicopters	Aerodynamics	Great stability and efficiency with less weight and drag
Transportation System	Traffic	Reduction of pollution in the atmosphere
Aviation	Market prices	Reduced ticket cost (compared to traditional airplane tickets)
Aviation	Operational Time	Easy and quick boarding procedures
Aviation	Mechanical complexity	Less mechanically complex than conventional fuel-powered aircraft

Source: Author's Elaboration.

Walrave and colleagues (2018) explained the challenges that firms face when trying to achieve the viability of the ecosystem in its broader sociotechnical environment, especially for those ventures that are developing an ecosystem around a path-breaking innovation. The authors argue that achieving ecosystem alignment is “just one side of the coin” (2018, p.3), meaning that firms should be aware of what is going on at the current sociotechnical regime outside ecosystem boundaries and that aligning ecosystem actions with this broader context is necessary when the ecosystem wants to perform path-breaking innovations changes.

3.1.1 Innovation Ecosystem Components

As an ecosystem uncertainties are a conceptual abstraction of phenomena that cannot be directly observed (Thomas & Autio, 2020), so we need to find a way to observe them by establishing correct operational measures. We found our theoretical support in Gomes et al. (2021) to define the IE we analyzed. It is relatively common for studies in the area of entrepreneurship and strategy to mention that they are studying ecosystems without really explaining which measures they use to guarantee construct validity. In this study, we made some efforts to avoid incorrect operational measures (Yin, 1994). Gomes et al. (2021) presented a literature review on the IE construct and its main components. Some similar efforts made by Talmar et al. (2020) and Jacobides et al. (2018) are also considered. We follow previous authors and present Table 10 which explains the IE's main theoretical elements and how we see these elements in the case.

Table 10 - EVTOL Ecosystem Main Components

Components	Topic to be analyzed	Author	EVTOL Case
Design	The ecosystem has a particular set of activities that interrelates firms; and resources and shapes the value proposition	Ganco et al. (2020); Gomes et al., (2021ª); Luo (2018); Shipilov and Gawer, (2020)	The main activities are related to the process of development, acquisition, and negotiation between IOMs, suppliers, and complementors; the aircraft air monitoring process; the process of integrating takeoff and landing with ground handling services; approvals and certification process.
Systemic innovation	The ecosystem is formed along a value chain in which companies can innovate.	Dosi (1982); Fine (2010); Lim et al (2010)	Companies from different market segments interact to form a new value chain. It adopts concepts from different industries (the versatility of a helicopter, the advantage of fighters and supersonics, the convenience of automotive, and the cruise flight of commercial aviation). The innovation envisions a safe, sustainable, affordable, efficient, clean, fast, quiet, and accessible air transportation system for passenger mobility within or traversing metropolitan areas.
Complementarities	The ecosystem has unique, generic, and supermodular complementarities that are important to deliver the value proposition to the market.	Jacobides et al. (2018); Shipilov and Gawer (2020)	There are complementarities along all the ecosystems. Some of them are supermodular (for example, the collaboration between OEMs - manufacturers - Fleet operators - Battery providers, and battery reuse providers). Unique complementarities between vertiports and OIMs, Air traffic control (ATC), and Air traffic control (ATC). Another example is the unique complementarity between the Intrusion Detection Systems (IDS) and Air traffic controllers (ATCs). Generic complementarities between 4th-Generation Wireless and OIMs.
Value System	The ecosystem has an established value system (actors know how to create and capture value from the ecosystem)	Talmar et al. (2020); Gomes et al. (2018); Pellikka and Ali-Vehmas (2016); Teece (1986)	There are collaborative processes and activities for creating value all over the ecosystem, for example, between OIMs and key aircraft complementors (e.g., electric propulsion, flight controls, fuselage complementors). Their value capture process follows a
Actors	The ecosystem has heterogeneous actors that establish some relationships process among them. Some companies assume the roles of orchestrators, while others might assume the roles of complements, providers, or even clients of the value proposition.	Talmar et al. (2020); Thomas and Autio (2020)	OEMs Manufactures, Fleet operators, Aircraft Complementors, Aircraft Providers, U-Space Service Providers (USSP/ UASP), Air Navigation Service Providers (ANSPs), Vertiports, Air traffic control (ATC), Pilot, Ground Handler, Mechanic, Passengers, Booking Platforms, Knowledge management, Regulators, Financing and Securing, City infrastructure, Aerospace test and research centers
Interdependence	Firms might establish some degree of technological, economic, and cognitive interdependencies. Changes in this	Shipilov and Gawer (2020); Gomes et al., (2021b)	There are cognitive technological, and financial interdependences. Some examples of Technological interdependencies include data from Air Navigation Service Providers (ANSPs) compiled by systems of Regulators and accessed by Air traffic controllers (ATCs). Cognitive interdependencies: security-related historical patterns of practices,

	interrelatedness process and activities might impact the ecosystem.		assumptions, values, beliefs, and rules shared between Air traffic controllers (ATCs), Regulators, and Fleet operators. Financial interdependencies - OEMs – Manufactures, Fleet operators, and vertiports.
Structure	Structure refers to the collective arrangement between the interconnected members of the ecosystem. The structure includes the number of partners, actors, and positions; the network's density and centrality which affect the creation and capture of value	Shipilov and Gawer (2020); (Adner, 2017); (Bogers et al. (2019)	The roles and structures of the ecosystem are not yet consolidated.
Collaboration	Combined efforts between companies are expected to achieve common goals and benefits.	Adner (2017); Hannah and Eisenhardt (2018)	There is a strong focus on collaboration inside the ecosystem through forums, and events to exchange information and share knowledge to accelerate the approval of aircraft with OEMs (examples of knowledge-sharing spaces are the Vertical Flight Society, the Vertical Lift Network, EUROCAE WG-112, ADS in the UK, ASD in Europe).
Competition level	Competition refers to when firms pursue their own interests at the expense of others. Competition may operate at two levels: within the ecosystem and across ecosystems.	Adner (2017); Talmar et al. (2020); Hannah and Eisenhardt (2018)	There is competition between companies that play the same role in the ecosystem (e.g., OEMs; and vertiport designers). There might be future external competition between the EVTOL IE and the helicopter market, although this is not yet clear to the members.
Activities	Activities are the complementary actions and interactions undertaken by ecosystem members to create and capture value	Talmar et al. (2020)	Interactions undertaken by ecosystem members that take place at private and public meetings, CONOPS reports and industry technical reports, and regulatory open forums, among other places.
IE Configuration	The way essential flows of information, knowledge, resources, and activities flow within the ecosystem structure.	Shipilov and Gawer (2020); Talmar et al. (2020); Gomes et al. (2021b)	Market-information and public acceptance-related flows – starting from Consultancy reports and public news, flow within the ecosystem structure. Suppliers' Technology improvements- related flows – starting from collaborative projects mainly between providers, complementors, and OEMs, flow within the ecosystem structure. Air Security and regulations-related flows – starting from OEMs data, Aerospace test and research centers, simulators data and flow within the ecosystem structure. Infrastructure-related flows – starting from CONOPs reports and simulation tests, collaborative projects flowing within the ecosystem structure.
IE Identity	The shared meaning and sense of belonging awareness that arises from IE members.	Gomes et al. (2021b); Thomas and Autio (2020); Cornelissen et al. (2007)	All stakeholders share the same idea that the flight has to be safe, free of bureaucracy operation, besides of economic viable. Beyond that, certain groups share the sense of belonging to the ideal of democratizing airspace.

Source: Author's elaboration based on Gomes et al. (2021b).

This new type of vehicle demands specific training and knowledge requirements for pilots and operators, airworthiness certification, international processes, and service characteristics. These vehicles have different levels of aircraft automation and might be based on piloted or remotely piloted/operated in the future.

3.1.2 Innovation Ecosystem Actors and Roles

Recent studies on ecosystems show that a series of collected data indicate the change between the actors, their activities, links, and positions in the ecosystem, and the modularities. We started by listing all names of ecosystem actors inside an Excel table. Then, we listed the roles they performed. Table 11 shows a summary of the main roles that actors play in an IE. To define the roles, we first followed our guess and coded for “orchestrators” if the actor shaped the emergence, performance, and evolution of ecosystems (Shipilov & Gawer, 2020) or if this actor was responsible for taking actions to change the market structure, given their interest in maintaining control (Dattée et al., 2018). We match the data with a consultancy report that mapped ecosystem actors in 2022 (AAM REALITY INDEX, 2023). This methodological step helped us to validate the inner perimeter of the IE (Thomas & Autio, 2020).

We see a variety of actors that interact and share different types and degrees of cognitive, technological, and financial interdependences. Inside this EVTOL ecosystem, multiple actors perform different roles (Adner, 2017) as complementors, suppliers, and orchestrators, among other roles.

Complementors are usually portrayed as composing the ecosystem structure. They provide complementary products, services, or inputs that contribute to the IE value proposition (Adner, 2017; Jacobides et al., 2018; Shipilov & Gawer, 2020). In the EVTOL case, these players are aware of the uncertainties that can undermine the ecosystem as they act directly in the operation of delivering the value proposition to the market.

Focal organizations (orchestrators) are the ones that advocate the IE value proposition to other actors within and without the ecosystem. They need to reassure participants that there is a consensus that value will be co-created. Also, they need to convince users and societal stakeholders of the ecosystem’s viability (Iansiti & Levien; 2004; Adner; 2017; Thomas & Autio; 2020). In the EVTOL IE, they know the actors, their interrelationships, strengths and weaknesses, level of proximity to the delivery of the VP, know how much they are contributing to the creation and how much value they are capturing in the ecosystem, know the drivers that motivate them to be part of it of the ecosystem.

Another important ecosystem member is the user, the adopter of the ecosystem VP. They enable non–ecosystem participants to better comprehend the value of the ecosystem by consuming the IE VP and demonstrably benefiting from it (Adner; 2017; Jacobides et al., 2018). In the EVTOL case, they know and experience the VP. They have a particular point of view about what are the strengths and weaknesses in terms of consumption of the value generated by the ecosystem.

Some external IE actors, like media, financial analysts, and competitors (Thomas & Ritala, 2021) engage with the ecosystem, nurturing, interfering, communicating, encouraging, and regulating the creation and delivery of the value proposition to the market.

Table 11 - Ecosystem Main Roles

	Roles	Description	Examples of Actors Playing These Roles
Aircraft-related	Orchestrator	Produces the aircraft that carries passengers and a pilot, capable of autonomous flights in the future.	OEMs - Manufactures
	Orchestrator	Manages the purchase, use, and maintenance of the aircraft fleet	Fleet operators
	Complementors	Key aircraft providers with a high degree of collaboration with the OEM and commitment to deliver the ecosystem's value proposition to the market	Aircraft Complementors (electric propulsion providers, flight control providers, wing providers, technology providers, fuselage providers, composites providers, battery recharge providers)
	Providers	Other aircraft providers that sell components to the OEM	Aircraft Providers (paint and glazing suppliers)
Infrastructure - related	Complementors	Manage traffic and share data to support shared situations awareness across stakeholders	U-Space Service Providers (USSP/ UASP)

	Complementors	Manages flight traffic on behalf of a company, region, or country.	Air Navigation Service Providers -ANSPs- (for example, Communication providers, Navigation providers, Surveillance -CNS- providers, Meteorological -MET- providers)
	Complementors	Provides ground facilities to take off and land, and passengers to board and alight, Connects passengers between the airport vertiport and the terminals.	Vertiports (located in Airports/Airport terminals, tops of parking garages, hotels, existing helipads, unused land surrounding highway interchanges)
	Orchestrator	Direct aircraft on the ground and through a given section of controlled airspace and can provide advisory services to aircraft in non-controlled airspace.	Air traffic control (ATC)
	Complementors	monitoring system that detects suspicious activities and generates alerts when they are detected. Based upon these alerts, a security operations center (SOC) analyst or incident responder can investigate the issue and take the appropriate actions to remediate the threat.	Intrusion Detection Systems (IDS)
	Complementors	Ensures the flight is safe efficient, and complies with the flight plan	Pilot
	Complementors	Provides ground facilities to take off and land, and passengers to board and alight.	Ground Handler (for example Ramp services, passenger services, ticketing, baggage handling and/or delivery, aircraft cleaning services, maintenance services, fueling services, screening/security services, catering, provisioning (including, but not limited to, supplying of food)
	Complementors	Provides aviation mechanic and maintenance	Vehicle Maintenance Hubs
	Complementors	Travers on Scheduled or on-demand flights	Passengers

	Complementors	Books UAM flights and coordinates bookings with fleet operators	Booking Platforms
	External Actors	Companies focused on training people, raising passenger awareness, disseminating market information, and helping the ecosystem to be legitimized through information sharing.	Knowledge management (for example Consultancy firms, research institutes, media bloggers, and forum organizers)
	Orchestrator	Public policymakers that ensure the flight is safe, efficient, and compliant with the flight plan.	Regulators and policymakers
	External Actors	Finance and insurance services to enable the commercialization of vehicles and the emergence of the ecosystem	Financing and Insurance companies
	External Actors	Urban infrastructure services	City infrastructure (for example, 4th-generation Wireless providers, urban infrastructure department of city halls, power cabling companies)
	Complementos	Carrying out tests for the verification and certification of materials, components, equipment, systems, and subsystems. Technical advice and the provision of services to official entities and bodies, as well as to industrial or technology-based companies.	Aerospace test and research centers

Source: Author's Elaboration.

3.1.3 Units of Analysis

We decided to perform ecosystem-level research. The ecosystem is the context that embeds human and non-human actors, institutions, and artifacts linked to one another by a flow of activities (Adner, 2017; Jacobides et al., 2018), no matter where they are located. Studying one IE is something challenging because the frontiers are blurry, the main value proposition might not be clear, and the actors might not recognize themselves as “members” of the same expanded value chain. In this sense, we decided to go deep into one IE and investigate how decision-makers are dealing with the uncertainties.

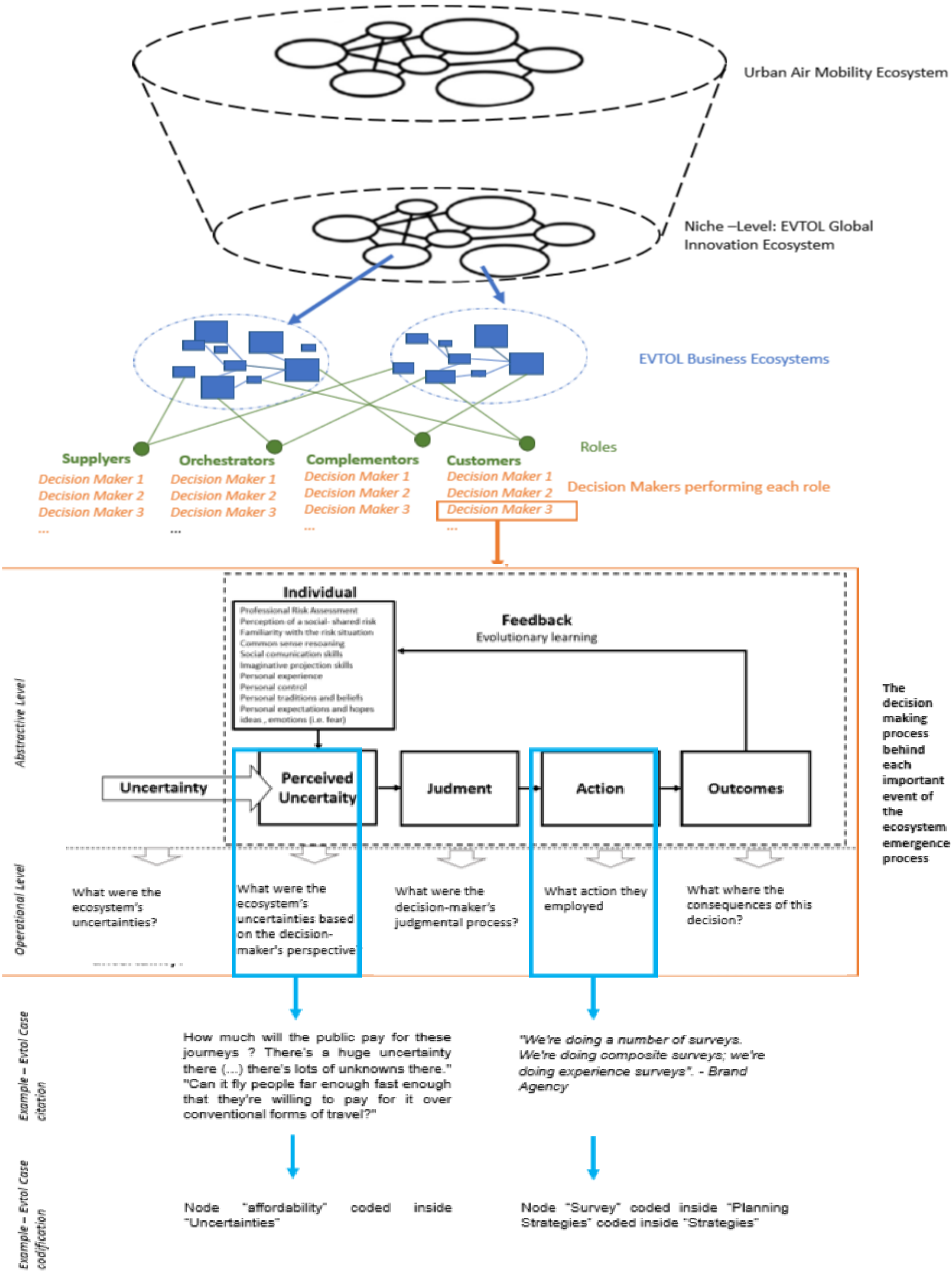
Inside the “urban air mobility ecosystem” we focused on the “EVTOL Global IE”. We are aware that the term “urban air mobility” indicates a limited view compared to “advanced air mobility” (AAM) as proposed by NASA. Yet NASA continues to use the term UAM as a subset of AAM, as do comprehensive reviews of the field. For this reason, we will use the term UAM, but we do not intend to exclude other applications of AAM, such as regional or rural air mobility.

Inside the “EVTOL Global IE,” we looked at the decision-making processes. This process involves uncertainty internalization, evaluation judgment, action, and outcomes. More precisely, we focused on two moments of this decision-making process. So, this is a single case with multiple unities of analysis embedded.

The first unit of analysis was **the ecosystem’s uncertainties based on the decision-maker's perspective** (i.e., the subjective beliefs decision-makers have based on their own vision, imagination, and new mental models). Decision-making differs considerably among social and cultural groups (Aven, 2010). The individual’s action is based on his/her own subjective viewpoint, which exists solely within his/her own mental framework. The way decision-makers percept uncertainties differ and directly influences their actions (outcome), as we can see in Gomes et al. (2022). It’s important to reinforce Peter Klein’s (2006, p.177) ideas that “judgment is distinct from boldness, innovation, alertness, and leadership.” All the perceived uncertainties and actions we mapped were related to the ecosystem emergence process.

The second unit of analysis was the **action decision-makers employed to deal with those perceived uncertainties**. In other words, we looked after the entrepreneur’s judgments manifested into actions. We were not interested in the cognitive process underlying the decision-making but in the effective action undertaken by entrepreneurs. We understand that beliefs are relevant only to the extent that they are manifest in action (the decision made) and produce outcomes. Figure 11 summarizes the unit of analysis.

Figure 11 - Unit of Analysis

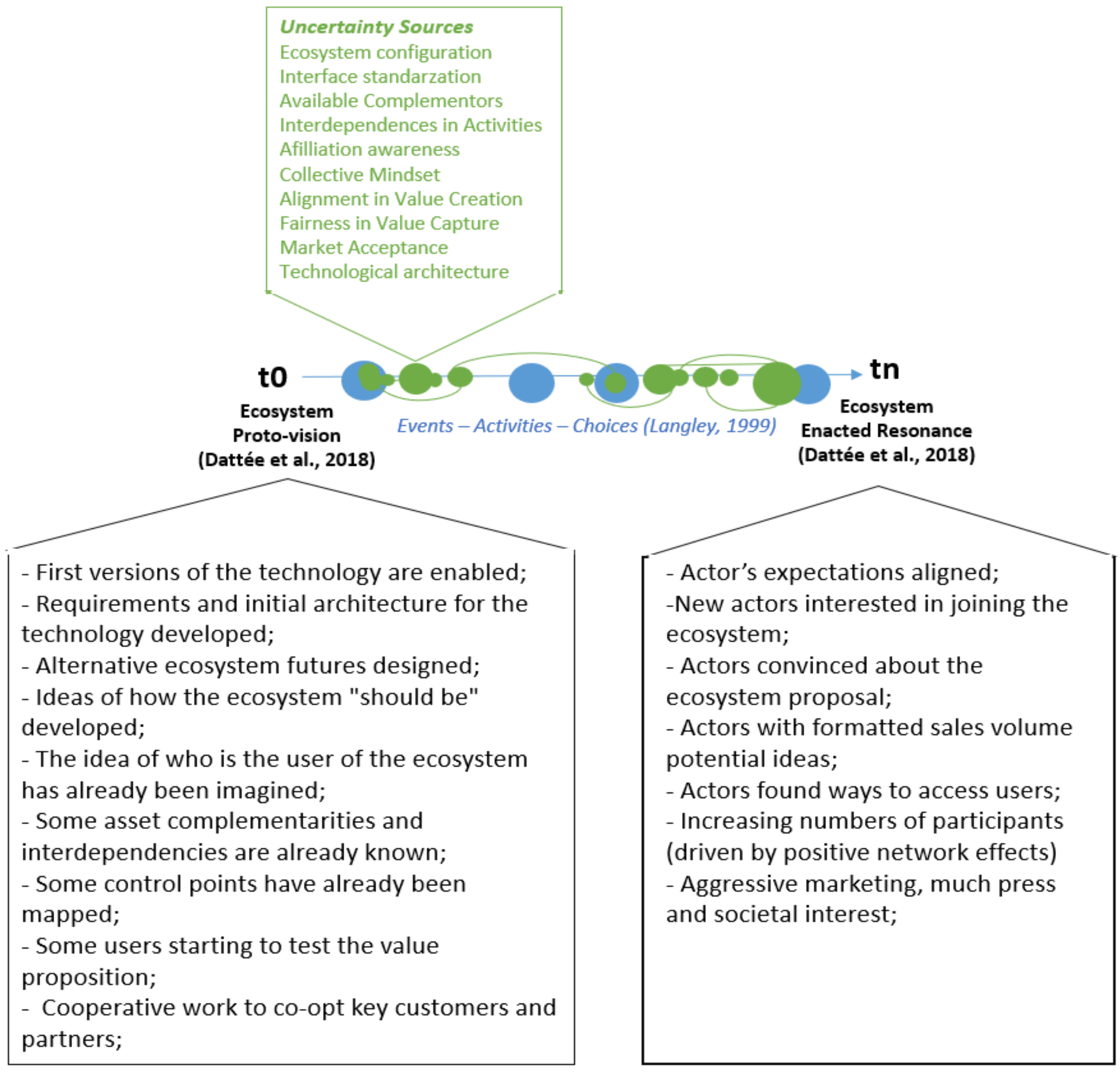


Source: Author's Elaboration based on Packard et al. (2017) and Yin (1994).

3.1.4 Time Interval of Analysis

To answer the question, we first need to define the time interval that we intend to analyze. For this study, the temporal moment we intend to analyze consists of practices to deal with ecosystem uncertainties that occur between the emergence of "Phase I-Proto-vision" (i.e., the emergence of the ecosystem proposal anchored by the orchestrator) and the moment "Phase II Enacted Resonate" when the ecosystem starts to deliver its value proposition to the market (i.e., actors are engaged, allocating resources, customers have already tested the idea). Figure 12 shows the attributes that configure Phases 1 and 2 of this study.

Figure 12 - Lower- and Upper-time Limit of the Analyzed



Source: Adapted from Dattée et al., 2018 and Thomas and Autio (2014).

We reconstruct the history of the ecosystem using different strategies. First, when conducting the interviews, we asked the respondents, “Tell me how the ecosystem-building process happened?" This question aimed to place the respondent on the same temporal page that we wanted to analyze. We tried to make the respondent remember when the ecosystem was in an emergency stage (time interval between Proto-Vision and Enacted Resonance):

> “Please try to remember the time when this IE just had finished formatting and structuring the core IE technology. The time when there was a very small group of actors involved in structuring this initiative. The time when there were some initial ideas about the IE configuration. The emerging ecosystem had already been born and was in the initial phase of configuration. There have already been some actors involved in defining the ways to deliver this value proposition to the market. A few actors were already involved.”

3.2 DATA GATHERING

3.2.1 Exploratory Phase and Pilot Test

The goal of the exploratory phase of this study was to understand ecosystem environments (what they are and how they operate), how to identify roles that actors play in these contexts, and how uncertainty manifests in respondents’ responses. The exploratory phase was carried out between July 2019 and July 2022 and included 360 hours of spending in meetings with experts, professors, and students (specifically talking about innovation, ecosystems, and uncertainty management strategies) and 218 pages of gray (non-scientific) literature.

The result of this phase was two systematic literature reviews (the first and the second presented at the Encontro da ANPAD in 2020 and 2021, respectively). One of these literature reviews was recently published (Souza-Luz et al., 2024). We also generated one unpublished technical report for a consultant company. We also developed two papers using the process-based methodology (both are “in review status” in Q1 journals).

In 2022, we validated the research protocol with two senior researchers and performed a pilot test of the research in the nascent healthcare ecosystems containing eleven interviews (we presented at the Triple Helix Congress in 2022). After this exploratory phase, we adjusted the research protocol (Appendix A) and consent term (Appendix B) and created a research website[2]

3.2.2 Descriptive Phase

We went to the field again to perform another exploratory interviews but now focused on the EVTOL Global IE. The goal of this second exploratory phase was to understand this particular environment (what they are and how they operate), how to identify roles that actors play in these contexts, and how uncertainty manifests in respondents' responses.

The exploratory phase was carried out between September 2022 and July 2023. We gather information about the EVTOL context through 1) primary and secondary interviews with aviation experts and researchers on EVTOL technology, 2) patent analysis (EVTOL technology), and 3) gray (non-scientific) literature.

We conducted different techniques to gather information through interviews. First, we interviewed, transcribed, codified, and analyzed 63 first-order data through **interviews with experts**. We started by performing a systematic literature review on "EVTOL" Scientific Publications (reading 127 abstract articles) and sent an e-mail asking the authors of the publications to participate in the exploratory research. We interviewed 22 researchers and asked them to present us with the main ecosystem actors in the market they knew. We employed the snowball technique after that.

Then, we interviewed other 41 ecosystem actors - highly experienced CEOS and engineers. We interviewed the internal IE actors (i.e., the network of leading key players directly interconnected to the IE orchestrator and the central IE value proposition) and external IE actors (i.e., the network of other peripherical players that do not have non-generic complementarity relationships with ecosystem members but even still have interesting points of view to add to this study). We searched for highly experienced CEOS and engineers because they tend to be more realistic about the true uncertainties underlying their judgments, despitefulness being overconfident (Dew et al. 2009). We found these professionals using our personal network and LinkedIn invited them. In this sense, we also participated in five EVTOL international events – two of them in person and three of them remotely. Some interviews were performed during these events.

Second, we collected second-order data. We listened, downloaded, transcribed, codified, and analyzed 101 **interviews with experts** listed on the podcast “EVTOL Insights” available on Spotify. All interviews and analyses were always conducted in the language of the interviewee to ensure the quality of the analysis. We finished our database with 164 interviewed people and 141,95 hours of recorded interviews. Table 12 summarizes all the data we collected.

Third, we complemented the search by accessing, downloading, and codifying data through four main electronic platforms. First, we searched inside the **Archive Platform** using the keywords “EVTOL” and “Urban Air Mobility and found some insightful material. Second, we complemented this search by looking inside consultancy **technical reports**, white papers, and other relevant sources. Third, we downloaded all news published on the “**Mundogeo**” blog. This blog regularly publishes the main news of the EVTOL market. Fourth, we inductively searched for materials available inside digital communities and websites (for example, inside the main players’ websites). We finished our database with 506 documents.

During this interactive process, we built a codebook (See the Glossary in Appendix) describing the main terminologies that respondents used. This codebook was especially helpful during the data analysis. As themes emerged from the initial analysis, our later interviews became more focused.

Table 12 - Interviews

Date M/Y	**Time Hrs:Min**	**Position**	**Actor's Representative**	**Country**	**Source**	**Place**
set/23	01:30	Chairman of the Safety & Operations Council	Gol Linhas Aéreas and EVE Air Mobility	Brazil	Primary Data	Virtual Event
set/22	01:00	Chairman of the Safety & Operations Council	Gol Linhas Aéreas	Brazil	Primary Data	Physical meeting
set/22	01:00	Researcher on novel transport concept modeling.	Technical University of Munich	Germany	Primary Data	Virtual Meeting
set/22	00:40	PhD graduate in Aviation Law	University of Cologne	Germany	Primary Data	Virtual Meeting
out/22	-	Postdoctoral Research Associate and Principal R&D Engineer	Rutgers University and Global Technology Connection, Inc	USA	Primary Data	Virtual Meeting

out/22	-	Researcher on Aeronautics	Chongqing Jiaotong University	China	Primary Data	Virtual Meeting
out/22	01:00	Professor in Law	Leiden University	Netherlands	Primary Data	Virtual Meeting
out/22	01:00	Professor in Engineering (Power Electronics, Machines and Control)	University of Nottingham	UK	Primary Data	Virtual Meeting
out/22	01:00	Specialist in Unmanned Aircraft Systems	German Aerospace Center Institute of Flight Guidance	Germany	Primary Data	Virtual Meeting
out/22	01:00	Professor in the Department of Aerospace Structures and Materials	Delft University of Technology	Netherlands	Primary Data	Virtual Meeting
out/22	01:00	Systems Administrator	Rensselaer Polytechnic Institute, Center for Mobility with Vertical Lift	USA	Primary Data	Virtual Meeting
out/22	01:00	Researcher on metaheuristics, machine learning, and safety-critical path planning	University of New Brunswick	Canada	Primary Data	Virtual Meeting
out/22	01:00	Research Student in Aerospace Engineering	University of Heidelberg	Germany	Primary Data	Virtual Meeting
out/22	00:40	Engineering consultancy in electro-mechanical engineering services	Infinite System Design	Australia	Primary Data	Virtual Meeting
out/22	00:30	Doctor in trauma surgery and researcher	Technische Universität München	Germany	Primary Data	Virtual Meeting
out/22	01:00	Graduate student in Electric Machinery and Electron	Department of Electrical and Computer Engineering at the University of Illinois	USA	Primary Data	Virtual Meeting
out/22	00:40	Researcher in Transportation Sustainability Research Center	Institute of Transportation Studies at the University of California, Berkeley	USA	Primary Data	Virtual Meeting
out/22	01:00	Senior Aviation Consultant and former researcher on NASA Langley research projects.	HMMH and Virginia Tech	USA	Primary Data	Virtual Meeting
nov/22	01:00	Pilot Boeing 777	Qatar Airlines	Qatar	Primary Data	Virtual Meeting
nov/22	01:00	Flight Mechanic	Agricultural school	Brazil	Primary Data	Virtual Meeting

nov/22	01:00	Aviation Law Research Assistant	University of Cologne	Germany	Primary Data	Virtual Meeting
dez/22	01:30	Flight mechanic, Instructor, owner of a Flight School, former Civil Aviation Inspector	Escola Aerovia and SERIPA	Brazil	Primary Data	Virtual Meeting
dez/22	01:00	Doctoral Researcher in electrical machine design for high power density applications and advanced modeling, simulation, optimization, and characterization techniques for electrical machines	University of Nottingham	UK	Primary Data	Virtual Meeting
dez/22	01:00	Air traffic controller	Porto Alegre Airport	Brazil	Primary Data	Virtual Meeting
jan/23	00:30	Pilot	Emirates Airlines	UAE	Primary Data	Virtual Meeting
jan/22	01:00	Project Leader	GOL Linhas Aéreas Inteligentes	Brazil	Primary Data	Virtual Meeting
jan/23	01:00	Chairman of the Safety & Operations Council	GOL Linhas Aéreas Inteligentes	Brazil	Primary Data	Virtual Meeting
jan/23	01:15	Planning Section, National Air Traffic Control Department	DECEA	Brazil	Primary Data	Virtual Meeting
fev/23	01:00	Revenue Management Analyst	GOL Linhas Aéreas Inteligentes	Brazil	Primary Data	Virtual Meeting
fev/23	01:00	Commercial Manager	Baterias Moura	Brazil	Primary Data	Virtual Event
fev/23	01:00	Event organyzer - EVTOL Forum	MundoGEO	Brazil	Primary Data	Virtual Meeting
fev/23	01:00	Head of Corporate Strategy & Innovation	Energy Source	Brazil	Primary Data	Virtual Meeting
fev/23	00:40	Operation and Business Development Manager	Bluenest (Openvia Air)	Spain	Primary Data	Virtual Meeting
mar/23	00:30	Markets and Business Development	Volocopter	Germany	Primary Data	Physical meeting
mar/23	00:30	Global Network Lead, CTO	Accenture and Sunrise	Spain	Primary Data	In-person event
mar/23	00:45	CEO, VP, Consultant, CTO, CCO, Manager	Axiata, Dassault, IBM, Manna Drone Delivery, Sateliot, Soracom	Spain	Primary Data	In-person event

mar/23	00:45	Consultant, VP, General Manager, CCO, SVP, Director Architecture & Solutions Enablement	Accenture, Cariad, KDDI, Palo Alto Networks, Ioki, Harman, Tonomus	Spain	Primary Data	In-person event
mar/23	00:45	Editor, CEO, 5G Innovation Manager, Founder and CEO, Co-founder and COO, Co-Founder and Head of Partnerships	Air Traffic Management Magazine, Ericsson Drone Mobility, TDC Net, Avy, Droniq GmbH, OneSky	Spain	Primary Data	In-person event
mar/23	00:45	Executive Director for Advanced Air Mobility and IoT Technical Director Head of Connectivity, Executive Vice President, Industry, Marketing & Sustainability, VP of Emerging Technologies, CEO and Board Member, Director of Strategy	GSMA, Aalto HAPS Ltd, Dassault Systèmes, Ericsson, OneWeb NEOM JV, Volocopter	Spain	Primary Data	In-person event
mar/23	01:00	Founder and CEO	Pildo Labs	Spain	Primary Data	Virtual Meeting
mar/23	01:00	Sales and Marketing - Regional Sales e Head of Marketing & Sales	IDS AirNav	Italy	Primary Data	Physical meeting
mar/23	01:00	CEO and Co-Founder	Heron Airbridge	Singapore	Primary Data	Physical meeting
mar/23	00:45	Senior Manager, Advanced Air Mobility - Market Development	Inmarsat	UK	Primary Data	Physical meeting
mar/23	00:39	Senior Manager	EUROCONTROL	EU	Primary Data	Physical meeting
mar/23	00:30	Business Development Specialist	ONUR	Turkey	Primary Data	Physical meeting
mar/23	01:00	Innovation na Business Director	Saipher ATC	Brazil	Primary Data	Physical meeting
mar/23	01:00	Head of Technology	Bluenest (Openvia Air)	Spain	Primary Data	Physical meeting
mar/23	01:00	Group Director of the Airspace Operational Efficiency Team	Boeing	Spain	Primary Data	In-person Event
mar/23	01:00	Vertical Flight Society's Transformational -		USA	Primary Data	Virtual Event

		Vertical Flight working group				
mar/23	01:00	Architect	Arquitetare	Brazil	Primary Data	Virtual Meeting
mar/23	01:00	Airworthiness Superintendent	National Civil Aviation Agency	Brazil	Primary Data	Virtual Meeting
mar/23	01:00	Founder and CEO	AAM Institute	USA	Primary Data	Virtual Meeting
mar/23	01:00	Aviation Senior Project Risk & Internal Controls Manager & Program Lead UAM	Fraport AG	Germany	Primary Data	Virtual Meeting
mar/23	01:00	Head of Market Development - Latin America	Vertical	Brazil	Primary Data	Virtual Meeting
mar/23	01:00	Manager Government Relations and Public Affairs Europe (Ground Infrastructure, Airspace integration and Funding)	Lilium Air Mobility	Germany	Primary Data	Virtual Meeting
mar/23	01:10	Business Manager ATM	Atech	Brazil	Primary Data	Virtual Meeting
abr/23	01:00	CEO	E-hang	Spain	Primary Data	Virtual Meeting
abr/23	01:00	COO	Umiles	Spain	Primary Data	Virtual Meeting
abr/23	01:00	Ex-Rolls-Royce and CEO at a Research and Innovation Center	UK Research and Innovation (UKRI)	UK	Primary Data	Virtual Meeting
abr/23	00:40	Technical Authority in Advanced Air Mobility	GKN Aerospace	UK	Primary Data	Virtual Meeting
abr/23	00:45	CTO	Umiles	Spain	Primary Data	Virtual Meeting
mai/23	00:35	Ecosystem and Stakeholder Engagement Specialist	EVE Air Mobility	Brazil	Primary Data	Virtual Meeting
mai/20	16:42	Communication Manager	Lilium	Germany	Secondary Data	Spotify
mai/20	15:25	Founder and CEO	Skyports	UK	Secondary Data	Spotify
mai/20	14:27	CEO e co-founder	Pyka	USA	Secondary Data	Spotify
jun/20	17:45	CEO	Jaunt Air Mobility	USA	Secondary Data	Spotify
jun/20	10:25	Founder	EVTOL Insights	UK	Secondary Data	Spotify
jun/20	21:15	Founder and CEO	Autonomous Flight	UK	Secondary Data	Spotify

jun/20	18:19	CEO	Sabrewing Aircraft	USA	Secondary Data	Spotify
jul/20	16:25	CEO	Vertical Aerospace	UK	Secondary Data	Spotify
jul/20	15:24	CEO	Urban Aeronautics	Israel	Secondary Data	Spotify
jul/20	16:21	CMO	Wisk	USA	Secondary Data	Spotify
jul/20	15:09	CEO e Founder	Varon Vehicles	USA	Secondary Data	Spotify
jul/20	14:17	CEO	Bye Aerospace	USA	Secondary Data	Spotify
ago/20	15:51	President e CEO	Piasecki Aircraft	USA	Secondary Data	Spotify
ago/20	11:40	CEO	Fraundorfer Aeronautics	Germany	Secondary Data	Spotify
ago/20	19:41	CEO e co-founder	Airflow Aero	USA	Secondary Data	Spotify
ago/20	14:35	Sales and Marketing Leader	Flock	UK	Secondary Data	Spotify
set/20	24;42	CEO E COO	Transcend Air’s	USA	Secondary Data	Spotify
set/20	18:58	CEO e Founder	Metro Hop	USA	Secondary Data	Spotify
set/20	22:26	MD	Faradair Aerospace	UK	Secondary Data	Spotify
set/20	28;33	CTO	Volansi	USA	Secondary Data	Spotify
out/20	36;17	CEOs	Swanson Aviation e Pascall + Watson	UK	Secondary Data	Spotify
out/20	27:35	Founder	Skyportz	Australia	Secondary Data	Spotify
out/20	20:38	CEO e CTO	Dufour Aerospace	Switzerland	Secondary Data	Spotify
out/20	15:00	CEO	Flight Crowd	UK	Secondary Data	Spotify
out/20	22:03	CEO	Canadian Advanced Air Mobility Consortium	Canada	Secondary Data	Spotify
nov/20	29;31	Head of Institutional Relations	Walle Mobility	Italy	Secondary Data	Spotify
nov/20	21:24	Researcher and Consultant Specialist	UC Berkeley	USA	Secondary Data	Spotify
nov/20	22:11	General Director	CIVATA global	UK	Secondary Data	Spotify
nov/20	16:04	CEO e Co-founder	Wingcopter	Germany	Secondary Data	Spotify
dez/20	22:32	Strategy and Business Development Manager	Elroy Air	USA	Secondary Data	Spotify
dez/20	31;05	Co-Executive Director	Community Air Mobility Initiative	USA	Secondary Data	Spotify
dez/20	20:23	CEO	Samad Aerospace	UK	Secondary Data	Spotify

jan/21	27;14	CMO	LIFT Aircraft	USA	Secondary Data	Spotify
jan/21	20:43	CEO	AeroG Aviation	USA	Secondary Data	Spotify
jan/21	25;14	Senior Director of Architecture	PS&S Architecture and Engineering	USA	Secondary Data	Spotify
jan/21	25;37	Aviation executive	Aerial Transportation Solutions	USA	Secondary Data	Spotify
fev/21	24;30	CEO	AV Living Lab	Slovenia	Secondary Data	Spotify
fev/21	29:24	CEO	Iris Automation	USA	Secondary Data	Spotify
fev/21	24:22	Product Manager	Carlisle Interconnect Technologies	USA	Secondary Data	Spotify
fev/21	27:09	Diretor-gerente e Associado Sênior	Levitate Capital	USA	Secondary Data	Spotify
mar/21	23:52	Chairman	Board at UAVOS	USA	Secondary Data	Spotify
mar/21	20:52	CTO	Urban-Air Port	UK	Secondary Data	Spotify
mar/21	25:03	VP of Business Development	Eve Urban Air Mobility Solutions	USA	Secondary Data	Spotify
mar/21	23:09	CEO e co-founder	eJet Aerospace	USA	Secondary Data	Spotify
abr/21	26:21	Lead Test Engineer and Chief Engineer	Vertical Aerospace	UK	Secondary Data	Spotify
abr/21	30:33	CEO and founder	P3 Tech Consulting	USA	Secondary Data	Spotify
abr/21	20:55	Head	Asia Pacific at Skyports	UK	Secondary Data	Spotify
abr/21	26:27	General Manager and Director of Operations	Hyundai Motor Group's UAM	South Korea	Secondary Data	Spotify
abr/21	20:00	CEO	Northern Plains UAS Test Site	USA	Secondary Data	Spotify
mai/21	33:37	CMO	Jaunt Air Mobility	USA	Secondary Data	Spotify
mai/21	24:28	CEO and founder	Robotic Skies	USA	Secondary Data	Spotify
mai/21	25:33	CEO and founder	Dynamic E Flow	Germany	Secondary Data	Spotify
mai/21	32:00	CEO and product director	Vertical Flight Society	USA	Secondary Data	Spotify
jun/21	21:58	Director	Wisk's Asia Pacific	USA	Secondary Data	Spotify
jun/21	21:38	CEO e co-founder	MightyFly	USA	Secondary Data	Spotify
jun/21	30:40	CTO	EP Systems	USA	Secondary Data	Spotify
jul/21	21:54	Partner	SMG Consulting	USA	Secondary Data	Spotify
jul/21	28:05	President	AcceleratUM	USA	Secondary Data	Spotify
jul/21	37:58	Co-founder e diretor executivo	Five-Alpha	USA	Secondary Data	Spotify

jul/21	24:49	CTO and co-founder and VP	Electro.Aero	Australia	Secondary Data	Spotify
ago/21	25:51	Renewable energy consultant and developer		South Africa	Secondary Data	Spotify
out/21	29:24	CEO	Avtrain	Ireland	Secondary Data	Spotify
out/21	24:22	Head of Battery	Vertical Aerospace	UK	Secondary Data	Spotify
out/21	22:10	Head of Next Gen Rotor Design	Vertical Aerospace	UK	Secondary Data	Spotify
out/21	26:42	Founder	Skyroads	Germany	Secondary Data	Spotify
nov/21	24:56	Head of Certification	Vertical Aerospace	UK	Secondary Data	Spotify
jan/22	23:00	Head of Strategy	Electra.aero	USA	Secondary Data	Spotify
fev/22	26:35	CEO e co-founder	Overair	USA	Secondary Data	Spotify
fev/22	42:04	CEO e CTO	Manta Aircraft	Italy	Secondary Data	Spotify
mar/22	26:18	Chair	Reed Smith’s Transportation Industry Group	USA	Secondary Data	Spotify
mar/22	17:36	Co-owner e director	Strativ Group	UK	Secondary Data	Spotify
mar/22	27:44	Head of Product	Joby Aviation	USA	Secondary Data	Spotify
abr/22	37:26	Executive Director and Director	NPUASTS e Thales	USA	Secondary Data	Spotify
mai/22	24:00	Co-founder and CEO	Talyn Air	USA	Secondary Data	Spotify
jun/22	20:42	Director of Solutions for A&D	Jama Software	USA	Secondary Data	Spotify
jun/22	27:27	Co-founder and CEO	HyPoint	USA	Secondary Data	Spotify
jun/22	20:14	CEO	Ascendance Flight Technologies	France	Secondary Data	Spotify
out/22	30:36	Managing Director	Ferrovial Vertiports	Spain	Secondary Data	Spotify
nov/22	18:58	Founder, chairman and CEO	ZEVA Aero	USA	Secondary Data	Spotify
nov/22	29:02	CEO and co-founder	AIR	Israel	Secondary Data	Spotify
nov/22	27:00	Co-founder and CEO	SKYFLY Technologies	UK	Secondary Data	Spotify
nov/22	37:48	Co-founders	EAMaven	UK	Secondary Data	Spotify
dez/22	31:42	CEO	Aircraft	Canada	Secondary Data	Spotify
jan/23	28:43	AAM Strategy Business Development & Partnerships Leader	CAE	Canada	Secondary Data	Spotify
fev/23	33:50	Director of Air Traffic Services	Inmarsat Aviation	USA	Secondary Data	Spotify

fev/23	33:30	Co-founder	Volatus Infrastructure	USA	Secondary Data	Spotify
fev/23	22:15	Policy and Analysis Lead	Reed Smith LLP	USA	Secondary Data	Spotify
mar/23	20:06	Director	Ohio Air Mobility Symposium	USA	Secondary Data	Spotify
mar/23	26:07	CEO and founder	Vports	Canada	Secondary Data	Spotify
mar/23	42:28	CEO	JobsOhio and Ohio Department of Transportation	USA	Secondary Data	Spotify
mar/23	25:29	President and CEO	Odawara Automation	USA	Secondary Data	Spotify
mar/23	36:32	Founder and CEO	HYSKY Society	USA	Secondary Data	Spotify
abr/23	23:37	Engineer and Project Manager	H2FLY	Germany	Secondary Data	Spotify
abr/23	27:19	CEO	Airspace Modernisation Team UK CAA	UK	Secondary Data	Spotify
mai/23	29:31	Head of the Drone and Vertical Mobility Academy	FIA Fund project	UK	Secondary Data	Spotify
mai/23	41:06	CEO	KinectAir	USA	Secondary Data	Spotify
mai/23	20:44	Founder	Advanced Air Mobility Insitute	USA	Secondary Data	Spotify
mai/23	23:22	President and CEO	Gilmore Group	USA	Secondary Data	Spotify
jun/23	25:59	Co-founder and CCO	Unisphere	Germany	Secondary Data	Spotify
jul/23	35:06	Senior Project Manager	CPK Poland	Poland	Secondary Data	Spotify
jul/23	26:10	CEO and Co-founder	Guardian AG	USA	Secondary Data	Spotify
	141:95					

Source: Author’s Elaboration.

3.2.3 Constructs Operationalization

3.2.3.1 Uncertainty Sources

Actors perceive uncertainties in different ways. Therefore, the process of making sense is investigative and contingent. Making sense is a process of rationalizing what people have done (Weick et al., 2005). In this thesis, the process of making sense of uncertainties occurs when the respondent rationalizes fears, anxieties, misinformation, and difficulties in accessing information. The process of making sense can also be something positive when respondent rationalizes about opportunities they opened.

Here we used different strategies to investigate the sources of uncertainty that permeated the ecosystem trajectory, based on Gomes et al. (2018, 2019) and Gomes and da Silva Barros (2022). Table 13 shows the questions we asked the respondents. We triangulated this information with secondary data. We observed the perceived uncertainty when respondents externalized previous decisions, commenting on the decision process.

Table 13 - Construct Operationalization – Uncertainty Sources

Question	**Notes**	**Authors**	**Citation Example**
What were the main challenges and uncertainties faced together with the partner companies? What uncertainties or knowledge gaps or unanswered questions did you have at that time?	Map uncertainties in the innovation ecosystem's evolving structure	Alchian (1950); Gomes et al. (2013; 2018; 2019); Moeen et al. (2020); Saghaei et al. (2020); Li et al. (2021); Kapoor and Klueter (2021); Rice et al. (2008); Wernerfelt and Karnani (1987); Gomes and da Silva Barros	*"The things that are less clear still (...) need research is how the noise affects people in a long-term sense (...) the psychological impact of the acoustics of these aircraft is still more or less unknown " "In most countries in the world (...) will the cities allow the disturbance their citizens with these aircraft flying?"*

How did it progress/evolve? What uncertainties, in your opinion, existed in the past and have already been resolved? Have you been looking for new information? What type of information?	Observe the evolution of the uncertainties along the IE trajectory	(2022); Milliken (1987); Adner (2012)	*“But is it all viable from a business point of view? (...) So this is the great difficulty we see today”. "I think that there are some risks that are not yet well. If you have a crash, if you have a fire and I don't know, toxic fumes." "We still have to understand these accident-related uncertainties."*

Source: Author’s Elaboration.

3.2.3.2 Strategies to Deal with Uncertainty

Here we investigated how ecosystem members deal with uncertainty (what strategies do they respond to the uncertainties) during the IE emergency. Strategies are the actions, the decisions that entrepreneurs make at the time they face uncertainty. More specifically, we searched for strategies recognized as enablers of uncertainty management. These practices can be individual or maybe collaborative (i.e., taken conjointly by them with IE actors such as customers, suppliers, and investors, among others) (Faccin et al., 2020). Table 14 shows how we operationalized the Strategies to Deal with Uncertainty.

Table 14 - Construct Operationalization - Strategies

Question	Notes	Authors	Citation Example
What decisions did you make? Did you use your power or influence to resolve this situation?	Observe how decision-makers frame the uncertainties (i.e., perceive them as opportunity vs. threat). In which moments the respondent used shaping and adapting. Check if the interviewees did some kind of alignment and experimentation to solve the problems that arose.	Furr and Eggers (2021); Kapoor and Klueter, (2021); Wiltbank et al. (2006); Milliken (1987); Gomes et al. (2019); Gomes and da Silva Barros (2022)	*When we were talking about the airport design -the design regulations, and certifications of these infrastructures- people were focusing on the machine. Even if the discussion was really targeting the infrastructure, was still the machine and the aircraft the major topics. So, I saw there like a gap. We believe that we could bridge that gap by focusing on the infrastructure only." - Vertiport Operator*
How did you deal with these knowledge/ information gaps and doubts at that time?			
How did you access this knowledge?			
Did you write a business plan at some point in the development of the venture? Did you use any visual planning techniques: Canvas Business Model, Technology road-mapping, among others? Or go straight to action, getting your hands dirty?			

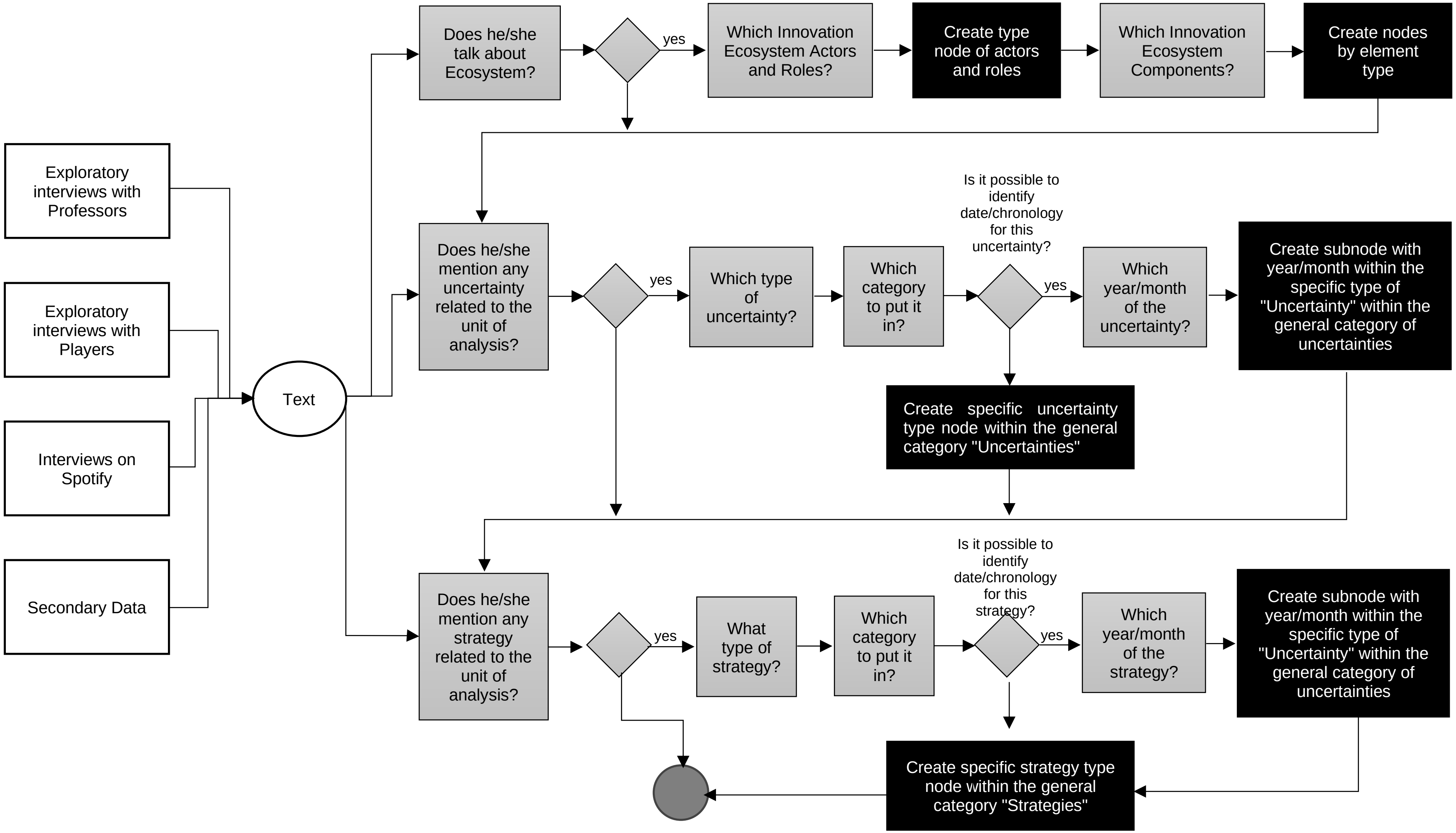
Source: Author's Elaboration.

3.2.4 Data Analysis

Here we describe how we analyze all the data we collected using multiple sources. We imported all transcribed data to NVIVO software. We read and analyze all aspects of the content. We follow Zayadin et al. (2022), who, in their interpretative study, analyzed unfamiliar aspects of the conversation so that anomalies were not dismissed but were considered as part of the conversation to be analyzed, which led to further analysis and theorizing.

In this sense, we developed a three-level codification process. In the first level, we search inside the text for the main IE Actors, and Roles and components. In the second level, we searched inside the text for the uncertainties and regrouped them into second-order category codes. In the third level, we searched for the strategies inside the decision-making process and regrouped them into second-order category codes too. To develop process theory, the process analysis has to focus on temporal relations among events in sequence (Gehman et al., 2018). Following this statement, wherever possible, information was coded in chronological order. Figure 13 shows the structure of the analysis of this thesis.

Figure 13 - Structure of Analysis



Source: Author’s Elaboration.

After these codifications, we employed Langley's (1999) visual map strategies and structured the codes into a visual map presented in the discussion section. We plotted the extensive list of uncertainties and strategies into a timeline visual map that tells this story of ecosystem evolution and relevant facts that occurred during this period, highlighting the uncertainties that emerged, at what time they emerged, and strategies to deal with them. The visual map strategy (Langley and Tsoukas, 2016) is useful for capturing valuable information and investigating issues in-depth and includes a representation of patterns that can be observed throughout each phase of the process (Langley, 1999).

3.2.4.1 Validity and reliability

We adopt some criteria to ensure data validity and reliability regarding retrospective bias and data analysis. The first-order data interviews with professors and ecosystem experts and players investigate how they rationalized today about the uncertainties of that environment in the past. We know that the reconstruction of processes from retrospective interviews has certain limitations, as people forget some points. Usually, people have accumulated other experiences, and maybe when they tell you when it happened, they may not give the same intensity to the event. So, the respondents' present perception of the phenomena that happened can impact their answers.

We reduce this limitation by following some steps. First, we interviewed respondents separately. Second, several members of the ecosystem were interviewed and asked the same questions, improving the reliability of the response. Third, additional file data help to minimize retrospective bias (data triangulation process). We also scheduled a meeting with some experts and presented the map to them. At the end of the presentations, we incorporated their thoughts and suggestions that could potentially contribute to improving the IE timeline. This data validation procedure helped to increase this study's reliability.

3.2.5 Ethical Aspects

To evaluate the ethical aspects of this research, this subsection clarifies that this thesis does not include research on human embryos, fetuses, children, patients, genetics, animals, the military, or potential for terrorist abuse. The ethical aspects of this research are respectful and aligned with the principles of the Charter of Fundamental Rights of the European Union.

First of all, uncertainty theory focuses on understanding the nature of unknowns and how managers make decisions and generate knowledge in situations where the future is unpredictably different from the past, and information about the future is incomplete, unknown, or unavailable. All uncertainties that emerged from the interviews were analyzed respecting the confidentiality and non-disclosure rules. The interviewees signed the Consent Form available in the Appendix of this thesis (9.2 Appendix B)

Second, ecosystem theory seeks to understand a new form of coalition between companies with some degree of cognitive, technological, and financial interdependence, that work aligned and in synchrony in pursuit of a value proposition shared by all actors.

Third, strategic formation investigates the process by which executives create a unique set of interdependent activities to create and capture value to understand why some firms in entrepreneurial settings create competitive advantage and succeed when dealing with uncertainty while others do not. All actions managers took under uncertainty captured from the data were also analyzed respecting the confidentiality and non-disclosure rules covered by Appendix B.

In terms of the ethics of the data collection process, it was ensured that the data collected were relevant and interesting for providing insightful evidence according to the purpose of this research. To analyze the evolution of the ecosystems, the data collection process did not invade any privacy or personal concerns, following the European Charter for Researchers guidelines.

Another key issue was, during the interviews, to provide each interviewee with complete and clear information about the whole research and to address any possible concerns at the beginning and throughout the research process. Thus, at the beginning of each interview, the interviewees were informed about the aim of this research, the type of data to be collected, and the procedure to do this (semi-structured interviews).

In conclusion, this research deals with the nature of data with no risk of ethical violation, due to the origin of the data (public) and due to the way of performing the interviews (the interviewees were informed of the aim of the research and the kind of data collected).

4 RESULTS

This chapter shows the results of the thesis in three parts. The first part (chapter 4.1) starts briefly by presenting the urban air mobility history. We briefly present it to contextualize this study. Then, we present the main events we mapped inside the ecosystem trajectory evolution grouped into three phases as proposed by Langley (1999).

The configuration of the ecosystem started with the first phase – the Vehicle Development (subsection 4.1.1) and certification process subsection 4.1.2). Then, we saw in the second phase that air (subsection 4.1.3) and ground (subsection 4.1.4) configurations emerged, almost synchronously at the same time. Finally, we saw the emergence of a third phase, where the macro infrastructures (cities and regions) start to coalesce to embrace the ecosystem on expansion (subsections 4.1.5 and 4.1.6).

4.1 ECOSYSTEM TIMELINE EVOLUTION

Cohen et al. (2021) recovered the urban air mobility history since its first embryonic idea appeared in the early 40’s. These authors showed historical information since the first experiments with vertical flight vehicles like helicopters and VTOL aircraft. The evolutionary trajectory covers flying car concepts from the early 1910s to the 1950s, early UAM operations using scheduled helicopter services from the 1950s to 1980s, and the re-emergence of on-demand services starting in the 2010s.

As we can see in Table 15, the vehicle design changed over time. This Table summarizes some of the main facts that market the history of the technology.

Table 15 - Evolutionary History Before 2010s

Year	Description	Photo
1910s to 1950s	Several inventors developed "flying car" concepts. Over the years, several have been built and delivered. However, none achieved commercial viability.	
1920s	Henry Ford developed a concept for “plane cars” and began developing single-seat aircraft prototypes	
1937	Waldo Waterman developed the Arrowbile, a hybrid Studebaker-aircraft with detachable wings, but the project dissolved due to a lack of funding.	
1940	This period was marked by several efforts including the first “flying car” to be approved by the Civil Aeronautics Administration (CAA), the predecessor to the FAA, the Airphibian. Despite the aircraft’s technical achievements, it never received investment capital. Inspired by the Airphibian, Moulton “Molt” Taylor developed the Aerocar prototype in 1949. The flying car was the second and last roadable (i.e., aircraft that can be driven on roadways as vehicles) aircraft to receive CAA approval.	
1947	Consolidated-Vultee developed the ConvAirCar in a two-door sedan equipped with a detachable airplane unit. However, the project ended after a crash on its third test flight.	
1950s to Late 1980s	Several companies provide early UAM services using helicopters in major U.S. cities. However, safety and fuel costs create challenges for mainstreaming. the late 1950s, Ford developed the Levacar Mach I, a vehicle prototype suspended just slightly above the surface by ducted air from three levapads on its underside.	
1958	The first early VTOL aircraft designed for military use, the Avrocar, was initially funded by the Canadian government but was dropped when it became too expensive. In, the U.S. Army and Air Force took over the project. However, this flying-saucer-shaped aircraft suffered from thrust and stability problems, and the project was canceled in 1961.	

1950s and 1980s	Among the several operators began providing early UAM services using helicopters in Los Angeles, New York City, San Francisco (SF Bay Area), and other cities. Helicopter services began to slowly re-emerge in Manhattan in the 1980s. Trump Air offered scheduled service using Sikorsky S-61 helicopters between Wall Street and LaGuardia airport connecting to Trump Shuttle flights. The service was discontinued in the early 1990s when Trump Shuttle was acquired by US Airways.	
1960s	Engineer Paul Moller began developing VTOL aircraft in the 1960s prototype hovered a few feet off of the ground in 1967.	
1966	Aerocar was able to reach 60 miles per hour (mph) on the ground and 110 mph in the air.	
1973	Advanced Vehicle Engineers (AVE) created a flying car by combining a Cessna Skymaster and a Ford Pinto; a test flight crash ended the project in 1973.	
1980s	The 1980s also saw several attempts to develop new VTOL aircraft. Boeing invested $6 million US into the Sky Commuter program and developed three VTOL prototypes before the program was canceled. Flying-saucer-shaped aircraft reached an altitude of 40 feet and remained airborne for three minutes. The project evolved into the Moller Skycar, which was under development until 2003.	

Source: Author's elaboration based on Cohen et al (2021).

We see that the vertical flight vehicles' trajectory had its periods of ups and downs in history. The ups and downs were usually related to technology unknowns and market sensibility - as any accident leads to project shelving.

After the 1990s, we see various small VTOL prototype aircraft built, but limited commercial adoption. In the early 2000s, due to the improvement of lithium-ion batteries, motors, and controllers enabled the development of multicopper drones. Since then, there has been an acceleration in the emergence of this market.

In this sense, we see that since 2010, the market started to be shaped mainly due to technological advancements in electric propulsion systems and energy storage solutions. In the early 2010s, NASA began projects focusing on unmanned aircraft systems (UAS). These projects have ultimately led to a new air traffic management philosophy that is being explored for UAM operations. Below we focus on explaining each phase of the EVTOL IE timeline evolution ever since. Below we provide a brief history of the EVTOL trajectory, the main events and themes that emerged from the phases of our analysis, and the uncertainties and strategies we have theorized based on these insights.

4.1.1 First Phase – Vehicle Development

4.1.1.1 Event Description

Dufour has been at the forefront of electric propulsion in aviation[11] launching Aero One, the world's first electric aerobatic plane. Since then, between 2011 and 2018, we have seen plenty of aircraft designers known as “first movers” such as Volocopter[4,] Lilium[12], Airbuss[17,] EVE[23], Beta technologies[100], Archer[174], and Lift Aircraft. Their designs ranged from models similar to helicopters and air cars[35] and hybrid vehicles between EVTOL and conventional aircrafts[170]. As operators started to investigate market feasibility for implementing EVTOLs on their routes[85 109], we also observed hybrid vehicles between EVTOL and conventional buses - i.e. the Skybus design[86].

The apex of this period happened when Uber Elevated published a report in 2016[19] commenting on this huge market opportunity for traditional aviation firms and new market players. Another important report from McKinsey, in the same year. These studies caught the attention of many companies and investors that started paying attention to the new market, as we can see in this excerpt:

> “They started to conduct those studies, if I take one percent of Uber Black, it will result in so many EVTOL operations (...) at that time, nobody had the vision that we have today, and everything was very much uncertain. There were some academic works, but everything was quite scattered.”

In 2018, over 100 different companies and startups actively developed EVTOL designs for urban air mobility and developing electric air vehicles[56]. Second movers started to enter the market after 2019[51]. In 2020 Uber and Joby partnered to introduce air taxi services more quickly in the market:

> It's been over a year since we closed the deal, and a substantial portion of us who were at Uber Elevate came to kind of build out this product at Joby (…) and it was really an amazingly complementary set of work (…) We knew Joby well. We've been working with them as a partner on the Elevate side for quite a while, and we knew where Joby technology was and the incredible hard work that the team here had been doing to make the vehicle technology real and get it to market in a rapid way. We were able to pretty much hit the ground running and take many, if not most, of the pieces of software and services that we had been building in the Uber context and kind of reimagined them. [73] (Head of Product at Joby Aviation)

New OEMs began to attract the attention of investors. According to a Brazilian national regulator: “De 2018 para 2019 começou a aumentar muito a questão dos investimentos e a indústria começou a aparecer mais”[32]. Fundability[24] [33] [34] was an important issue for OEMs while helping them to accelerate the development, certification, and commercialization of EVTOL[110]. In September 2020, traditional aerospace companies and new entrants invested more than US$2 billion globally in developing this aircraft[59]. In 2021, the number of companies worldwide that developed EVTOL aircraft rose to more than 200 companies[80].

After the fundability events took place, we saw that technology evolved from scratch to technically viable models due to battery capacity[47], autonomy, and onboard technology[36] [31]. Among the main challenges, developing and producing high power and high energy batteries was the big issue that companies are still facing right now[106]. Some of them are partnering, like Molicel and Vertical Aerospace, to solve this problem[122]. Aircraft data gathered through wind tunnel tests helped OEMs to improve EVTOL control rules and performance indicators[177]. After the end of 2020, we started to see solutions to some fundamental issues (e.g., collision avoidance systems, onboard sensors, and cognitive systems)[62].

Succeeding technical issues, the interoperability that could exist among aircraft providers to assemble safe and functional aircraft became the new ecosystem challenge. Actors searched for the right partners[68] to develop interface standardization and interoperabilities[66].

4.1.1.2 Uncertainties

As the ecosystem began to be shaped, uncertainties related to the development of the aircraft emerged. The first phase had three classes of uncertainties: The first class was the aircraft design - related to the vehicle design [u], such as Vehicle Reliability [r], performance efficiency [s], and controllability [t]. This subphase is also related to the aircraft materials and components [q], expected to attend to vehicle needs and uncertainties related to the fundability [l].

The second class was the aircraft development and prototypes. Uncertainties at this subphase were related to the limits of the actor's roles (who is responsible for doing what) [ak], collaboration with the right players [al], and if the actor's experience would be constructive to the operation [c]. Also, questions related to sharing data [ad] among actors and accuracy in estimating operating values [m].

The third class was aircraft testing: how would the customer experience throughout the journey be [g], whether they would be willing to pay [p] for the journey, and how much the user's lack of knowledge [d] regarding aircraft operation would influence the ecosystem success.

4.1.1.3 Strategies

Decision makers used a set of different strategies to deal with the uncertainties of the ecosystem using different approaches during this first phase of the ecosystem. To deal with technological uncertainties related to vehicle development (reliability [r], performance efficiency [s] and controllability [t] and design [u]) they employed three main shaping strategies: pivoting, opening a new company", and partnering to shape the market strategy among others). Some adaptative strategies come into play (i.e. passive learning, being conservative strategy), and also transformative strategies (triangulation and redundancy). We only see a few number of planning strategies.

To deal with relational uncertainties that occurred during the aircraft developing and prototypes phase – uncertainties related to the blurring of roles and boundaries between actors [ak], partner selection [al], market experience [c], data sharing [ad] - actors invested in long-term partnerships using opening a new company strategy, learning by borrowing and planning next alliances strategies. These strategies reinforce the relationship between ecosystem actors, ensuring that relational uncertainties are controlled and better understood.

Finally, to deal with financial uncertainties (affordability [p] and operational costs [m]) they employed opening a new company strategy, passive learning, CONOPs and also planning next alliances strategies.

4.1.1.4 Summary

In general, among all the strategies that emerged during this phase, we see a mix of different strategies. Here we highlight the main that emerged from the dataset: Pivoting (shaping), Passive learning and Learning by Borrowing (adapting), Proof of concept, adapting to current systems (transformative), and Planning next alliances strategies (planning). Table 16 summarizes all events uncertainties and strategies from the first part of the first phase.

Table 16 - Events, Uncertainties, and Strategies from the Vehicle Development Phase

Phase Nº	1.1
Phase Description	Vehicle Development
Sub Phase Description	Design, Developing Prototypes, Testing and piloting (Conops)

Event Nº	**Date**	**Event Description**	**Uncertainty**	**Shaping Strategies (H/H)**	**Planning Strategies (H/L)**	**Transformative Strategies (L/H)**	**Adaptative Strategies (L/L)**
2 3 4 5 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24 26 31 33 34 35 36 37	2009 2010 2011 2013 2014 2014 2014 2014 2015 2015 2015 2015 2015 2015 2016 2016 2016 2016 2017 2017 2017 2017 2018 2018 2018 2018 2018 2018	First NASA Prototype - Personal Air Vehicle Nasa projects Volocopter Beginning FAA selects states for AAM testing (EE) Tests - CONOPS - NASA UTM Concept is introduced Vertical Flight Society Launch White Canvas World's 1st Electro Aerobatic Plane Lilium starts 1- Fundability 2- Technical Viability 3- Defining design 4 -Selling and Flying Challenges 1st EVTOL Airbus Vahana World Cup in Brazil Electrification Market Projections - McKinsey Uber White Paper Airbus Accomplishments Eve starts Market projections Levina Aircraft Moura started producing Lithium Battery Market investments Market Projections Lift Aircraft emergencies Technological advances Uber Elevate Event	•Battery •Vehicle Reliability •Vehicle Performance •Efficiency •Controllability •Vehicle Design •Fundability •Overlaps and blurry frontiers - Ecosystem roles •Collaboration with the right players •Market Experience •Data sharing •Operational Costs •Interface standardization and Interoperability •User full journey experience •Affordability	•Bottleneck •Imaging •Pivoting •Opening a new company •Creating a cluster •Platform and systems •Dictating trends •Partnering to shape the market •Educating •White papers •Standardization of concepts, nomenclatures, and key terms •Manuals-handbooks-reports.	•Students' competition, •Planning next alliances •Being enthusiastic •Made assumptions •Risk assessment •Survey •Simulations	•Make it simple •Selecting uncertainties to focus on •Concept of operation and •Consortiums •Spreading •Information •Commitment •Triangulation and redundancy •Proof of concept (POC) •Get your hands dirty •Bricolage •Adapting to current systems	•Partnering to build knowledge and co-create solutions •Passive learning •Playing by the rules •Sharing uncertainties •Breaking the problem into pieces •Lessons learned •Trial by error •Learning by borrowing •Being conservative •Doing nothing and wait

42	2019	DOE investments	•Lack of knowledge			•Agile methods	•Being an outlier, researching
43	2019	Hyundai entering the mkt					
44	2019	Market projections					
45	2019	NASA Study					
47	2019	Jan - beginning of national market structuring					
49	2019	Jun - Flight Plan 2030 Embraex					
51	2019	Jun - Pika entrance in the market					
56	2019	Total manufacturing enterprises					
57	2020	CONOPS EVE					
58	2020	E-hang test flights					
59	2020	Investments in the market					
62	2020	Technical Uncertainties resolutions					
66	2020	May - Scaling up production challenge					
68	2020	Jun - Partnership Embraer-Eve-Helisul					
70	2020	Sep - EGNSS Galileo no UAM					
71	2020	Oct - EVE launch					
73	2020	Dec - Uber and Joby Partnership					
74	2020	Embraer seeks ANAC to start in Brazil					
80	2021	EVTOL manufacturers					
84	2021	Apr - Hyundai creates its own Business Ecosystem					
85	2021	First Brazilian operator starts researching the market					
86	2021	Jan - Skybus project GKN+ partners					
87	2021	Jun - Gol is targeted by other companies					
88	2021	Jun - GOL Vertical market research starts					
89	2021	Jun - Partnership EVE and Helisul helicopters					
91	2021	Jul - GOL starts EVTOL operations					
93	2021	Airport Shuttle and Air taxi and Export and tax revenue					
94	2021	Market research (consumer behavior)					
95	2021	Set - Atlas Crest Investment Corp merges with Archer					
98	2022	Mar - Partnership Lilium-Netjets					
100	2022	Apr - Beta technologies raises 360mi					
101	2022	Apr - Lilium starts new testing phase in Spain					
102	2022	Apr - Market Projections					
103	2022	Apr - Partnership E-hang-Prestige Aviation Indonesia					
106	2022	Apr - Battery designs					
107	2022	May - 1º flight Volocopter					
109	2022	May - Committee Archer and United Airlines					

112	2022	May - Partnership Airbus-Ita Airways Italia					
113	2022	May - Partnership Airbus-Magical motors					
115	2022	May - Partnership Microsoft-Volocopter					
116	2022	May - CONOPS EVE Publication					
117	2022	Jun - Avolon -Gol Vertical					
119	2022	Jul - Design update EVTOL EVE					
121	2022	Jul – E-hang Demonstration flight					
122	2022	Jul - Partnership Vertical Aerospace and Molicel					
123	2022	Aug - EVE USA Flight Simulations					
124	2022	Aug - United Airlines and Archer - purchase EVTOLs					
125	2022	Sep - Airbus and Hiratagakuen Japan					
126	2022	Sep - EVE and Blade expansion to India					
127	2022	Sep - Jaunt Air Mobility - MintAir					
131	2022	Oct - Volocopter 1º manned flight in Italy					
132	2022	Oct -1º public flight Xpeng Dubai					
134	2022	Nov - Gol purchases EVTOLs Vertical					
137	2022	Nov - Tests E-hang Spain					
140	2022	Dec - 1º E-hang in Spain					
141	2022	Dec - EVE - Volatus					
142	2022	Dec - Partnership EVE-Flybis-BR Operations					
143	2022	Dec- Partnership EVE-Volatus-Managing Software					
145	2023	Jan - NASA windtunnel simulations for UTM dev					
146	2023	Jan - openness for collaboration					
147	2023	Jan - Partnership Stellantis - Archer Manufacturing USA					
148	2023	Jan - Stellandis - Archer					
151	2023	Feb - Moya Fundraising with FINEP					
153	2023	Feb - Joby assembling EVTOL in CA (USA)					
163	2023	Mar - Market Projections					
164	2023	Mar - Market underdeveloped					
167	2023	Mar - Battery Tests					
169	2023	Apr - Lithium battery for EVTOL					
176	2023	May - E-hang - Monarch Airplane Manufacturing					
177	2023	May - Eve completes tests in a wind tunnel					
178	2023	May - Forum EVTOL					
174	2023	May - Archer completes assembly Midnight					

Source: Author’s Elaboration.

4.1.2 First Phase – Certification/Regulation process

4.1.2.1 Event Description

Certification is a key milestone for all EVTOL manufacturers[6]. Certification validates that the aircraft design and manufacturing meet stringent safety standards for passenger transport set by aviation, and unlocks additional private funding and liquidity. Moreover, aircraft operators require certified aircraft to consider purchase agreements. In other words, certification opens the door to large orders helping OEMs to transition from a small prototype stage to an advanced manufacturer ready for growth.

Since 2014, many aeronautics events started aiming to accelerate the development of safe and scalable advanced air mobility flight operations[9 37 61]. Working groups and consortiums became quite popular [70] as a channel to discuss topics around the vehicle and the "common agreements" that should be settled to allow the ecosystem to grow and help OEMs to concur the certification process – i.e. internal cohesion, standardization of concepts and nomenclatures:

> "Now the challenge is not too much on the technologies themselves, but mostly on the regulation part and the urban implementation. And those are the challenges that we are confronting to make this dream come true." (Spotify episódio 11)

In this sense, the first dialogues between national regulators to accelerate the certification processes happened when NASA representatives, who assisted EVTOL certification through modeling, simulation, and the development of new airspace management systems - in 2016, showed optimism around these EVTOLs at a White House workshop on Drones and the Future of Aviation [20]. One year later, NASA created an Aeronautics Research Mission Directorate studies [25].

In 2019, Switzerland shut down drone delivery operations due to a small incident. Although this event had not directed relation to the EVTOL IE, it showed us how sensible and fragile the new unmanned aircraft operations was[48].

OEMs also got close to reputable, experienced aerospace private partners to get assist with developing vehicle components, support, and accelerate the certification process. In 2022, Joby announced the acquisition of Avionyx, an aerospace software engineering company, to assist in the certification of electric aircraft with the FAA[114].

> "There was no regulation, nothing. Nobody knew how these requirements are today. We do have a regulation in place for implementing the urban airspace, but it still is not providing all the answers to what we are working on. But at least we have the regulation."[168] (Engineering company)

Besides these dialogs, partnerships between OEMs and public authorities to carry out flight demonstrations also marked the ecosystem trajectory. Since 2018 when Airbus helped create business rules[28], companies got close to the public agencies to support and accelerate the certification process – i.e., Pika[69] and E-hang[79]. In 2023, FAA, EASA, ANAC, CAAC, and other public bodies worked closely with OEMs through the certification process including establishing means of compliance, safety requirements, and flight testing.

In 2020, the FAA revisited concepts and nomenclatures around UTM – first released in 2018[64]. Two years later, in November 2020, Eurocontrol unveiled the new EU Drone Strategy[72]. In May 2022, The FAA established the Part 23 Reorganization Aviation Rulemaking Committee to overhaul outdated certification standards for light aircraft, important for EVTOLs. Ecosystem actors have expressed frustration over what they see as a lack of clarity on the FAA's intentions[185].

EASA in Europe is collaborating closely with the FAA on EVTOL standards and frameworks to streamline international certification. In July 2022, EASA published regulations[120] [150] and CAAC replicated EASA certification standards[108]. In February of 2023, we saw some Certification reviews in Brazil[152]:

> "Now at this moment, it is all about what must be fulfilled in terms of security. In some EVTOL certification or validation processes, what we are currently discussing is the certification basis and the document that will be verified in the context of certification." (National Regulator)

In September 2022, DECEA published an ordinance establishing the concept of operations in Brazil for UTM systems. The safe drone management system is intended to pave the way for future EVTOL regulations[128]. In June 2023, the FAA published a long-awaited document outlining proposed pilot training and operating standards for EVTOL aircraft, a key milestone intended to keep the agency on track to have operating rules in place by the end of 2024[187].

In October 2022, E-hang started the certification process in China[130]. In May 2022, Joby received a Part 135 Air carrier certificate from the Federal Aviation Administration, clearing the way for commercial on-demand commercial air taxi operations[188] – see photo 12. In February 2023, Traveler X2 designed by Xpeng, gets certification with CAAC in China[155]. In the same month, Vertical commented on targeting certification in Britain, Japan, and EUA. Figure 14 shows one example of an event related to the certification process.

Figure 14 - Joby Aircraft Certification

Source: Joby Aviation.

4.1.2.2 Uncertainties

In this phase, we observed uncertainty related to the aircraft certification process [ac]. Actors didn't know the possible strategic movements that regulators would take in the case of implementing new regulations [af] and how flexible they would be when adding new amendments to existing legislation [ag]. These are a category of uncertainties mainly faced by OEMs.

4.1.2.3 Strategies

In order to deal with regulatory uncertainties- i.e. certification process [ac], regulator's decision-making [es], and flexibility in adapting the ecosystem rules [ag] - actors didn't usually employ planning strategies. Besides, we see a vast number of shaping strategies employed to deal with the certification/ regulation process [ac]. Actors placed two sets of strategies focusing on resolving this uncertainty.

The first set covered proactive mindset- standardizing operations, merging firms into new companies, spreading trends, educating people, and writing white papers- and adaptative strategies - learning, and experimentation like partnering to build knowledge, co-create solutions, and learning by borrowing. The second set covered reactive mindsets that also emerged- playing by the rules, doing nothing and waiting strategy, passive learning, and being an outlier strategy.

4.1.2.4 Summary

Table 17 summarizes all events uncertainties and strategies from the second part of the first phase. This phase is smaller compared to the first and the group of events and strategies used to mitigate uncertainties as well.

Table 17 - Events, Uncertainties, and Strategies from the Certification Phase

Phase Nº			1.2				
Phase Description			Certification/ Regulation process				
Sub Phase Description			Certification				
Event Nº	**Date**	**Event Description**	**Uncertainty**	**Shaping Strategies (H/H)**	**Planning Strategies (H/L)**	**Transformative Strategies (L/H)**	**Adaptative Strategies (L/L)**
20	2016	Meeting - Whitehouse - Jaiwon Shin NASA	•Certification/ Regulation Process •Expected strategic move •Flexibility and dynamicity in changes	•Standardization and Modularity •Opening a new company •Dictating trends •Educating •White papers	•Business plans	•Make it simple •Adapting to current systems •Compliance demo	•Partnering to build knowledge and co-create solutions •Passive learning •Testimonials and good faith •Playing by the rules •Lessons Learned •Learning by Borrowing •Doing Nothing and wait •Being an Outlier
25	2017	NASA's Aeronautics Research Mission Directorate studies					
28	2018	Airbus helps create business rules					
30	2018	Current Aviation regulations worldwide					
38	2018	UTM Concept formalized					
48	2019	May - Switzerland shuts down drone delivery operation					
50	2019	Jun- Paris Air Show in 2019					
52	2019	Jul - Alignment of concepts FAA-Embraex					
61	2020	NASA Working Group					
64	2020	UTM Concept revisited					
69	2020	Aug - Manned flight demo for secretary of the US					
72	2020	Nov - Advisory Eurocontrol					
75	2021	Aircraft crew archetypes definitions by NASA					
76	2021	Call for a common taxonomy					
77	2021	Call for new certification standards					
79	2021	E-hang 1st flight in partnership with the Police					
82	2021	NASA Conops- UAM AAM Definitions					
104	2022	Apr - Revised document DCA 351-2					
108	2022	May - CAA replicates EASA certification standards					
111	2022	May - FAA new rules					
114	2022	May - Partnership with Joby-Avionics to accelerate certification					
120	2022	Jul - EASA publishes regulations					
128	2022	Sep - Standardizing concepts and definitions UTM Brazil					
130	2022	Oct - E-hang China certification process					
150	2022	Sep - EASA Publication					
152	2023	Feb - Certification reviews in Brazil					
155	2023	Feb - First EVTOL in China gets certification					

156	2023	Feb - Vertical - Starts certification process					
160	2023	Mar - Fraport - Lack of regulations					
168	2023	Mar- Regulation in Europe					
170	2023	Apr - Limosa Canada certification process					
185	2022	May - FAA - Part 23 Reorganization Aviation Rulemaking					
187	2023	Jun - FAA Publication					
188	2022	May - Joby awarded Part 135 certification by the FAA					

Source: Author’s Elaboration.

4.1.3 Second Phase – Air Traffic Operation

4.1.3.1 Event Description

Air Traffic Management systems are complex and consist of many different functions. In 2014, NASA started with FAA a UAS Traffic management system, creating a framework for safely managing the growing use of low-altitude airspace[6].

In 2016, Uber in partnership with Airbus offered, for a short period, Ubercopter, an on-demand service offered in the city of São Paulo to test the market. [189] This project encouraged the emergence of Voom, an app with a similar purpose and wider coverage area[39]. According to press releases, this new project declined in 2020 due to the Covid-19 pandemic[190].

> (…) in 2018, there were already people working on the app, Voom, which was for providing an on-demand helicopter service.[32] (Brazilian National Regulator)

In 2018, NASA partnered with SESAR and Japan UTM to redesign air traffic management services. In traditional aviation, services were provided through a central entity such as a control center, and the services are deployed in masse. Functions included the acceptance and approval or rejection of flight plans, tracking of aircraft, providing guidance and separation services to pilots, and handling emergency situations[40].

In 2019 Kitty Hawk and FAA launched the New B4UFLY App. The app focused on displaying air traffic management rules for drone operators[46] to better integrate flight demands with the traditional American air system. This and other initiatives – like the North Texas infrastructure platform[54]- also pave the way for more complex urban air traffic management systems, such as EVTOL.

Based on these new ideas, a new idea for traffic management services, with multiple players building and providing services, each aircraft choosing entities to communicate locally in nearest neighbors. These services could be certified by regulatory bodies and air national service providers (ANSPs). This new market caught the attention of companies specialized in the development and commercialization of software and solutions for ATC[83]:

> What we have observed (...) in the meetings I attended during the presentations (...) is that Uspace (...) needs to be expanded to meet the needs of this new segment (...) We are talking about something slightly more serious (...) with this initial vision, it would not meet the minimum safety requirements to support an EVTOL-type operation[175]. (ATC Service provider)

Moreover, this report commented on a change in actors' roles, where human air traffic controllers would become new airspace managers, focusing on oversight, safety, and security[29].

> I think eventually we get there, but the question is how long that would be. For businesses. Whether it's viable for us to be able to continue to operate while still burning some cash because the market is underdeveloped at this point[164].

In June 2021, EVE and Atech Software embarked together on the development of an air traffic management software prototype. Two years later (May 2023), the companies publicly announced the completion of their prototype[90]. In 2023, EVE also partnered with Ferrovial Vertiports to test this agnostic urban air traffic management software[165].

In Jan 2022 a Brazilian Air National regulator promoted a seminar on UAM. To bring companies together and engage them to exchange ideas and design the new air traffic management system [96].

Another relevant fact occurred in the new air skills required of pilots and in the training settings. One example was the Lilium and Collins Aerospace partnership. These firms come together to design, develop, and build side-stick control systems used by pilots to maneuver the new aircraft. This invention simplified operations by assisting in navigation, takeoff, and landing, reducing the pilots' workload, and impacting flows in urban airspace[162].

In October 2022, a US-based firm - Skyway Technologies – started developing and testing a navigation service for autonomous aircraft software. This software had the goal of applying artificial intelligence technologies for tasks such as airspace compliance, autonomous aircraft separation, and deconfliction resolution[133].

More recently, in 2023, Lufthansa, which plays the role of operator, teamed up with the world's leading professional aviation flight simulation companies training company (FlightSafety International) and OEM Lilium to develop and provide training programs for the qualification of future pilots and mechanics around the world. The agreement establishes FlightSafety as the exclusive developer and supplier of flight training devices for the Lilium Jet [173].

4.1.3.2 Uncertainties

The uncertainties related to the air traffic operation were many. These are a category of uncertainties mainly faced by actors engaged in airspace management. In terms of airspace design, actors didn't know which guidelines would be appropriate to support the vehicle in terms of new air communication systems [ae] and cybersecurity safety [am].

While some actors commented on unknowns related to how to tailor the aircraft to fit into the current airspace system, another group commented on how to create an entirely new airspace operation design, with new rules and new forms of control on these aircraft. During this process many uncertainties emerged, some of them related to actor's new positions in the ecosystem - which actor would be available and interested in orchestrating these with aerial systems?

Moreover, uncertainties related to air traffic city climate issues [x,] and possible challenges that pilots of these vehicles would have [ah] – i.e. piloting and navigating a new type of aircraft in a low altitude zone competing with other types of vehicles [w] emerged. The first one was much more frequently mentioned compared to the second one.

4.1.3.3 Strategies

The strategies used to manage airspace uncertainties are complex as it is not yet clear whether new airspace will be re-purposeful changed or not. One main shaping strategy emerged from the data - platform and systems strategy- although other seven strategies were mentioned by the interviews too.

In this sense, two adaptative strategies - partnering to build knowledge and cocreate solutions strategy and learning by borrowing – showed that learning together is an important movement actors played to solve this big set of uncertainties. They also employed planning strategies by making assumptions and simulating scenarios in a tentative of reduce the air traffic problems that could emerge during the flight.

In contrast, a group of actors defended that EVTOL is not worth a completely new air system. Thus, they mentioned two transformative strategies – making it simple strategy by reducing air traffic complexity (number of interactions with the control tower, process reduction) and adapting to current systems.

4.1.3.4 Summary

Table 18 summarizes all events uncertainties and strategies from the first part of the second phase.

Table 18 - Events, Uncertainties, and Strategies from the Air Traffic Operation Phase

Phase Nº			2.1				
Phase Description			Aircraft Traffic Operation				
Sub Phase Description			Design, Implementation				
Event Nº	**Date**	**Event Description**	**Uncertainty**	**Shaping Strategies (H/H)**	**Planning Strategies (H/L)**	**Transformative Strategies (L/H)**	**Adaptative Strategies (L/L)**
6 189 39 27 29 32 40 46 54 60 190 83 90 96 133 165 162 173 175	2014 2016 2017 2018 2018 2018 2018 2019 2019 2020 2020 2021 2021 2022 2022 2023 2023 2023 2023	NASA UAS Traffic Management System Jun- UberCOPTER App for helicopters starts operations Mai - Voom App for Helicopters starts operations SESAR Joint Undertaking U-space Change in ATC roles EVTOL ideas and Uber Black demand Microservices Partnership Kitty Hawk -FAA North Texas infrastructure Low Altitude Authorization Voom App for Helicopters finish operations Saipher entrance EVTOL market Jun - Partnership EVE-Atech Software Jan - seminar on UAM promoted by the DECEA Oct - Partnership EVE-Skyway – Software Development Mar - Partnership EVE - Ferrovial Software USA and RU Mar - Lilium and Collins Aerospace - control system May - FlightSafety and Lilium develop simulators May - Disbelief in the current UTM system	•New Air Communication system •Traffic Density • (Micro) Weather peculiarities •Interference in current systems - air Cybersecurity safety •Interference in current ATC systems - communication •Air disorder and unexpected Interferences •Training	•Bottleneck •Imaging •Pivoting •Opening a new company •Platform and systems •Dictating trends •Partnering to shape the market •White papers •Manuals-handbooks-reports	•Made assumptions •Simulations •Business plan.	•Make it simple •Spreading information •Proof of concept (POC) / business case •Adapting to current systems	•Partnering to build knowledge and co-create solutions •Passive learning •Playing by the rules •Breaking the problem into pieces •Learning by borrowing •Doing nothing and wait

Source: Author's Elaboration.

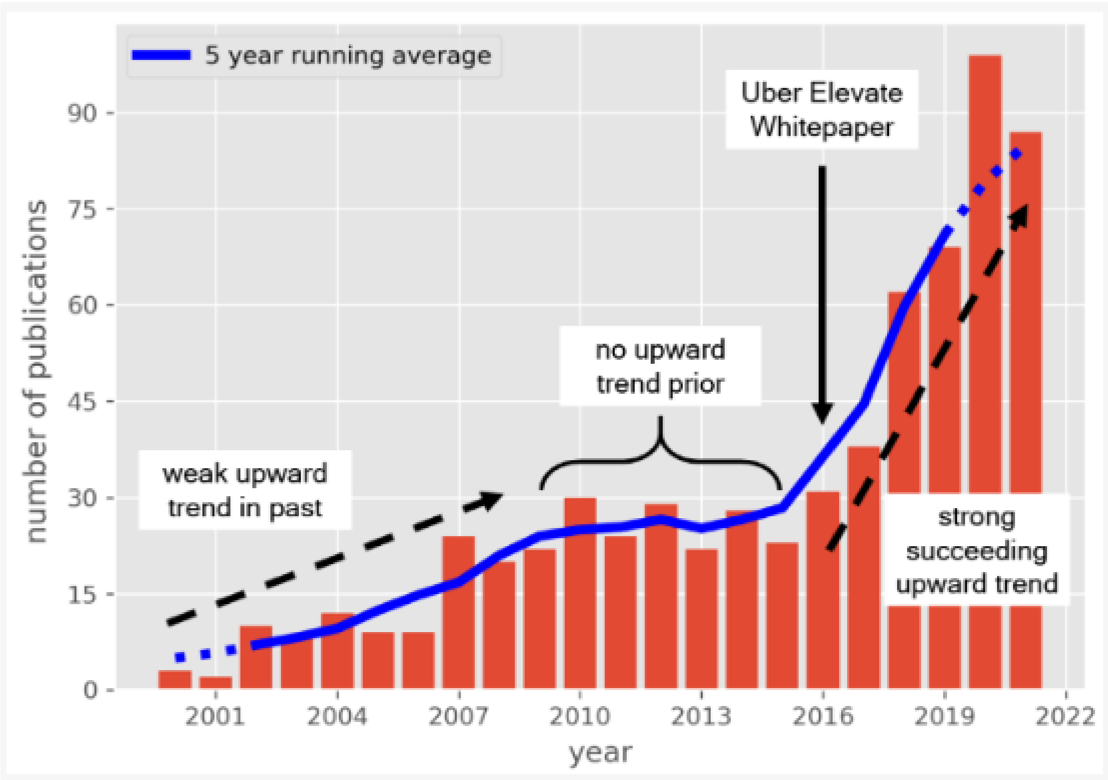
4.1.4 Second Phase – Ground Handling Infrastructure

4.1.4.1 Event Description

Groundhandling infrastructures embrace vertiports and vertistops designing and building operations. Vertiports are large multi-landing locations that have support facilities. These infrastructures can be new or redesigned airports. On the other hand, a Vertistop is a single-vehicle landing location where no support facilities are provided, i.e., a helipad.

Thinking that these new infrastructures would demand new challenges, in 2016, Uber's white paper envisioned these new networked landing sites to enable air taxi services in cities.[21] Figure 15 we see a publication related to UAM ground infrastructure as listed in Scopus after the year 2000 and about the publication of UBER's whitepaper in 2016:

Figure 15 - Publication related to UAM Ground Infrastructure



Source: Schweiger, K., & Preis, L. (2022).

In this sense, 2019 was the year when Volocopter and Skyports partnered to build the World's First Full-Scale Air Taxi VoloPort[182]. They presented some first ideas of operation, mentioning Singapore as the city model for EVTOL operations[67]. In the same year, international architectural firms specialized in airport design and operational analysis started investigating these opportunities[41].

In January 2021, Ferrovial and Lilium partnered to develop a network of at least 10 vertiports. One month later, a partnership between the multinational infrastructure consultancy company AECOM, Ferrovial to build vertiports in Florida[184]. In 2021 Bluenest – a spinoff of Globalvia, the world leader in transport infrastructure management- started operations focused on the EVTOL market[81].

2022 was the year of construction of the world's first 'skyport' for flying taxis and delivery drones are underway in Coventry[186]. In March, Skyports raised 23mi to focus on advanced air mobility infrastructure and EVTOL operations[97], and in April of the same year, EVE brought to light the importance of accessibility for inclusion in these new infrastructures[99].

Source: dailymail.co.uk

In 2022, we saw some OEMs with airports - e.g., in June 2022, the partnership between Airbus and Munich Airport [118] - and with infrastructure firms – e.g., the partnership between EVE and Globalvia[136] and with Volatus[157] - to develop infrastructure for landing and takeoff.

> One of the areas that we're having more discussions now is how we can leverage that simulation to support in data-driven decisions around complex environments. So essentially, you're looking at where would you place verticals into an ecosystem? How do we move people around? And I think that type of planning is going to be essential to make sure that we can make intelligent decisions ahead of time (Episode 84)

OEMs also partnered with architecture professionals to develop infrastructure for the landing and takeoff of ambitious and creative projects, as we can see in the partnership between E-hang and Arquitetare[129].

In November 2022 Paris inaugurated the first integrated passenger terminal for EVTOL in Europe. The tests took place at the airport Pontoise–Cormeilles and aimed to prepare infrastructure for commercial operations during the 2024 Olympics[135]:

> "There are a lot of activities in other airports and cities like in France, for example, especially their plans for commercial air taxi services during the Olympic Games next year in 2024. There are Italian prototypes for vertiports. There are very, very ambitious plans from Asia like the Korean airport, Incheon, which was the strategic advisor to our master planning process. Dubai has also very interesting plans for the air taxi services in 2026." Ground handler operator[179]

In March 2023, the Aviation Senior Project Risk & Internal Controls Manager & Program Lead UAM from a German groundhandler that owns and operates several airports commented: "We have some strategic partnerships, we have some vertiport operators, we are talking with skyports as well. Another stakeholder we collaborate are de ANSPs and the regulators."[160] In the same period, the partnership between Volocopter and Sita for developing new passenger/flight/aircraft operating standards, baggage processing, border management, and a digital-first passenger experience in vertiports[166] took place.

4.1.4.2 Uncertainties

While a group of actors concentrated on describing uncertainties related to the construction of completely new areas - new groundhandling infrastructures designers [ab]-, another group focused on reducing uncertainties related to existing groundhandling infrastructures [at].

In terms of existing groundhandling infrastructure adaptations, due to the possible noise and related social resistances that could occur in urban centers, some ecosystem actors began to position these infrastructures near environments such as the seas and lakes, in an attempt to reduce noise uncertainties.

The issue of where to position these infrastructures was a big uncertainty that appeared in the database.

New players get interested in entering this new market, such as heliports and private parking lots owners. Thus, uncertainties on "how could we adapt our current infrastructure to embrace take-offs and landings" [at] and "how our infrastructure will support vehicle maintenance" [aj] emerged.

Due to the high costs of both old infrastructure adaptations and new infrastructure buildings, we saw that ground handlers didn't know to what extent they should put their vertiports/vertistops design projects into practice or if they should wait more time and see how things evolve [ap].

4.1.4.3 Strategies

Regarding groundhandling infrastructures, we observed partnering with different players as a strategy to build smart and holistic design projects. In addition to partnering, another shaping strategy adopted to mitigate different infrastructure uncertainties [ab to aj ap] was the pivoting strategy – i.e., in cases where it was not possible to plan a vertiport construction in the urban center due to noise issues, the actors pivoted the projects, allocating the structures in regions close to coastal regions.

Regarding adaptation strategies, the most used strategy is the "doing nothing and waiting for strategy". There are also many adaptative strategies related to knowledge sharing. The authors benchmarked other sectors (i.e., commercial aviation and helicopters, drones, and jets) searching for best practices and successful infrastructure examples. The main goal is to build something functional and smart. A smaller number of transformative strategies and planning strategies appeared in the database.

4.1.4.4 Summary

Table 19 summarizes all events uncertainties and strategies from the second part of the second phase. These are a category of uncertainties mainly faced by groundhandling operators.

Table 19 - Events, Uncertainties and Strategies from Groundhandling Phase

Phase Nº			2.2				
Phase Description			Groundhandling Infrastructure				
Sub phase Description			Design, Implementation				
Event Nº	**Date**	**Event Description**	**Uncertainty**	**Shaping Strategies (H/H)**	**Planning Strategies (H/L)**	**Transformative Strategies (L/H)**	**Adaptative Strategies (L/L)**
21 41 55 182 67 81 97 99 118 129 135 136 186 149 157 166 179	2016 2019 2019 2019 2020 2021 2022 2022 2022 2022 2022 2022 2022 2023 2023 2023 2023	Uber published a white paper envisioning networked landing sites called "vertiports" to enable air taxi services in cities. Airports interested in Groundhandling operations Jul - The growing of vertiports projects Oct - World's first vertiport showcase in Singapore May - Skyports first operation Globalvia starts Mar - Skyports Investiments Apr - Accessibility Jun - Partnership Airbus and Munich Airport Oct - Arquitetare invited to Vertiport design Nov - Paris Vertiport Inauguration World's First Full-Scale Air Taxi VoloPort Unveiled in Singapore Nov - Partnership EVE-Globalvia- Sist Gerenciamento Jan - upcoming challenges Feb - Volatus infra-announcement Mar - Partnership Volocopter-Sita- Vertiports Systems	•Groundhandling infrastructure •Design Existing Groundhandling infrastructure adaptations •Vehicle Maintenance •Chicken and egg problem	•Bottleneck •Pivoting •Creating a cluster •Partnering to shape the market •White papers	•Planning strategies •Planning next alliances •Survey	•Make it simple •Selecting uncertainties to focus on •Conops and •Consortiums •Get your hands dirty •Adapting to current systems •Agile methods.	•Partnering to build knowledge and co-create solutions •Passive learning •Lessons learned •Learning by borrowing •Doing nothing and wait •Researching

Source: Author's Elaboration.

4.1.5 Third Phase - City Embeddedness

4.1.5.1 Event Description

The city embeddedness phase underlined two things. The first thing is the IE actors' actions to embrace and integrate EVTOL technology into cities' lives. The second thing was the country-level competition that took place. In other words, who would win the competition and be recognized as the first country to successfully integrate EVTOL in urban centers? According to Deloitte's 2021 report: "The country that develops its domestic capabilities and is first to deliver state-of-the-art AAM products that are safe, accessible, secure, and readily available at scale could emerge as the global leader[78]."

One year after Deloitte's study, in 2022, an Urban Air Mobility Initiative cities community (UIC2) brought together 37 city representatives from all around the world to exchange insights and expertises[105] showing that, besides competition, cities could work together to deliver this technology to the population.

In this sense, industry, academic, and federal representatives began building strong partnerships to smooth the process of integrating the technology into the cities life[4]. Some first actions we observed were the accomplishment of tests in specific cities in states such as San Francisco, Alaska, and Dakota, among others. The tests aimed to understand how the new vehicles behaved in regions with different climatic and geographic characteristics. Below we see an example of this event:

> Specifically, they chose San Francisco as one metropolitan area to provide detailed geographic, land use, infrastructure, weather, and operational constraint considerations to bring real-world issues into their study. This permitted NASA to develop a detailed Concept of Operations for how the vehicles would be used and where the required supporting infrastructure could be placed. This NASA study provides several insights that help better understand the feasibility of conducting very dense operations (far more than any existing city experiences with helicopters today).

Oems strengthened contact with authorities to start national operations[74]. In 2017, E-hang partnered with the southern Chinese city of Guangzhou to set up regular flight routes[181]. In July 2019 some actors founded the operations of the Community Air Mobility Initiative (CAMI) that worked at the state and local levels to integrate the EVTOL ideas into a sustainable community transportation system[53]: “But the missing piece was the conversation with the communities where this new form of transportation would roll out.”

In 2020, the Los Angeles Department of Transportation, City Planning, and the Mayor’s office collectively and proactively developed the policies and procedures to regulate UAM operations in anticipation of greater adoption. They released guidelines for vertiport design and operations in the city[183]:

> The role of the city is to ensure that Los Angeles has a safe, efficient, and modern transportation system that improves the quality of life for its communities and assures equitable and sustainable access to mobility and connectivity choices for all residents, businesses, and visitors. The City is taking a comprehensive approach to the transportation network through consideration of how transportation needs impact the community's priorities, from public safety to economic and community development (…) a major component of the City’s strategy will be the planning, regulation, and enforcement of an orderly development of a vertiport network, and how the vertiport network will be integrated into the City’s overall transportation network.

Another important and relevant fact was the integration of technology waste into the city. The partnership between Siemens and Skyway for vertiport electrification in February 2022[154]. Was important to address the electrification issue. The companies searched for solutions for energy supply:

> So just yesterday we officially started construction of our new charging stations. The charging infrastructure is of the most vital importance to this industry. And we finally got the points of all the supply chain issues. And we officially we announced the official start of production for our charging stations. So, this is a vehicle agnostic charging station. We've worked with several of the OEMs, to get an understanding of what their needs are.” (Volatus infrastructure co-founder)

In March 2023, reverse logistics for battery use began to be developed in the Brazilian market, and electric mobility startups got interested in participating in the ecosystem[161]. In 2023 we saw the first vertical project presentation in Brazil, in Curitiba. On this occasion, city members came together to think about how to create a safe zone for EVTOL flights in Curitiba during the Curitiba City Expo14.

Unfortunately, this launching of the project wasn't released at the occasion, which reinforced the fragility of the public infrastructure to embrace technology at that time[159].

More recently, in April 2023, GKN commented on noise and acoustic projects as a company priority[171]. These projects were relevant because, as we will see next, noise is a key uncertainty in unlocking the growth of the ecosystem. Any action taken in this sense is very important.

4.1.5.2 Uncertainties

This phase embraces uncertainties related to the embeddedness of the EVTOL IE in the urban context. What adaptations do cities need to perform to offer this new ecosystem to the population [y] as a safe new transportation option? How to deal with visual pollution impacts [h], the auditive (noise) effects on population [i], natural resources [j], and biotic beings impacts [k]?

Moreover, leaders share uncertainties on what city-level changes should be implemented on the energy matrix to enable aircraft implementation in big centers [z]. Here leaders faced uncertainties on possible mass societal movements that regions could experience in the case that some groups coalesce against this new type of vehicle [e].

4.1.5.3 Strategies

In general, the uncertainties related to the city's embeddedness phase are very complex and have few linked strategies. There was a small number of strategies mentioned by interviewees to solve the uncertainties that occur in this phase [h z i k]. In general, the uncertainties are related to shaping and planning ideas. For example, managers need to imagine solutions and plan long-term ways to solve them.

> I think the most efficient step would be to prepare a solid and detailed business model that would already consider the input of potential business partners and secondly, prepare the specification for the design. Then, of course, the design process itself, the construction, and all of it finished with the certification process" - Infrastructure Operator

In this sense, we did not identify adaptative strategies. Decision-makers with adaptative mindsets assume that they cannot control or even predict the future. However, changing an urban infrastructure to embrace EVTOL is a big challenge that needs a proactive mindset – mainly from governmental bodies.

Thus, they tend to try to predict and control the changes in urban centers. For example, we saw this attempt to control and predict when dealing with uncertainties of visual impact [h], auditory [j], and infrastructure [z] and coalition of social groups. When using shaping strategies to deal with a coalition of social groups [e], decision-makers address multiple shaping strategies such as imagination, creating a cluster, and education.

Regarding transformative strategy, we also see a small number of experimentations to reduce uncertainties related to the city embeddedness phase. For example, this phase embraces Complex Geographic and Urban Design [y], as we can see below:

> " If he has an engine failure you have to choose the building that it will fall on (...) depending on where he is he might be able to get to the beach (...) São Paulo has no option." "Rio de Janeiro’s geography is challenging for mobility, due to the existence of mountains, forests, lagoons, rivers, bays, and settlements." (OEM Manufacturer)

When dealing with this type of uncertainty, the infrastructure operator employed a Proof of Concept (POC) strategy: "In July we are going to fly these falcons (...) So you start experimenting and thinking ‘what can go wrong’ before you go to passengers". But as we said above, there are not many cases in which experimentation is used to resolve complex uncertainties like this.

4.1.5.4 Summary

Table 20 summarizes all events uncertainties and strategies from the first part of the third phase. These are a category of uncertainties mainly faced by city representatives.

Table 20 - Events, Uncertainties, and Strategies from City Embeddedness Phase

Phase Nº			3.1					
Phase Description			City embeddedness					
Sub phase Description			Design, Implementation					
Event Nº	**Date**	**Event Description**	**Uncertainty**	**Shaping Strategies (H/H)**	**Planning Strategies (H/L)**	**Transformative Strategies (L/H)**	**Adaptative Strategies (L/L)**
181 53 183 74 78 184 105 171 144 154 159 161	2017 2019 2020 2020 2021 2021 2022 2023 2023 2023 2023 2023	E-Hang and Guangzhou city project to conduct flight tests. Jul - Start of operations of the Community Air Mobility Initiative Los Angeles guidelines for vertiport design and city operations Embraer seeks ANAC to start in Brazil Country-level competition perspective Vertiport network for the launch of EVTOL operations within 3 years Apr - Coalition among cities Apr - GKN noise and acoustic projects Jan - Vertiport project presentation in Curitiba Feb - Partnership Siemens-Skyway - vertiport electrification Mar - E-hang canceled operation in Curitiba, Brazil Mar - Start of trading recycled batteries	•Complex Geographic and Urban Design •City Visual Impact •Auditive (Noise) Impact •Natural resources impact •Biotic beings impact •Energy infrastructure •Coalition of Social Groups	•Standardization and modularity •Imaging •Pivoting •Opening a new company •Creating a cluster •Platform and systems •Educating, standardization of concepts nomenclatures and key terms	•Business plan •Simulation	•Proof of concept (POC) / business, case strategy	None

Source: Author’s Elaboration.

4.1.6 Third Phase - Scaling

4.1.6.1 Event Description

The commercialization of EVTOL vehicles for urban air mobility is still emerging but has rapidly accelerated in recent years thanks to electrification, automation, and other key technologies. In 2021, NASA developed the UAM Maturity Level scale to describe the maturity of the entire UAM ecosystem to indicate how the UAM industry may mature over time[75]. Commercial deployment with advanced automation is expected in multiple urban, suburban, and rural areas by 2038. Commercial deployment at scale with full automation is expected by 2042.

On May 7, 2021, Eve Air Mobility was the global pioneer in securing a firm order for Evtol vehicle production, which most companies still have in the design and development stages. This represented an important milestone for the ecosystem, signaling the intention of a major airline to offer regional flights with these new electric aircraft[158].

In 2022, some airlines got interested and announced billions of provisional deals to buy OEMs that had not yet announced prototype aircraft. Major funding activity - In 2021, American, German, Brazilian, and English OEMs raised hundreds of millions of dollars in fresh capital. Instead of launching traditional initial public offerings (IPOs)[110], some of them merged with special purpose acquisition companies (SPACs) as a faster path to go public. As a result, they became publicly traded stock. The new funds helped them expand operations and development toward certifying their aircraft. Going public also helped boost the credibility of EVTOLs. Meanwhile, some of these companies decided to merge with a SPAC in 2022, while others canceled or avoided SPAC plans.

By the end of 2022, many partnerships were formed, and vehicles were sold for airline commercial operators around the world – for example, a billion-dollar agreement to sell EVTOs to a Brazil-based airline. U.K. OEM-based partnered with a helicopter operator to purchase up to 50 EVTOs. Japan Airlines is working toward “permanent” air taxi operations with a commercial launch in the next years:

> "I can feel that the industry is starting to coalesce around a few themes six, nine, 12 months ago. Indeed, it felt quite homogenous. So, if you looked at the OEMs, they needed to think about absolutely everything, whether that be consumer demand, whether it be the design development, the certification of their aircraft, or how is it going to interact with air space? What about the ground infrastructure, how the service, these things? Who's going to develop all of that out, etc.".

In this sense, we saw EVTOL projects all around the globe: Xpeng flights in Dubai[132], Volocopter in Italy[131], EVE in India[126], Airbus in Japan[125,] and so on. By March 2023, the company already had an order book for the production of over 2,700 aircraft.[158]. In July 2023, a groundhandler operator commented on the growing of EVTOL orders: "We have the SMG consultant analysis about the orders for air taxi prototypes, plates by airlines operators, which already extended 12,000 units worldwide"[179].

In 2023, numerous organizations have already passed the research and development (R&D) stage and are currently performing testing and piloting. With proofs of concept (POCs) in place and continuous regulatory engagement, initial deployment with less complex commercial operations is likely to occur in a few cities around 2025.

> Over time, you can start to feel that people are getting more, more and more comfortable with their roles (…) you see a lot of startups coming through now thinking about UTM going forward and how do they help take the pressure off of air traffic controllers in the pilot and make the exchange of data much more autonomous and automated. - Ferrovial Vertiport's Managing Director

Recently, some countries encouraged the development of 100% autonomous unmanned aircraft for sparsely populated regions like rural areas[151]. As a Spanish ground handler operator commented, we need more tests in safe areas before the autonomous vehicles go to urban areas: "We are going to fly these falcons the one from logistics and medical supplies from hospital La Part to Madri. So, you start experimenting and thinking 'What can go wrong' before you go to passengers[180]."

In 2022, a partnership between Microsoft and Volocopter aimed to accelerate system developments for unmanned aircraft- Managing reservations, Operational and Flight planning, Real-time monitoring, and Data recording and analysis[115].

In 2023, Honeywell presented an improved version of the satcom system introduced in 2021 by the company. The satellite communication system expands the boundaries of connectivity when outside cellular coverage. The system enables real-time vehicle position tracking, vehicle command, and control, as well as data transfer and video streaming[172].

On the other hand, In March 2023, players playing different roles in the ecosystem were still reluctant, as we heard during the World Canso event in Genebra from an ATC provider: “I think eventually we get there, but the question is how long that would be. (…) Whether it's viable for us to be able to continue to operate while still burning some cash because the market is underdeveloped at that point” [164].

4.1.6.2 Uncertainties

“What are the scale-up challenges needed to take the ecosystem to another level?” In this phase, we saw uncertainties related to this topic, as well as “What if the mass demand for EVTOL travels thrived?” and “What if flying those aircraft did not become a profitable reality?”. In this phase, the need for alignment [a] among actors was crucial to create an ecosystem identity [b]. The uncertainties related to these issues emerged and shaped the ecosystem. These are a broader category of uncertainties mainly faced by orchestrators and complementors of the ecosystem.

New actors get interested in starting operations in this market by dedicating strategic focus to this. In the phases, we observed unknowns related to persistence and consistency needed by actors to continue to operate in a nascent ecosystem over time[ao]. The “persistence unknowns” were high because the actors didn’t know what the financial earnings of the ecosystem would be- i.e., the value capture uncertainty[n].

4.1.6.3 Strategies

The scaling phase is the last phase of the ecosystem emergence process that we identified according to analyses of the evolution of its trajectory. We see different patterns of strategies used to deal with uncertainty at this phase.

As we mentioned in the previous subchapter, the uncertainties related to this phase are complex and focused on the group of actors as a whole (they are shared by OEMs, complementarians, orchestrators, etc.).

There is a heterogeneous group of both uncertainties and strategies to deal with them at this phase. Regarding shaping strategies, we found creating a cluster, opening a new company, dictating trends, standardization of concepts, nom., manuals-handbooks, educating, bottleneck, and partnering to shape the market strategy.

Adaptative strategies also appeared on the database. The group of adaptive strategies that emerged seemed to be more reactive and somewhat opportunistic in this phase- playing by the rules, being conservative, passive learning, doing nothing and waiting, learning by borrowing. For example, when dealing with the unknowns of consistency and regularity of the IE scalability [ao], or possible impacts of accidents in the ecosystem scalability [ar], whether the technological evolution of the ecosystem will advance as expected [as], decision makers prefer being conservative. In other words, they do not make decisions before others. They prefer waiting and learning from the first movers.

A large number of transformative strategies also emerged during this phase. The largest number of strategies in this category were related to safety or the right to privacy [f] because decision-makers didn’t know if the public would accept the levels of security and right to privacy provided by these new aircraft. To reduce this uncertainty, they improvise solutions by thinking they can control the environment:

> " As EVTOL has a weight limit of 450 kg, we conduct the weight and balance of the aircraft before the flight. How are we going to know the weight of the passenger? It's a bit complicated, isn't it? It's a rather tricky question.” (Aircraft Operator)

Finally, a diversified base of planning strategies is used to deal with uncertainties in this last phase - business plan, made assumptions, regression analysis, survey, economic models/ foresight, survey, and planning next alliances.

4.1.6.4 Summary

Table 21 summarizes all events uncertainties and strategies from the second part of the third phase. These are a category of uncertainties mainly faced by all actors in the ecosystem.

Table 21 - Events, Uncertainties, and Strategies from the Scaling Phase

Phase Nº			3.2				
Phase Description			Scaling				
Sub Phase Description			Less complex commercial operations with limited automation				
Event Nº	**Date**	**Event Description**	**Uncertainty**	**Shaping Strategies (H/H)**	**Planning Strategies (H/L)**	**Transformative Strategies (L/H)**	**Adaptative Strategies (L/L)**
92 110 138 139 158 172 180	2021 2022 2022 2022 2023 2023 2023	Jul - Time to talk about partnerships May - EVE USA IPO Dec - expert opinion Dec - ecosystem maturation Mar - EVE's order books May - 5G System Satcom Jul - EVTOL Medical Flight Madrid Globalvia	•Market Sensibility •Consistency and regularity when scaling •Safety or right to privacy •Alignment •Social equity •Ecosystem Identity •Value Capture •Autonomous Vehicles time-to-market.	•Creating a cluster •Opening a new company strategy •Dictating trends •Standardization of concepts, nom. •Manuals-handbooks •Educating •Bottleneck •Partnering to shape the market strategy	•Business plan •Made assumptions •Regression analysis •Survey •Economic models/ foresight •Planning next alliances	•Triangulation and redundancy •Spreading information •Make it simple •Commitment •Spreading information •Bricolage •Adapting to current systems	•Being conservative •Lessons learned •Doing nothing and wait •Playing by the rules •Partnering to build knowledge and co-create solutions •Learning by borrowing •Researching •Passive learning

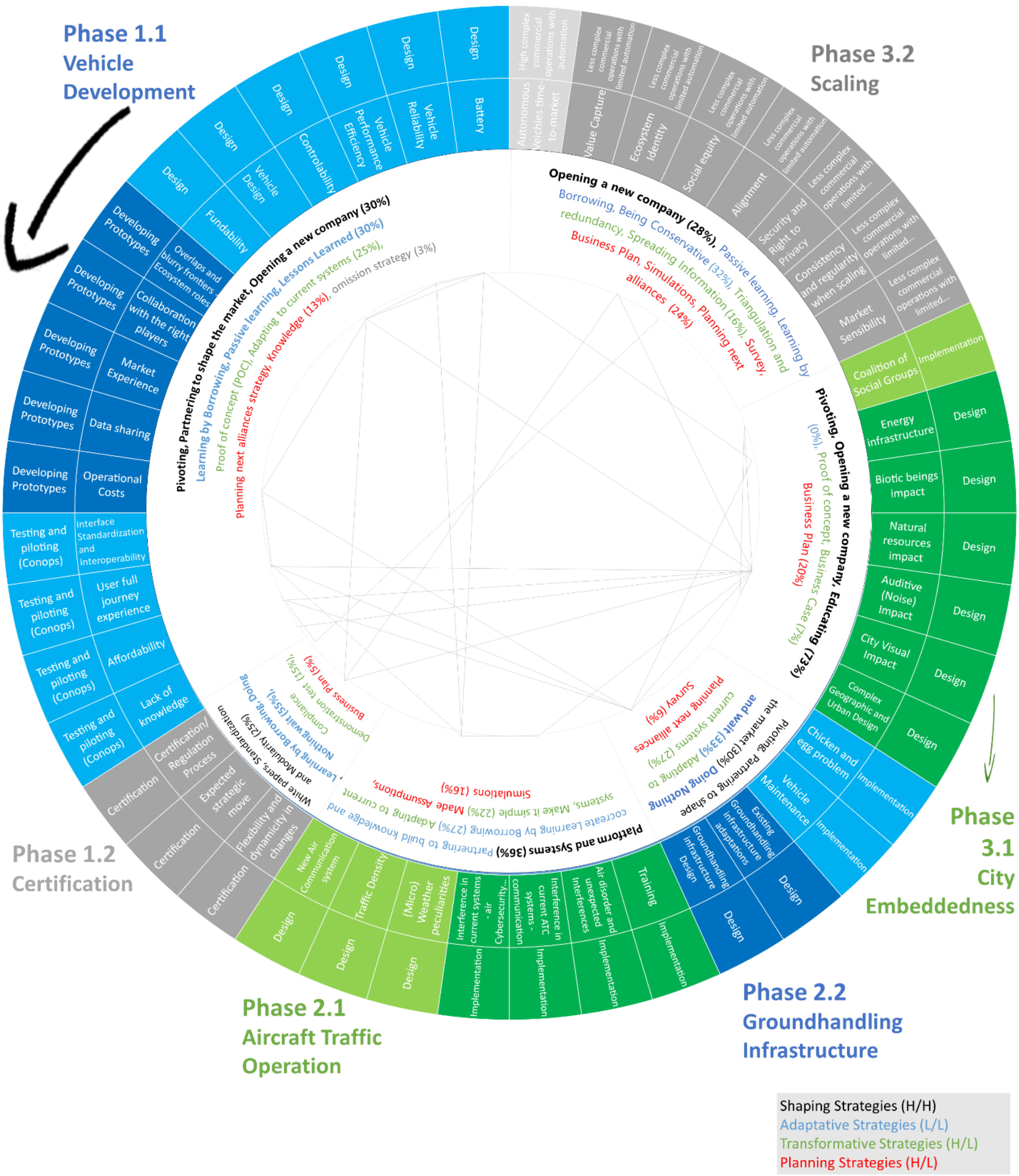
Source: Author’s Elaboration.

4.2 VISUAL MAP: PHASES, UNCERTAINTIES AND STRATEGIES

Figure 16 shows a visual map that could represent how the uncertainties and strategies evolved over time. This figure had some layers. The external layer shows the 6 phases of ecosystem evolution in a counterclockwise direction. The second inner layer shows the uncertainties most strongly associated with each phase. The third layer shows the strategies associated with the uncertainties of each phase (divided by colors according to their nature). Finally, the innermost layer of the circle shows the relationships between the uncertainties.

- The first result is that the EVTOL ecosystem has 6 phases: Vehicle Development, certification, Aircraft Traffic Operation, Ground handling Infrastructure, City Embeddedness, and Scaling.
- We found 45 uncertainties related to the community, environment, financial, air and ground infrastructure, regulatory, training, and technologies. We inductively named, framed, and ranked these uncertainties by their degree of intensity. Then we grouped them inside each phase of the ecosystem timeline evolution;
- The third result is that we found some interesting relationships between some of the uncertainties. Based on this analysis, we found that uncertainties related to noise and weather drive complex sets of other uncertainties. We explore this inside section 5.3.3;
- The fourth result that we found was the strategies. We found 50 strategies in total. The visual map shows what strategies are mostly used to deal with each group of uncertainties.

Figure 16 - Visual Map: Phases, Uncertainties and Strategies



Source: Author’s Elaboration.

We also created a Table that shows in detail all the relationships between each strategy and each uncertainty of the ecosystem. Due to the size of this table, we prefer to insert it as an Online Appendix.

5 DISCUSSION

In this section, we performed multiple analyses of the data. We divided the analysis into three parts. The first part (section 5.1) presents a cross-section analysis of all uncertainties that emerged from the data in greater detail. Firstly, we inductively named and attributed a description/meaning to the uncertainties in the light of the uncertainty theory. We presented a summary in Table 22). The second part of the analysis (section 5.2) presents a cross-section analysis of all strategies that emerged from the data in greater detail. We grouped strategies by each strategic school and presented a summary in Table 24.

After inductively defining names and meanings for each uncertainty and strategy, we related them in section 5.3. We performed multiple longitudinal and cross-section analyses inside this subsection and presented the propositions and theoretical model of the study.

5.1 ANALYSIS OF UNCERTAINTIES IN LIGHT OF THE THEORY OF INNOVATION ECOSYSTEMS

For many decades, experience has led the aviation industry to focus on safety as a priority. A conservative approach to operations has led air travel to be considered the safest form of global transport. Even in the case of a new and disruptive ecosystem, the strong aviation culture influences the way managers make decisions to deal with uncertainties in this market.

In this sense, some previous work showed uncertainties associated with the five pillars of NASA's UAM Organizational Framework - Existing regulatory environment; community acceptance; and concerns about safety, noise, social equity, environmental impacts, infrastructure and airspace management needs, as well as business model constraints (Patterson et al., 2021).

This work was a good start to understanding the uncertainties. Below we go deep in the understanding of all uncertainties that decision makers presented during the interviews and based on the secondary data we analyzed.

We found 45 uncertainties related to the community, environment, financial, air and ground infrastructure, regulatory, training, and technologies. We regrouped these uncertainties into ecosystem main elements as presented in Table 22.

Table 22 - Uncertainties that Emerged from the Data

Ecosystem Elements		**Ecosystem-bounded Uncertainties**			
Element	**Descriptions (Theory)**	**Subgroups**	**Descriptions**	**Citations example**	**Intensity**
Value Proposition	A particular set of activities and resources that interrelate firms and shape the value proposition	Alignment[a]	Uncertainty whether the companies in the ecosystem will align their goals and times.	"I need new policies happening and then making sure they're all working together at the right time and going through and talking to each other." "Achieving global leadership in AAM could be difficult without significant coordination and agreement between the government and the industry."	Medium
Ecosystem Identity	The shared meaning of the ecosystem that arises from the consciousness of its members.	Ecosystem Identity[b]	Uncertainty regarding which identity will be crystallized in the ecosystem	"How do you manage that integration with conventional aircraft?" "Here there are many very established companies that have a way of doing things and when a company is large and has managed that for 30 years and it continues to work, change that vision and say let's start doing things differently, because if not, this other industry that we could access is not going to work. It is very difficult."	Low
		Market Experience[c]	Uncertainty about the impacts of the OEM's lack of deep knowledge of traditional aviation on the ecosystem emergence	"Startups that among their founders generally have people linked to aviation, but without the support of a large company in the aeronautical sector (...) can be a point of attention in terms of safety." "Aviation relies on a lot of long, deeply rooted relationships between legacy players and their long-term regulatory partners (…) there's a whole new set of folks that you need to engage in, that you don't necessarily have those pre-existing relationships with."	Low
Value Creation	The collaborative processes and activities of creating value for customers and other stakeholders	Lack of knowledge[d]	Uncertainty regarding customer knowledge gaps regarding the technology and its security levels.	"Fear comes largely from not understanding the technology and not having the full appreciation of this new form of mobility and how it will operate". "Not only do they have to be safe, because it is obvious that they have to be. Okay, that's what easa is up to, faa. etc If not, it is critical that it appears safe to the people you are going to. Yes, because no matter how much you say that my aircraft is certified. Are you going to enter in it anyway?" "So, the average member of the public doesn't really understand that helicopters are not safe. You know that they're safe in a legal sense, but they're a hundred times more likely to kill even a large commercial transport. So, when people start to figure that out. So how will they see these EVTOL aircraft? So that the users the real user archetype isn't just driven by the economic system, by those perceptions of this as a mode of transport?" (Ex-Rolls-Royce and CEO at a Research and Innovation Center)	Medium-Low

		Coalition of Social Groups[e]	Uncertainty related to the possible division of social groups (flying and non-flying public), possible differing opinions regarding the use of the vehicle or the business model in general.	"There is uncertainty about how much of today's infrastructure will be useful and used by EVTOL because many are built in private buildings (...) many do not want to receive this public." "For the non-flying public, the system also needs to provide at least indirect benefits to them, such as through expanded employment opportunities". (NASA UAM CONOPS)	Medium-Low
		Security and right to privacy[f]	Uncertainty related to the public acceptance of levels of security and right to privacy	"One must ensure that this aircraft, in any immediate flight condition to any eventuality in the face of a problem or adverse weather condition or whatever, is capable of responding safely and without putting the lives of passengers at risk. which is within the integrity of the aircraft itself." "One of the biggest challenges will be to gain trust in the implementation of the entire system, from the manufacturer, the authority, the operator, to the end customer because all of this doesn't happen, it isn't viable if you don't have the person really wanting to use the service." (Pilot)	Low
		User full journey experience[g]	Whether the consumer will enjoy the experience of flying.	"My experience as a helicopter pilot for over 40 years is that a lot of people don't like vertical, especially when it's an elevator fast vertical (...) will the people in the back want that?" "Are they willing to fly twice the altitude of the Empire State?" "What about being in a confined space?"	High
		City Visual Impact[h]	Uncertainty of how EVTOL's impact on the landscape will affect public acceptance.	"If just 1% of the 2.2M people in central Paris commute by UAM each day, there will be more than 11,000 flights per hour over the city during peak times."	Medium-Low
		Auditive (Noise) Impact[i]	Uncertainty of how EVTOL's noise will affect public acceptance.	"The things that are less clear still (...) need research is how the noise affects people in a long-term sense (...) the psychological impact of the acoustics of these aircraft is still more or less unknown " "In most countries in the world (...) will the cities allow the disturbance their citizens with these aircraft flying?"	Very High
		Natural resources impact[j]	Uncertainty related to environmental issues as to irresponsible, inappropriate use of natural resources and the consequences of these uses in the long term	"Environmental concerns around battery inputs and disposal of used electric vehicle batteries also persist and need to be addressed by UAM stakeholders before widespread implementation can take hold." "Cobalt, lithium, and nickel ores are finite. In addition to being a problem for the ecosystem, it is also a social problem. We are seeing some islands facing even more problems there in Congo."- Battery producer	Medium-Low
		Biotic beings impact[k]	Uncertainty related to how ecosystem actors will address vehicle impact on the biological ecosystem	"Air taxis have the potential to cause ecological impacts to avian populations in cities, increase risk of bird collisions and other impacts on animals." - UAM Market Study	Low
Value Capture	How what kind, and how much value created by the ecosystem is	Fundability[l]	Uncertainty related to the members' decision-making process related to founding raising and new business	"If you can raise a billion dollars over time, then you have a shot (...) to potentially get one of these aircraft certifications. One of the biggest questions (...) is this company, is this CEO, going to be able to raise a billion dollars?" For us is a risk (...) whether create a	High

	captured by a particular actor (i.e., direct financial gains, reputation increment, higher efficiency, knowledge)		model resource allocation willingness.	fully dependent business model or if we incorporate some external investors." - Infrastructure service provider "El punto de vista de las empresas, diría que si te va muy bien es muy difícil dedicar recursos a algo que todavía no está claro."	
		Operational Costs[m]	Uncertainty regarding the cost of the development of the service as a whole.	"What's the cost base of the aircraft? Is it one billion or is it 12 million? (...) the aircraft and its operation are really uncertain." "How much will the aircraft cost?"	High
		Value Capture[n]	Uncertainty regarding the economic viability of the ecosystem.	“But is it all viable from a business point of view? (...) So this is the great difficulty we see today”. "So, our revenue, our income sources around energy (...) real estate infrastructure. How are we going to propose to generate land value or just a way for us to solve the city growth problem?" "We've done quite a lot with other people and quite a lot of economic analysis (...) there is a scenario where it's a stupid thing to do economically and a scenario where it's a brilliant thing to do. So, there's this economic uncertainty."	High
		Social equity[o]	Uncertainty whether the costs and cons related to the development of EVTOL will be fairly split precisely among the participants of the ecosystem to avoid the perceptions that EVTOL is a way only for wealthy households to buy their way out of congestion	"It's highly uncertain how many people will pay this. In most countries in the world, if that only exists for very wealthy people, will the cities allow the disturbance of their citizens with these aircraft flying? But almost everybody can't get value from them." "Who pays for the infrastructure (...) if the public is paying for the infrastructure, the public can't afford it to use the services, what kinds of equity challenges does that have?" "I have the fear that we aren't developing a system which is just providing exclusive transportation solutions for just the upper ten or five percent of society (...) what kind of society is really benefiting from it?" - Aerospace Center Institute of Flight Guidance	High
		Affordability[p]	Uncertainty whether the consumer is willing to pay to use the service and whether the public will be convinced that the benefits of EVTOL outweigh the challenges posed by the additional mode option	"How much will the public pay for these journeys? There's huge uncertainty there (...) there's lots of unknowns there." "Can it fly people far enough fast enough that they're willing to pay for it over conventional forms of travel?" - Polytechnic Institute, Center for Mobility with Vertical Lift	Medium
Systemic innovation	The “conducting wire” for the companies in the ecosystem, the main innovative ideas that shape	Battery[q]	Uncertainty about the viability and implementation of the vehicle battery system that meets the necessary requirements to enable the operation.	"Urban Air Mobility demands batteries with high power, high-energy density, long cycle life, and fast rechargeability and this is currently one of the main challenges of battery manufacturers." "The higher the voltage, the more likely you're going to have problems with partial discharge(...) We've got systems out there trying to run it up (...) Do we have cables and connectors and motor windings, all the electronics? All these things can be affected by this partial discharge. So this was the question."	Very High

	the ecosystem itself.	Vehicle Reliability[r]	Uncertainty or the variables that can trigger accidents (Crashes, fire)	"I think that there are some risks that are not yet well. If you have a crash, if you have a fire and I don't know, toxic fumes." "We still have to understand these accident-related uncertainties."	Medium-High
		Vehicle Performance Efficiency[s]	Uncertainty regarding Vehicle Performance Efficiency (Power density / electric propulsion)	" As critically important as that is, it's (...) the high torque capability for a relatively lightweight. That kind of ratio kilowatts per kilogram. Those are the kinds of things that needed to be solved or resolved to look at a primary propulsion system with electric motors."	High
		Controllability[t]	Uncertainty regarding Vehicle Controlability	"Controllability is also challenging for these multi-rotor EVTOs (...) the simplicity afforded by using multiple solid rotors makes these vehicles potentially less maneuverable"	Low
		Vehicle Design[u]	Uncertainty about how manufacturers will deal with multivariate engineering tradeoffs inherent in EVTOL design (i.e. Short-term hover power x long-term cruise energy)	"VTOLs will spend far more time in cruise which raises the question of how to optimize such a vehicle across short-term hover power versus long-term cruise energy." - Uber Elevate Report (2016) "Adding wings to enable high aerodynamic cruise efficiency combined with being able to tilt rotors or turn on/off different prop-rotors to provide lift or cruise power is a likely solution when biasing designs for a cruise more than hover. These solutions, however, add weight, which increases power requirements for takeoff and landing due to the increased disc loading."	Medium-High
Design and Structure	A particular set of activities and resources that interrelate firms and shape the value proposition	Traffic Density[w]	Uncertainty related to the number, types, and distances between aircraft operating over a given metropolitan area. Operations in close proximity to other air traffic.	"How do you control this density, which is going to increase exponentially?" "Imagine flying 50 at the same time. Then it's almost impossible for it to happen the way the system is today."	High
		(Micro) Weather peculiarities[x]	Uncertainty on weather indicators in low altitude routes	"Studies need to be performed to determine which strategies could be used to mitigate the effects of adverse weather and assess the degree to which operational uncertainties around weather may influence demand." "Today we have METAR meteorological software installed at airports. STATIS supports aircraft and flight operations. We are questioning if this softwares are enough for this new context. Maybe we have to create a new level of information for me to really have a more accurate view of this microclimate. Will it be like having to introduce other mathematical prediction models to support these operations? So there are still unknowns." – ATC software operator	High
		Complex Geographic and Urban Design[y]	Uncertainty of how the practice of maneuvering vehicles will be in regions of high geographic complexity.	"If it has an engine failure (...) it has to choose the building it's going to fall on, (...) depending on where it is it might be able to get to the beach (...) São Paulo has no place." "Rio de Janeiro's geography is challenging for mobility, due to the existence of mountains, forests, lakes, rivers, bays, and settlements. As a result, access to some neighborhoods is limited and susceptible to significant delays and congestion." - OEM Manufacturer	Low

		Energy infrastructure[z]	Uncertainty regarding the national infrastructure changes needed to enable the energy matrix coming from renewable energy sources.	"This challenge of having the capacity to absorb this system, the grid." - National ATC Regulator "UAM operations will require fast charging or battery swapping so that operations are efficient and cost-effective. However, the infrastructure (charging stations, electrical grid, energy availability, etc.) required for ultrafast charging (>350kW) is still under development."	Medium-High
		Groundhandling infrastructure Design[ab]	Uncertainty regarding the design of the ground handling infrastructure.	"Vertiport itself, there is not a precise architecture." "The infrastructure required for ultra-fast charging does not exist yet." "How many people will the vertiport need? Airport attendants? Cleaning staff?"	High
		Existing Groundhandling infrastructure adaptations[at]	Uncertainty regarding the use and adaptation of existing resources for EVTOL	"There is uncertainty about how much of today's infrastructure will be useful and used by EVTOL because many are built in private buildings."	Medium
IE Configuration	The essential flows of information, knowledge, resources, and activities within the ecosystem structure.	Certification/ Regulation Process[ac]	Uncertainty regarding the flow of information and rules created and implemented by regulatory bodies	"Gaps in the existing certification framework where UAM will experience challenges." "Which of the existing FAA certification standards apply to the types of vehicles being considered for the UAMs, and/or how existing certification standards can be met or should be amended." "There isn't even a regulatory environment. The regulators have a real struggle because they don't know what to regulate to." “EASA la FAA tienen que certificar si este tipo de aeronaves, pero que no hay experiencia en la certificación de este tipo de aeronaves, así que sigue quedando un nivel de incertidumbre.”	Very High
		Data sharing[ad]	Uncertainty of being able to access IE strategic information (e.g aircraft, groundhandling databases)	"We don't have any data off of the EVTOLs (...) It's so hard to get any performance data from the manufacturers! (...) just as uncertain because there are lots of unknowns there. So how many hours can you fly the day in the aircraft?" "You don't know what kind of wind they can withstand(...) Half so all the surrounding parameters are not really published. And if you ask them, they will not share that because they are to have multiple competitors and it's a huge market " - Aerospace Center Institute of Flight Guidance	Medium
		New Air Communication system[ae]	Uncertainty whether new air communication technologies and systems will be operationally feasibly built and perform better than the current traditional aviation system. Uncertainty related to the feasibility of restructuring communication channels between pilots and airspace regulators.	"The communication from ATC to the supervisor can be my voice. But for the routine communications, we want to work toward automating those. So, the voice would only be used for making a change due to some unforeseen phenomena."	Medium-Low

Activities	Routines that take place between ecosystem members to create and capture value.	Expected strategic move[af]	Uncertainty about the regulator's decision-making	"While groups like the FAA have assured EVTOL companies that they will be able to certify their aircraft within the coming years, there is uncertainty as to whether they can uphold their promise (...) the risk of mishandled certification squandering EVTOL success is much scarier than the technical challenges faced by the vehicles themselves."	Medium
		Flexibility and dynamicity in changes[ag]	Uncertainty of whether ecosystem rules and regulations will be flexible enough to quickly incorporate changes and improvements over time.	"The congressman (…) said 'I wanted to establish the categories in law'. And we told him 'Please don't do that! because I want to be able to review this rule after rewriting it'. If you write this into law, it will stick for 20 years!". - National Regulator	Low
		Training[ah]	Uncertainty in new pilot training methodologies	"You know, these mechanics don't exist yet. We also need to think that a part that's another uncertainty."	Low
Complementarities	The unique, generic, and supermodular complementarities that are important to deliver the value proposition to the market.	Interface Standardization and Interoperability[ai]	Uncertainty whether the companies in the ecosystem will create modular, adaptable, and easily interoperable systemic interfaces.	"The recharging stations available on the market only have basic Open Charge Point Protocol functions implemented, and several notable features for management and control are in the form of APIs, making it difficult to integrate different charging stations manufacturers with the same CSMS" "How do we standardize them such that charging facilities can be standardized across markets, and you get to scale with a single for so many different OEMs"	High
		Vehicle Maintenance[aj]	Uncertainty regarding the creation of peripheral supply chains (as in the automotive case, vehicle repair markets outside of dealerships) as technology reaches maturity.	"Will there be parts dealers for these vehicles?" - Pilot and aircraft mechanic	Very Low
Competition level	The degree of competition that companies in the ecosystem have among themselves.	Overlaps and blurry frontiers - Ecosystem roles[ak]	Uncertainty regarding who occupies which position in the ecosystem and whether this company can be an ally, competitor, or co-coopetitor.	"Who will be in charge of this airspace? (...) Will each city have its own system controlling it? Each region?" "The cards are on the table (...) it could be others, including private ones." - Software development for ATC "You don't have one service provider which is in charge (...) different companies are competing against each other." - Infrastructure and Airspace Designer "The other one is the energy infrastructure, how we're going to manage the energy needs of our systems?"	Medium-High
Collaboration level	The combined efforts between companies to achieve common goals and benefits.	Collaboration with the right players[al]	Uncertainty of relating/ committing/collaborating with the right players.	"But it's the main risk (...) is to really be able to start these collaborations with the right players."	Medium

Competition outside IE	Other ecosystems that compete to deliver the same focal value proposition to the market.	Interference in current systems - air Cybersecurity safety[am]	Uncertainty related to being able to create an Air infrastructure design that does not conflict with or overlap with traditional aviation design.	"It's also it's also the source of a significant risk, which is the cybersecurity piece." "You have multiple different levels, the federal level, state level, municipality and that includes the county, township, and city. Each one has something to say in that space who protects the airspace well at the federal level (...) the risk of interference on traditional aviation safety equipment is growing."	Medium
		Interference in current ATC systems - communication	Uncertainty related to being able to create an Air infrastructure design that does not conflict with or overlap with traditional aviation design.	"How do we integrate new technologies into our legacy systems in a way that is manageable for air traffic controllers? (...) how do we communicate? - ANSP regulator	Medium
		Air disorder and unexpected Interferences[an]	Uncertainty related to the organization and distribution of airspace considering the flying elements that may interfere with the paths of EVTOLs.	"Unexpected military activity at SBCR, SBAF, and SBGL. This includes military drones, fixed wings, fighters, and helicopters." "How can these aircraft co-exist with each other if they have not even been invented yet? And how can we make sure that we manage that change?	Medium-Low
Ecosystem Emergence and Design	Elements of the "incipient" evolution stage of IE development situated after birth and before its growth/ expansion	Consistency and regularity when scaling[ao]	Uncertainty if the ecosystem will grow consistently over the long term	"Aviation as we know it today where we conduct a demand study, see the size of the city, see the main connections, and then we decide to launch a flight (...). Then you have a three-month maturation period to figure it out (...) But when we look at EVTOL, it's totally different." -Aircraft Operator “The challenge is designing a system that can remain relevant as technology progresses and market needs mature without knowing what that future will look like.”	Medium
		Chicken and egg problem[ap]	Uncertainty on defining the sequencing actions where each seems to depend on others being done first.	"Los reguladores de Estados Unidos, los reguladores de Europa han metido muchos millones para desarrollar un marco regulatorio que realmente está legislando esto. Y démonos cuenta de que normalmente en el mundo de la innovación las cosas funcionan al revés. Normalmente viene la innovación y después viene el legislada."	High
		Market Sensibility[ar]	Uncertainty regarding the possible impacts that accidents, misconduct, errors, and failures may result in the ecosystem.	“If we have one crash, people are going to start getting a little bit nervous about this. If we have too many accidents or mishaps early on, then there is the potential to really set the industry back years, if not decades.” “So many airlines are very worried. If something goes wrong with the platform, it's going to be their brand that's going to be affected.”	Very High
		Autonomous Vehicles time-to-market[as]	Uncertainty of whether the technological evolution of the ecosystem will advance as expected.	"Current legal framework does not address issues related to operations over people, beyond visual line of sight, commercial operations carrying cargo or people, and airworthiness certifications. Assured autonomy remains a challenging technical and legal problem."	Medium

Source: Author’s Elaboration.

5.1.1 IE Value Proposition Uncertainty

The first set of uncertainties relates to the unknowns that configure the IE Value proposition macro-level uncertainty. When investigating the ecosystem's value proposition, we noticed that some members understand that the pillars that support the interrelationship of the ecosystem's firms are safety, quality of service, efficiency, viability, integration, and simplification. Table 23 shows that not all members perceive the value proposition at the ecosystem level. In this sense, ecosystem members don't know whether the companies in the ecosystem will align their goals and times.

This table shows some citation examples related to how members perceive the ecosystem-level **value proposition**. Some actors defend an idea centered on the democratization of airspace. We noticed that the value proposition of the ecosystem is undefined and embraces different elements.

Table 23 - Innovation Ecosystem Value Proposition

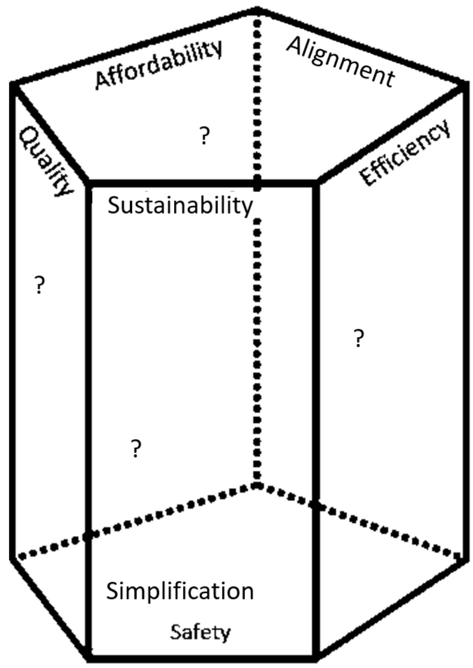
Citation - example	IE Actor	VP - level	Safety	Quality of Service	Affordability	Efficiency	Sustainability	Alignment	Simplification
"Safety has no flag (...) this business has to be safe. It has to be bulletproof and provide a quality service."	OEM Operator	Ecosystem-level	x	x					
"UAM's vision is to revolutionize mobility around metropolitan areas by enabling a safe, efficient, convenient, affordable, and accessible air transportation system."	Nasa	Ecosystem-level	x	x	x	x			
"I think the main goal really is to enable aircraft to fly in the urban airspace and to provide socially and environmentally safer ways for doing this in the future."	Urban traffic management software	Ecosystem-level	x				x		
"There has to be a middle ground between issuing a safe operation and one that can be scaled up, providing means, systems, etc."	National Regulator	Ecosystem-level	x		x				
"Try to focus on three kinds of guiding principles: Safety, dignity, and security. Safety is about protecting people. Dignity is about protecting their rights, and security is about protecting the critical systems that we rely on."	UAM institute	Network-level	x		x				
"That means transporting goods and passengers from A to B with a fully electric emission-free solution. And we are also working on the whole ecosystem around it. That means integrating all the partners needed, for example, infrastructure, telecom, and so on. In order to safely operate the aircraft in operations."	OEM Manufacturer	Firm-level	x	x				x	
"Our objectives of safety, integration, simplification, and environment. And then importantly, that collaboration with industry, engaging with stakeholders and I'm going to use Simon's word earlier journey, making sure that we're all on that journey together to deliver on that big ambition that we have quite rightly set ourselves."	Consultancy firm for the aviation sector	Firm-level	x				x	x	x
"It's the idea that the whole project under development is extremely sustainable, there's the issue of the solar panel, the reuse of water, everything geared towards sustainability."	Architecture office	Firm-level				x	x		

Source: Author's Elaboration.

According to the Table, we see that some visions are broadly defined. For example, Nasa vision includes the transport of people and goods and does not specify approaches or solutions, such as aircraft sizes or modes of operation. On the other hand, some actors link the value proposition with safety, quality of service, affordability, efficiency, and sustainability – well inspired by the on-demand helicopter industry.

Although it seems that actors might agree that safety is an important element of the multifaceted element, they still diverge on perceptions about other elements that might complement the value proposition of the ecosystem (see Figure 17).

Figure 17 - Innovation Ecosystem Value Proposition Unknowns



Source: Author's Elaboration.

The uncertainties related to the Value proposition element is **Alignment** which is the particular set of activities and resources that interrelates firms and shapes the value proposition. Alignment means ecosystem members unknowns of whether the companies will succeed when aligning their goals and times. For example, some OEMs act as first movers, while others are waiting to decide when to enter the market. Likewise, at the public infrastructure level, some city halls and regional actors cooperate with groundhander operators to define urban planning guidelines to accommodate vertiports/ vertistops while in other places there are only sketches of architectural projects but no execution of collaborative projects.

5.1.2 IE Identity Uncertainty

The second set of uncertainties relates to the unknowns that configure the **Ecosystem Identity uncertainty** is the unknowns related to the shared meaning of the ecosystem. In other words, members don't know which identity will be crystallized in the ecosystem - a more formal, regulated, bureaucratic identity or a more flexible, modular, adaptable identity.

Another uncertainty is the **Market experience,** meaning that members don't know which impacts decision markers coming from nontraditional aircraft-related sectors might influence IE ecosystem value proposition. Is the lack or excess of accumulated knowledge (coming from other sectors such as aeronautics) a positive influence on the ecosystem's emergence?

5.1.3 IE Value Creation Uncertainty

The third set of uncertainties relates to the unknowns that configurates the IE Value Creation macro-level uncertainty - The collaborative processes and activities of creating value for customers and other stakeholders. The unknowns that integrate this macro-level uncertainty are lack of knowledge, user full journey experience, coalition of social groups, security and right to privacy, city visual impact, auditive (noise) impact, and natural resources impact.

Lack of knowledge is the customer knowledge gaps regarding the technology and its security levels (whether the public will accept the ecosystem's levels of security and right to privacy). This lack of knowledge can often be a blessing and can even help drive the growth of the ecosystem.

The EVTOL value creation processes and activities might be associated with how its users perceive this vehicle as something useful for them. However, there are unknowns related to this too. For example, the user's **full journey experience is unknown** (whether the consumer will enjoy the experience of flying).

There is also a **Coalition of Social Groups Uncertainty** related to the possible division of social groups (flying and non-flying public) and possible differing opinions regarding the use of the vehicle or the business model in general. These social divisions can cause social pressures and derail entire projects.

Another value creation-related uncertainty is the **security and right to privacy**, which means uncertainty related to whether users will be confident about the levels of vehicles' security and right to privacy levels. We still don't know how to deal with environmental issues. For example, how does EVTOL's impact on the landscape and affect public acceptance (**City Visual Impact uncertainty**)?

Auditive (Noise) is another important uncertainty. When the vehicle takes off, there is noise because of the diameter of the blade that pushes the air. How will noise affect public acceptance? What new metrics to measure noise in cities? Another uncertainty is the natural resources impact uncertainty related to environmental issues as to irresponsible, inappropriate use of natural resources and the consequences of these uses in the long term and the benefits of the ecosystem.

Moreover, although NASA pointed out the potential risk of the EVTOL on the **biological ecosystem**, we did not identify statements from interviewees related to this uncertainty. Even so, we might consider that there is an uncertainty related to how ecosystem actors will address vehicle impact on the biological ecosystem.

5.1.4 IE Value Capture Uncertainty

The fourth set of uncertainties relates to the unknowns that configurates the IE Value Capture macro-level uncertainty – meaning, uncertainties related to how, what kind, and how much value created by the ecosystem is captured by IE actors. In the EVTOL ecosystem, there is uncertainty regarding the cost of the development of the service as a whole (**Operational costs uncertainty**). Too many variables might interfere with these estimates and with the economic viability of the ecosystem:

> "We've done quite a lot with other people and quite a lot of economic analysis (...) there is a scenario where it's a stupid thing to do economically and a scenario where it's a brilliant thing to do. So, there's this economic uncertainty."

In this sense, **Affordability uncertainties** which means whether the consumer is willing to pay to use the service and whether the public will be convinced that the benefits of EVTOL outweigh the challenges posed by the additional mode option. Is the consumer willing to pay for this ride? **Fundability uncertainties** (members' decision-making process unknowns related to founding raising and new business model resource allocation willingness). We know that not all companies are ambidextrous, especially if they have deep roots in the exploitative traditional aviation business model. Therefore, allocating resources to the exploration sector (i.e., putting money into the development of a new technology for a new market) can be challenging.

Social equity uncertainties cover whether the costs and cons related to the development of EVTOL will be split among the ecosystem members to avoid the perception that EVTOL is a way only for wealthy households to buy their way out of congestion.

5.1.5 IE System Innovation Uncertainty

The fifth set of uncertainties relates to the unknowns that configure the IE Systemic innovation macro-level uncertainty. The “conducting wire” for the companies in the EVTOL ecosystem is related to the aircraft technology and design. It means that the uncertainties related to this shape the ecosystem itself. Therefore, the unknowns that integrate this macro-level uncertainty are Vehicle Design, Battery, Vehicle Reliability, Vehicle Performance Efficiency, and Controllability.

The main IE systemic innovation uncertainties are the **Vehicle Design** (Uncertainty about how manufacturers will deal with multivariate engineering tradeoffs inherent in EVTOL design (i.e. Short-term hover power x long-term cruise energy). VTOLs will spend far more time on cruise which raises the question of how to optimize such a vehicle across short-term hover power versus long-term cruise energy. The ecosystem has already presented ideas to deal with this uncertainty, but there are still some open questions.

Battery Uncertainty deals with the viability and implementation of the vehicle battery system that meets the necessary requirements to enable the operation). This is a huge uncertainty discussed in a variety of forums. **Vehicle Reliability uncertainty** or the variables that can trigger accidents (Crashes, fire). Uncertainty regarding **Vehicle Performance Efficiency** (Power density / electric propulsion), for example, how to perform with high torque capability for a relatively lightweight.

5.1.6 IE Design and Structure Uncertainty

The sixth set of uncertainties relates to the unknowns that configurates the IE Design and Structure macro-level uncertainty – it means, the set of activities and resources that interrelates firms. We know that the ecosystem is made up of relationships and resources shared between companies. Some of these interdependencies are very important to enable the emergence of the ecosystem.

In this sense, the unknowns that integrate this macro-level uncertainty are related to the Airspace Infrastructure (activities and resources related to Traffic Density, Micro Weather, Complex Geographic and Urban Design) and also Groundhandling Infrastructure (activities and resources related to Energy infrastructure, Groundhandling infrastructure Design, Existing Groundhandling infrastructure adaptations). In the case of EVTOL, the design and structure challenges of the ecosystem are huge. They involve airspace infrastructure-related uncertainties and groundhandling infrastructure-related uncertainties.

On the ground, there are uncertainties related to **energy infrastructure** (national infrastructure changes needed to enable the energy matrix coming from renewable energy sources). Moreover, uncertainties are embracing **new groundhandling infrastructure**s (the vertiports and Vertistops designs (i.e. which vertiport design will be dominant and what elements need to be considered in that design). Uncertainties associated with repurposed infrastructures (adaptations **to existing groundhandling infrastructures** like airports **-** What these adaptations will be like and whether these investments are worth it or not.).

On air, there are uncertainties related to air route design due to air **Traffic Density** unknowns (for example, what will be the distances between aircraft operating over a given metropolitan area). There are also high-level uncertainties related to (**Micro) Weather** (how to deal with weather in low altitude routes) and **complex Geographic and Urban Design uncertainties** (how to maneuver vehicles in high geographic complexity regions).

5.1.7 IE Configuration Uncertainty

The seventh set of uncertainties relates to the unknowns that configure the IE configuration macro-level uncertainty. The essential flows of information, knowledge, resources, and activities within the ecosystem structure. The uncertainties underlying the configuration are the certification/ regulation process, data sharing, and the new air communication system.

Uncertainties related to **ecosystem certification and regulation** embrace the unknowns of rules that will be created and implemented by regulatory bodies. What regulations and rules will govern each country? Are the rules applied for urban transport the same as for interurban transport?

There are also uncertainties related to **data sharing access** of information. This new type of aircraft has its own characteristics and the fact that there is still no dominant design brings complexity to the heterogeneous sets of data analysis. The historical data from helicopters and other aircraft vehicles has low use when projecting scenarios for EVTOL aircraft and groundhandling infrastructures. Moreover, most of the data is concentrated with OEMs and their close strategic partners, disabling the seamless flow of data between the other IE members.

We named the uncertainties of whether new air communication technologies and systems will be operationally feasibly built and perform better than the current traditional aviation system as **New Air Communication system uncertainties**. This uncertainty deals with the feasibility of restructuring communication channels between pilots and airspace regulators, considering the complexity of the current air traffic communication model:

> "The communication from ATC to the supervisor can be my voice. But for the routine communications, we want to work toward automating those. So, the voice would only be used for making a change due to some unforeseen phenomena. "

5.1.8 IE Activities Uncertainty

The eighth set of uncertainties relates to the unknowns that configurates the IE activities macro-level uncertainty. Ecosystem activities deal with routines that take place between ecosystem members to create and capture value. The ecosystem has a variety of activities. Interviews uncovered uncertainties related to three activities in particular. The first is expectations generated (on the **regulator's decision-making and its strategic moves**). Some actors commented on the risk of mishandled certification. They don’t know what action will be taken by regulatory bodies, or what models will be adopted inside each country, and this movement creates insecurity among the actors involved.

The second is **flexibility and dynamicity in changes**. Ecosystem members don’t know if regulators will be able or flexible enough to quickly incorporate changes and improvements over time – as the ecosystem matures and things become clearer. These issues of changes in regulations are complex because, depending on the country, they may involve public authorities. In the United States, changes in public authorities’ positions influenced management positions and activities inside air regulatory bodies. In Brazil, public authorities almost influenced the activities of management positions in regulatory bodies as well:

> "The congressman even went there and said, 'I wanted to establish the categories in law.' And we told him, 'Please, don't do that! Because I want to be able to review this rule after rewriting it. If you put that in law, it will be there for 20 years!”.(National Regulator)

The training tasks and activities uncertainty is also relevant to the activities' macro-level uncertainty. The aircraft are still being defined. There is still no pilot training for them. This set of operational activities is not clear.

5.1.9 IE Complementarities Uncertainty

The ninth set of uncertainties relates to the unknowns that configurates the IE complementarities macro-level uncertainty - the unique, generic, and supermodular complementarities that are important to deliver the value proposition to the market.

Interface standardization and Interoperability uncertainty refers to whether the members will concur modular, adaptable, and easily interoperable systemic interfaces among each other. Interoperability both between parts of the aircraft (such as electric propulsion systems, flight controls, wings, digital aircraft systems, fuselage, and composites) and between the aircraft and recharging points, parking, for example.

Few members commented on the **Vehicle Maintenance uncertainty**. There are some unknowns about the creation of peripheral supply chains as technology reaches maturity - new supply chain structures as in the automotive case, vehicle repair markets outside of dealerships.

5.1.10 IE Coopetition Uncertainty

The tenth set of uncertainties relates to the unknowns that configure the IE coopetitive macro-level uncertainty. There is uncertainty regarding who occupies which position in the ecosystem whether this company can be an ally, competitor, or competitor, and which degree of competition and collaboration companies have among themselves outside and inside IE. **Overlaps and blurry frontiers uncertainty** means that, as the ecosystem emerges, it is not possible to know who intends/will occupy which position in the ecosystem and whether this company can be an ally, competitor, or coopetitor:

> "Who will be responsible for this airspace? (...) Will each city have its own system controlling it? Each region?" "The cards are on the table (...) it could be others, including private ones." - Software development for ATC

Firstly, it's unknown "who intends" to occupy a position in the ecosystem. A company that wants to "control everything and everyone" because it understands that has resources, experience, and capabilities to create relevant interdependencies in the ecosystem. According to a Ferrovial Vertiport's Managing Director: "*So there are some OEMs that are saying 'Look, we want to own the vertical stack', and I completely get it! From a strategic perspective (I understand why) they want to do that!".*

Secondly, although we know who "needs" to orchestrate – once socially required to do so- it's unknown if these actors will accept and assume the orchestration role. For example, Decea is a national regulator in Brazil that is being pressured to assume the orchestration position, but we still don't know if they want to actively assume this position. The same Ferrovial Vertiport's Managing Director commented on this idea too: "*You also get some players (…) They're not excited. They're not focused. But people are saying "Look, this is our nation, and this is what we want you to take care of!"*

Thirdly, OEMs are perceived as levers of the ecosystem. Levers are actors who create greater value for the ecosystem and can present plausible reasons to move other actors in the ecosystem. For example, an OEM might raise money from investors and consequently motivate the country to get the infrastructure project off the ground.

In conclusion, the Overlaps and blurry frontiers uncertainty had to do with how much this "clarity" of the role actors play interferes with their survival as IE members. And how does this “role undefinition” impact the evolution of the ecosystem itself?

Competition level from the outside -in also appeared on our database. These unknowns relate to outside competitors – actors from other ecosystems that compete to deliver the same focal value proposition to the market. The boundaries between the value proposition of the EVTOL. The boundaries between the value proposition of the EVTOL ecosystem and other value propositions in the drone, jet, and traditional aviation markets are fuzzy, as are the levels of competition outside the ecosystem.

Creating an Air infrastructure design that does not conflict with or overlap with traditional aviation design is a challenge. The **interference in current systems** uncertainty is related to possible conflicts, overlaps, and interferences that the EVTOL will have on the current air Cybersecurity safety and communication systems.

Air disorder and unexpected Interferences is an uncertainty related to the organization and distribution of airspace considering the flying elements that may interfere with the paths of EVTOLs: “Unexpected military activity (…) includes military drones, fixed wings, fighters, and helicopters."

Collaboration with the right players is the uncertainty of relating/ committing/collaborating with the right players to achieve common goals and benefits: “But it's the main risk (...) is to really be able to start these collaborations with the right players."

5.1.11 IE Emergence and Design Uncertainty

The eleven sets of uncertainties relate to the unknowns that configure the IE Ecosystem Emergence and Design macro-level uncertainty. This is a higher-order group of uncertainties at a more abstract level that refers to unknowns related to the IE driving and restraining forces for growth. **Consistency and regularity when scaling** is the uncertainty of the ecosystem will grow consistently over the long term. Ecosystem actors might change: *“The challenge is designing a system that can remain relevant as technology progresses and market needs mature without knowing what that future will look like.”* This quote portrays the uncertainty regarding tomorrow, and how the ecosystem itself will evolve.

This uncertainty goes beyond the doubt regarding whether the business model "will work or not". For the ecosystem to thrive, it needs to make sense for a large group of actors. They need to know that a simple business model adaptation from traditional sectors does not support this new complex ecosystem. However, there is a huge lack of knowledge about it: "*I think when we started, we didn't have any. I don't think we were sure that this was going to be a huge market by any means.*"

Chicken and egg uncertainty is the unknown of defining the sequencing actions where each seems to depend on others being done first. For example, regulators wait for OEMs for decision-making and vice versa. The same occurs among groundhandling infrastructure operators who wait for regulators and public authorities to make decisions and vice versa. Below we quote one citation that exemplifies this uncertainty. The interviewee is a Groundhandling infrastructure Designer who doesn't want to act before others:

> "What do we do? We just made some plans for infrastructure. We made some plans for air spacing. We did transport processes, but all of those are just plans. We have them ready whenever that comes to certification or at a time when your regulators and authorities say 'OK, right now we are confident that we can offer you a certificate, then we are ready to go.' But right now, it's just, you know, we can't do anything anymore."

Market sensibility uncertainty regarding the possible impacts that accidents, misconduct, errors, and failures may result in the ecosystem. Some previous accidents in medical delivery operations with drones showed us that no matter how many successful operations you have, one problem might be sufficient to shut down one entire national operation. Another example is the helicopter sector where noise problems severely constrained the entire scaling operations. These problems related to other sectors impact the new IE ecosystem, generating a "waterfall effect": "If we have one crash, people are going to start getting a little bit nervous about this. If we have too many accidents or mishaps early on, then there is the potential to really set the industry back years, if not decades."

What if the technological evolution of the ecosystem will advance as expected? We named this as **Autonomous Vehicles' time-to-market** uncertainty. Although OEMs expect autonomous vehicles to fly in the next years, there is so much work to be done. As we showed above, uncertainties of different natures manifested inside the ecosystem.

5.2 ANALYSIS OF STRATEGIC MAKING UNDER UNCERTAINTY

After analyzing uncertainties in light of the theory of IEs, we search for strategies used by decision-makers during the uncertainty management process. In this subsection, we describe strategies to deal with uncertainties. Some of these strategies can be used to mitigate risks, while others might help to reduce some more profound uncertainties (unknown unknowns).

The set of strategies that emerged from the data varies from very proactive sets of strategies to very reactive ones. Below we comment on each one of them.

Table 24 presents a summary with some examples of strategies employed to deal with the uncertainties we found. We inductively named the strategies and descriptions and showed some examples of citations related to each strategy. Strategies are often made up of groups of strategic management tools. For this reason, some groups of tools were mentioned, and we chose to include them as strategies in the analysis. This table contains an informative column, mentioning whether the strategy used is a Strategic tool (ST) or not.

Table 24 - Strategies that Emerged from the Data

Level of Prediction/ Control	**Strategy (Strategic Tool (ST) or Strategy (S)?**	**Description**	***Citation Example***
H/H	Bottleneck strategy S	To map the critical points of the ecosystem and positioning them within them to design ways to resolve uncertainties.	*"There was quite an uncertainty on what is needed to make a UAM a reality. So, who do you need? Who is taking which decision? (...) now this is clear to us and we (developed) a blueprint on how to launch a city and deal with the city." - OEM Manufacturer*
			“And our intention is not to be a bottleneck in this process. Our main concern as a regulatory service provider is the safety of air operations and their viability. So, we have to find that middle ground between issuing a safe operation and ensuring that it can be scaled up, providing means, systems, etc. That's the perspective we have to work with.” - National Regulator
			"When we were talking about the airport design -the design regulations, certification of these infrastructures- people were focusing on the machine. Even if the discussion was really targeting the infrastructure, was still the machine and the aircraft the major topics. So, I saw there like a gap. We believe that we could bridge that gap by focusing on the infrastructure only." - Vertiport Operator
H/H	Pivoting strategy S	Searching for alternative paths to solve an uncertainty, usually by changing or adapting some aspects of its core products or services to ensure that the business remains viable and profitable.	*Walle Vertiport Design - Company's Website*
			"So, but what that means is that everything from performance to safety optimization on a standard automotive has to be on the vehicle because they can't guarantee the automotive supply, can't guarantee where it is going to be charging it." - OEM Manufacturer *"An automotive battery charges, we don't know exactly where that could be at home, a service station, your grandma's house. You could even be charging off the grid, a windmill (...) it's a panacea in terms of what we're looking for. So, what that means is that everything from performance to safety optimization on a standard automotive has to be on the vehicle because they can't guarantee the automotive supply, can't guarantee where it is going to be charging it." - OEM Manufacturer*
			“Well, one of the main reasons why we picked the slow rotor wing compound is that it is really an evolution from the helicopter and can be certified using those existing standards therefore we believe can be developed and deployed into commercial applications at a much lower cost and with a much more certain timeline. It still is going to require some number of years for the product development and certification, but the key thing is that we've narrowed down the technology risk to some specific areas that we then can focus our efforts on (other things)." - R&D center for design, fabrication, and flight testing of experimental rotorcraft and unmanned air vehicles
			"It can only be done in a certified workshop and certified is a workshop for the model of plane you have, let's say you have a Cessna 152. Then you go to the workshop in Passo Fundo, which has a workshop specializing in Cessna 140s, it doesn't have an operating specification, which is like this relationship between the aircraft models you're going to work on. It has to be like Citroën, you have to send it to a workshop that specializes in a Citroen model. You have to look for a certified

			workshop in the area and send it to them, it's not just a matter of arriving or having it serviced. It's not even if you're a mechanic, you're not a mechanic, I can come here to your hangar and work, no, you have to be linked to a company, if that's the case, you have to have authorization to work outside the company's headquarters."
			"We want these things to be able to fly as far as they can. They have to have a certain amount of extra charge on the batteries. Batteries are too heavy to be able to fly. As far as we want to be able to fly with the battery resources that are left over, we must make the rest of the aircraft very, very light." - Designers and manufacturers of high-performance wire and cable
H/H	Imaging strategy (backing into the future) S	Envisioning a desired future state and its possible IE-related uncertainties and then working backward to identify the steps needed to get there from the present.	*"We looked at 200 or so of the world's largest cities and we said, OK, how many aircraft do we think each of these cities will need or how many aircraft do we think." - 1st tier Supplier*
			"So, we started doing our own design work. And we created our own tools and processes to designing EVTOL aircraft" - OEM Manufacturer
			"We think that it might be interesting for a lot of female pilots because these flights will be not long-distance flights. They will be short flights so you can normally be home on the weekends."
			"So now you're looking into what diagnostics can we what can we move some of those diagnostics off? What can we what can we consistently operate? Can we look at removing the mass pike and moving off Bolt? So maybe we can move some things onto the charger that just went before? It also opens up other opportunities. So, safety detection methods, what can we do during a charge event that wasn't possible before? Can we have high-frequency sampling of data, for instance? And what input does that give us both in terms of a safety case, but also our performance metrics? So, I think charging may be a good example.
			"I want to be able to walk to my flying machine fly really close to where I need to go, and then walk to the destination without involving getting in a car or driving down the freeway. So that's the ultimate goal. (...) to do that, you need to have distributed Vertiports." - OEM Manufacturer
H/H	Opening a new company strategy S	To reduce uncertainty by starting a profit/non-profit company dedicated to spreading that solution out into the ecosystem.	*"We found a solution to really solve the problem with the continuous power and the peak power discrepancy. And so that's where it all started in the little garage in Munich. That's how it started." - Electromobility Startup*
			"We are helping people with the certification. Engineers compile all this evidence and get it, you know, make it, you know, ready for EASA and the FAA to look at and pore over." - Digital Safety Engineering Firm
			"We have the data infrastructure, how we can be very creative in ways to acquire, process and sell very, very new data to different markets." - Ground handling Operator
			"We are a technical society (...) the key as dimension is really the networking and the connections, the vertical places inside our whole reason for existing is to advance vertical flight (...) to help promote the development of advanced technologies" - Nonprofit Society
H/H	Creating a cluster strategy S	To reduce uncertainty by building an entrepreneurial context	*"The Aviation Village is really to create an environment and infrastructure for the development of various technologies required for the eventual sector. At the same time, manufacturing the aircraft in the same part and same place, also having residential for all of the people who are coming to work*

		dedicated to facilitating IE emergence in a specific region.	*in India, in that village, in a modern area where there are all of the support facilities, including schools and museums, entertainments and the medical center, the hotels, you know, sports centers, all everything that a community would require and create a cluster of various sizes of companies to come and innovate, develop, but also manufacture and operate this type of aircraft next to a runway that could be used as one of the air taxi centers for this type. So, creating an environment creates synergy, and the collaborations within between the two companies and groups provide benefits for these companies, but also the outside suppliers and supply chain network for food for this sector."*
			"So, we have tried to look for a local solution to make the operation viable, potential disruptions and even in financial terms. And above all to develop the local industry."
H/H	Platform and Systems Strategy S	Development of a platform to increase technological interdependence between actors and reduce ecosystem interoperability uncertainties.	*"They are developing an automatic space control system that will allow a continuous flow of these aircraft. It will take off previously approved to make that trajectory."*
			"We've been working on partnerships to figure out how we can have a sales channel for booking a flight, how I can integrate the ground mobility service so that I can get to the specific take-off point." - Aircraft Operator
			"The platform which we call 'Platform for UAM' which we are developing together, also with strong partners like Microsoft and Lufthansa. We are focusing on, of course, customer value on the front-end solution, so you have a customer app integrated into the overall platform. At the same time, we are working closely with cities and regulators to their needs. So, for example, a city wants to understand how many aircraft are in the air, what is the status, where they're flying, language conditions, and so on." - OEM Manufacturer
H/H	Dictating trends strategy S	Being imperative and mentoring what actors should do to resolve uncertainties	*"To fast-forward to the safest possible operational state for VTOL vehicles, network operators will be interested in the path that realizes full autonomy as quickly as possible." - Uber Elevate Report (2016)*
			"Inform the community. Open communication and flow of information can help the public understand the need, be familiar with the factors that inform decision making, and provide more meaningful input." - Deloitte Report (2020)
			"As changes are made to the ConOps, all stakeholders must be drawn into the change validation process to ensure a consensus understanding of emerging UAM operations." - NASA UAM Conops (2021)
			"Many, many different government organizations have been actually putting out roadmaps and public intentions on how they plan to introduce EVTOLs in their countries." - Infrastructure Operator
H/H	Partnering to shape the market strategy S	Collaborative initiatives of high prediction and information control aiming to solve ecosystem uncertainties.	*"With the FAA, we're working with the next-gen office and with the standards group and started taking this as a starting point for discussion to build the standards and the means of compliance for how to get operational approval to do this. It will take some changes in the air traffic side to implement this minimal voice communication activity"*
			"All this work only to mitigate the risks and to be sure that our solutions are for some fit into the market. So, we are present into these working groups to try to standardize these as much as possible, yet there are no unique solutions." - Engineering Company

			You cannot rely on existing things. You have to develop everything (...) problem from scratch." - OEM Manufacturer
			"There is an unprecedented opportunity to shape this new industry (...) a number of the Asia-Pacific countries are really embracing that and working together on it. (There is an) active conversations with various states in Australia and in the US, State governments, central government (... working on ways that they can promote advanced mobility". - OEM Manufacturer
			"We need OEMs. We need basically the A-Team, air traffic management providers, regulators, you know, to participate. We are exploring their startup community. Accelerators, because we don't believe that it's in the city that one company will help end-to-end solution for it. We believe that this will be some kind of partnership and we are talking about multi-modality integration. So, there is quite a lot of conversation with cities" - Living Lab
			"While we are looking at the operator's business, we are helping the infrastructure partners to model what the vertiports of the future will look like." - Aircraft Operator
H/H	Standardization of Concepts, Nomenclatures , and Key Terms S	Communicating Concepts, Nomenclatures, and Key terms based on the consensus of different IE actors to create a common knowledge base for uncertainty resolution	*"Glossary Sections" inside each UAM and AAM consultancy report and CONOPS publications, Technical/ White Papers, and Academic Papers. (For a revision see Andritsos, Scott, and Trimarchi, 2022).*
			"We aim to help the community to understand urban mobility through interpreting an industry developed jargon into less technical and ordinary words, and then leave for the public to make their own call as to what they think of their sustainable, innovative transportation." - Global UAM Platform
H/H	Standardization and Modularity Strategy S	Building modular and interoperable components to reduce interoperability-related uncertainty	*"So, the engineers really all they have to do is focus on the task of their creative efforts of solving problems and doing the design of the of the air system itself (while) Java is helping engineers compile all this evidence and make it ready for EASA and the FAA to look at and pore over."*
H/H	Manuals-handbooks-reports strategy ST	An official document published by an actor in the ecosystem to serve as a report or guide on a problem and how to face it.	*"What we have a guidebook coming out on four planners based on the webinar that we did. We're working on a guidebook to four small regional airports and another one with foundational information that provides the kind of whole package of information from the aviation industry side. So, aspects of aircraft and operations. And then I will also be developing some model policies and best practices that you should see that coming out in the next year or so" - Local Entity*
			"I'm working with Julien and Pascal and Watson on a couple of them on the infrastructure side (...) to develop something that we're calling the Advanced Air Mobility Infrastructure Reference Manual, which is basically an attempt to try and gather together best practice from the aviation industry to apply to advance air mobility." - Consultancy Firm
H/H	White papers strategy	An official document published by an actor in	*"We published three white papers where we discussed this general topic of analyzing historic weather data to understand service availability." - Software Development Firm*

	ST	the ecosystem in order to serve as a report or guide on a problem and how to face it.	*"I confess to being surprised at how useful the white paper was that we published. We had seen that as a bit of a form of exercise initially, but we've had an extremely encouraging response. A lot more people read it than we thought. We feel that it is a very good basis for informing and discussion. You (...) give a view of how things could come together (...) provides very valuable background for discussion." - Air Infrastructure designer*
H/H	Educating strategy S	To develop a teaching and learning process to broaden the community's knowledge of the ecosystem.	*"Education is a key component and how do you get that education down to the lowest level? So, I think introducing this technology, introducing this whole thought process on transportation into the lower levels of the school. So, you know (...) to educate people from the (ground) because then they take that information (...) back to their parents and they learn about it at the same time." - Consultancy Firm*
			"We need to get people to see those demonstrations to understand what's going on, to see that the world doesn't end, the sky doesn't fall all those sorts of things." - Global Trade Association of the AAM
L/H	Make it a simple strategy S	To act and do things in an easy-to-understand way, avoiding excessive bureaucracies	*"The conversation between the states must be simplified (...) We can come out with something more concise, more aligned with the operation - certification, operation of the aircraft and airport, rules of the airport with the rule of the aircraft (...)."*
			“EVTOL has a weight limit (...) how do we know the weight of the passenger? it's a bit of a complicated question to ask. So, to check in digitally you need to be standing on the ground to take your photo. But nobody tells you that inside the square there's a scale automatically linked to your photo. It's great. Your weight comes out automatically." - Aircraft Operator
			"El entrenamiento de pilotos haciendo la aeronave lo más simple posible. y que sea lo más fácil de lograr (...) El entrenamiento de los equipos de tierra, mantenimiento y auxiliares de vuelo se pueda unificarlo a máximo.”- OEM Manufacturer
			"When you find systems that have a lot of complex manufacturing operations associated with the integration that adds to the complexity of maintenance operations, you really start to get worried about what that's going to do to the readiness of your vehicles, of course, to the cost of the operations that the customers are going to have to absorb." - 1st tier Supplier
			"Our approach is to try and show that you can have something which is extremely simplistic because in many cases engineers try to complex. But at the end of the day, they end up with high-complexity instruments, which in the air creates a very, very high bar because you need more certifications and more testing. So, you have to go to the opposite of complexity, to the extreme simplicity". - OEM Manufacturer
			"The congressman even went to Anac and explained 'I wanted to establish the categories in law'. And we told him ‘Please don't do that! because I want to be able to review this rule after rewriting it'. If you write this into law, it will stick for 20 years!" - National Regulator
			"It's not going to be feasible on a 15-minute flight to change frequencies four times. How is this going to be overcome? By introducing new technologies and reducing the need for so much oral communication between the pilot and the air traffic management agency."

L/H	Selecting uncertainties to focus on strategy S	Make a judgment about whether or not to expend energy to resolve an uncertainty based on the analysis of several factors.	*"Some of the top manufacturers are looking at. What do they really want to spend their time on? You know, do they want to try to develop a motor, be vertically integrated?" - Automation Firm* *"So, you know, for all of those reasons, we're like 'that's not a problem we want to go after'". - Aircraft Operator*
L/H	CONOPS (Concep of Operation) and consortiums strategy S	An inclusive approach to capture the assumptions and tradeoffs made via multiple UAM stakeholders by defining clear operational boundaries for UAM and capturing the needs and desires of the many different stakeholders of the National Airspace System.	*"It was us, EVE, MADs, Vertical, Lilium, Airports, London Airport, we set up a consortium within this CAA Innovation Hub and we developed the concept of operation for the city of London and it is published there and available on the Internet (...) This was the result of our first vision on this issue of air traffic management to support the urban air mobility ecosystem taking into account this new equipment." - OEM Manufacturer* *"They did the CONOPS in Rio de Janeiro (...) they took a container from Skyports, which is doing this in Europe, mainly in France because of the World Cup (...) with a facial check-in system, an outdoor area." - Aircraft Operator* *"CONOPS between Miami International Airport and the Miami Beach Convention Center. The consortium is made up of EVE, Skyports, L3Harris Technologies and Community Air Mobility Initiative (...) evaluated the ecosystem needed for the passenger and vehicle experience, received important public input and feedback (...)accessed local public data (...) information used to establish a broad understanding of how UAM could safely integrate with existing Airport operations and other county locations." - MundoGeo News (2023)*
L/H	Spreading Information Strategy S	Communicate findings extracted from first-order data to the IE community through different communication channels	*"We present at seminars organized by the regulatory body." - ATC Operator* *"Going public also helped boost the credibility of EVTOL and the air taxi business model in general, experts said." - Flyingmag Blog (2021)* *"Anybody who wants to learn or get involved in technology would want to attend, they're free and open to everybody to attend. Then you can access the past webinars and you can get them on a cart or for a membership." - Local Entity*
L/H	Commitment strategy S	Show commitment and dedication to resolving an ecosystem uncertainty	*"But if this is not enough, we have to build new ones and new reports, and these have to be committed". -OEM Manufacturer* *"We are working very closely in partnership-oriented (...) to not just see us in the driver's seat, but everyone has to deliver on their promises." - OEM Manufacturer*
L/H	Triangulation and redundancy ST	The use of a variety of data sources, including time, space, and persons to deal with uncertainty by increasing the validity and reliability of the results.	*"How many aircraft do we think each of these cities will need or how many aircraft do we think, you know, a lot of these airports will need, and we sum those up and we compared those numbers to the consultancy. Numbers published on the project. Specifically, we actually use mobile phone data. We collected people's trip data in London"* *"The use of multiple (typically six or greater) electric motors, controllers, and a redundant battery bus architecture avoids the problems of catastrophic engine failure by having full propulsion system redundancy. An engine failure might result in diminished speed or climb capability, but full control authority within the aircraft's operating envelope can be maintained. Improvements in this area can*

			be expected to reduce accident rates even further than the previously specified goal." - Uber Elevate Report (2016)
L/H	Refining and Validating strategy S	Going deep into a knowledge area and checking or proving the validity or accuracy of that knowledge	*"We work with all schools to test it out (...) and so we've got more, more and more detail (...) so essentially, we've gone around validating it." - OEM Manufacturer* *"He tested things, broke things, measured things, and converged to something that the point that I met him was already flying in a very, very efficient way." - OEM Manufacturer*
L/H	Compliance Demonstration test ST	Trials and tests to demonstrate that the method, technique, tool, and software effectively fulfill previous requirements to resolve the uncertainty.	*"We follow the manufacturer's lead and configure the setup, and we follow the measurements and everything. The certification meets very extensive requirements that cover all the aircraft's systems - electrical systems, hydraulics, propulsion, aerodynamics, flight control rules - and we observe them."- Federal Regulator.*
L/H	Agile Methods strategy S	Use of a set of processes, practices, and tools to resolve uncertainties.	*"You have to set up your company properly so that you work very focused on your and you, of course, measure what you're doing more or less like real project management. But in the whole company" - OEM Manufacturer* *"Our first move was offering free ordering, and this is mainly I mean, people are depositing small amounts of money, and this is mainly to gain feedback from the market." - OEM Manufacturer*
L/H	Proof of concept (POC) / Business Case Strategy S	Practical experimentation or operationalization of a theoretical concept to check if it reduces the uncertainty.	*"The company will always inevitably make prototypes." National Regulator* *"So, the next step is to get a subsidy or a client like that so we can move forward and put a first pilot into practice, taking our products and adapting them to real cases. Taking the client's requirements." - ATC Software Operator* *"In July we are going to fly these falcons (...) So you start experimenting and thinking "what can go wrong" before you go to passengers" - Infrastructure operator* *"You have to keep trying and keep trying to come to the edge of the situation and measure it and see what really happens in reality (...) you have to push the boundaries by testing. That's the key message." - OEM Manufacturer*
L/H	Get your hands dirty strategy S	Doing something /Acting proactively to resolve the uncertainty by executing some action	*"And then we went to the reality in this case and went to Australia and said, 'We want to work with you and see how this works, how this concept would be tested'." - OEM Manufacturer* *"You must have the battery here. I need to know the battery even to talk about it" - 2nd Tier Supplier* *"For us to really understand the market we had to launch. We had to step into the pool (...) It wasn't something that we could just do paper studies. And just sitting at a desk, you had to get your hands dirty and understand." - 1st tier Supplier*
L/H	Bricolage strategy S	Creatively rearrange, and improvise available resources	*"We're obviously taking what's easiest, what's most accessible (...) So we're going backward, and we know how to take simple components such as cables connectors screws covers metal structures and we've already developed, for example, our own BMS in partnership with a company in Sweden*

		(technological, financial, human, infrastructure resources, partner's resources, etc.) to obtain solutions that reduce ecosystem uncertainties.	*using their base and we're going one step at a time backward and forwards in search of this path." - Battery 1st Tyer Supplier*
			"Since EVTOL has a weight limit of 450 kg, we weigh and balance the aircraft before the flight. How do we know the passenger's weight? It's a bit of a complicated question, isn't it?" - Aircraft Operator.
L/H	Adapting to current systems strategy S	To successfully accommodate EVTOL 's new tools, software's, methods, and technologies to deal with the IE-related uncertainties inside traditional aviation system	*"On top of that, we've been creating and raising various other hypotheses. So, I have to introduce this equipment without creating a disruption in general aviation (which) will still, probably for many years, have priority over these new aircraft like EVTOLS."*
			"When we've done a lot of studies, it looks like an airplane. It looks like a helicopter. It looks like something you might have flown in, or you surely see flying every day." - OEM Manufacturer
			"We did a canvas but basically what we are doing is to adapt our products into a new business." - Vertiport Operator
			"Airport layout plan is the official FAA process to make a change or addition to it. If you're going to put a new product or a new building in an airport (...) it is a process that involves both the FAA and the Department of Transportation."
			"New air environments (...) here we saw that you have the normal ATM environment of airplanes, current systems, expertise, and business rules. (...) and you have a future environment you have the UAM which are the EVTOL S and the current systems with adaptations." - ATC Operator
			"For initial operations, it should be assumed that current operational regulations for airplanes and helicopters (RBAC 91,119 and 135) will not change drastically but should be slightly adapted to enable the introduction of EVTOLs." - Global Regulator
L/L	Partnering to build knowledge and cocreate solutions strategy S	Cocreating solutions to solve ecosystem uncertainties.	"We listened to them, we discussed this growing architecture, we talked to him, we passed on a scientific white paper with ideas." - ATC Operator
			"We need the battery to do this study to see if we can really (make it viable). If we're going to use the whole (inaudible), or if we're going to reuse the module. So, we really need to study what chemistry is." - Electrification Provider
			"We talked to the competition too because we, you know, for example, on charging. we need to agree on one standard (...) So we've been trying to integrate on some of the things also on infrastructure, also because we need to develop the standards together (...) even though we're competitors, you know the aircraft need to land in the same space. And otherwise, we cannot have each of us the own infrastructure that doesn't make sense. Well, we are in dialogue with them." - OEM Manufacturer
			"This collaboration between DOE labs and universities is focusing on lithium-metal batteries, overseen by an industry panel board including Tesla, IBM, and PNNL to ensure manufacturable solutions. While this effort is pursuing a 1,000-cycle life, it's also pursuing a cost target of less than

			$100 per kWh. If this cost threshold can be achieved, the cycle life would be highly acceptable." - Uber Elevate (2016)
			"Constraints can potentially be addressed through ongoing intragovernmental partnerships (i.e., NASA-FAA), government and industry collaboration, strong industry commitment, and existing legal and regulatory enablers." - Bozz Alle Hamilton (2018)
			"So, the next step is to get a grant or a client like that so we can move forward and put a first pilot into practice, taking our products and adapting them to real cases. Taking the client's requirements."- ATC Operator.
			"NASA has already begun working with regulators to determine how electric propulsion systems for UAM can best be certified by the FAA." - Report Charter (2019)
L/L	Passive Learning S	Foster discussion on relevant topics to address IE-related uncertainties through Forums, Seminars, Working Groups, and Communities.	*"As future actions, it is important to identify opportunities to influence discussions on regulations and legislation in key target markets." - OEM Manufacturer*
			"We have on our website to communicate, to reach out to communities, to provide information like we're doing now with this podcast, and to set up collaborations. So, this is really where can we moving forward can work to bring the stakeholders to the table in any community or region and facilitate that discussion to understand what this new technology is." - Private Association
			"Last year we held the first forum focused on urban mobility. We have private events involving everyone we've already named and who are important to the ecosystem. I think that by getting to know each other and seeing each other's difficulties and then proposing solutions, we'll be able to make progress on this issue." - ATC Regulator
			"Now, all of the aircraft in this sector are targeting low noise, and they are going to be tens, if not 100 times, quite literally, then a helicopter, which will make a huge difference. But we have to get that right and we have to communicate that well as a sector." - OEM Manufacturer
			"There are the NASA community integration working groups (...) there's also the Community Mobility Initiative, which is an ecosystem association that has both kinds of public and private sector members." - Technological Research Center
L/L	Researching strategy S	Interact with ecosystem actors to integrate them into the discussion and discover insights that help reduce ecosystem uncertainties.	*"We are trying to engage the public in some proper discussion (...) So I've asked people, do you like it? Yes, no. It's not very useful as just the public has got no idea what they are." - Research and Innovation Center*
			"We've done our market hypothesis testing. We have done market studies and so on." - OEM Manufacturer
			"We looked at site locations. Ground-based heliports had the higher volume of accidents at about 127 (...) We identified 15 compositional additional factors the top five being obstruction, all hazards, design failures, improper size, basically trying to put too many aircraft in too small a space." - Consultant firm
			"We've started doing research" - Architecture firm
			"So, it's opening up the field to other technologies that are being studied both today and in Asia and Europe. So they're doing a lot of research and trying to come up with other technologies that will

			serve various markets, as we've seen, the United States itself, they're always doing a lot of research and trying to come up with other technologies that will serve various markets, as we've seen there, not just the market (...) Today, for example, lithium-ion batteries can achieve 50,100 charge and discharge cycles, but there's also a lot of research being carried out to make this or other technologies viable." - 1st tier supplier
			"At first, we started looking at the development of an air network (...) we thought 'Let's study our capitals and do air network studies' (...) we started studying and evaluating this part of Finance." - OEM Operator
L/L	Testimonials and good faith strategy S	Openness to accept that the information shared is honest and sincere.	*"The manufacturer who declares compliance and assumes all responsibility and authority evaluates whether that demonstration of compliance with the requirement is okay and if it fulfills it (...) It also involves tests and testimonies to prove compliance with a certain requirement."*
L/L	Sharing Uncertainties strategy S	Genuine and altruistic efforts to broaden the IE actor's knowledge of uncertainties by sharing information	*"So, number one is to make the uncertainties visible (...) It actually exposes the uncertainties. (...) it's actually going to make it possible to get the whole ecosystem of knowledge." - Research and Innovation Center*
			"We've been very open with the authorities intending to sort of saying, you know, 'our failures are your failures too'. They're worth sharing what we learn, you need to learn at the same time. And with that in mind, when we needed to do some work around battery testing at the beginning of last year, we did a fire test on a battery with a drop test on the battery. We invited the officer in the CIA in to witness those tests so that we can share what we're experiencing, and they can learn from our more endeavors." - OEM representative
L/L	Breaking the problem into pieces S	Map and understand the smaller challenges that need to be addressed so that a larger uncertainty can be resolved.	*"Severe weather conditions, such as severe thunderstorms, will delay all aircraft including VTOLs in any market. This means that VTOL operators are likely to prioritize initial VTOL operations in markets that do not present prohibitive environmental or weather conditions." - Uber Elevate Report (2016)*
			"For unmanned applications to thrive, many stakeholders must come together to advance their respective domains. Advances can be accomplished in phases, with each phase dependent on the previous ones. This model was first proposed for autonomous vehicles and mirrors SAE J3016A22." - Aircraft Manufacturer
L/L	Lessons Learned strategy S	Use previous experiences as support in resolving current uncertainties. Use previous negative examples as support in resolving current uncertainties.	*"So, there are some uncertainties that they're asking themselves. But let's say we've learned how we could validate these uncertainties in the future." - Engineering Consultancy*
			"We've gone through this process, and we've learned some things the hard way and we've found out." - Consultancy Firm
			"They are one of the largest commercial operators of helicopters maybe in the world (...) They have built up a tremendous fund of expertise at how you go and operate fleets of vertical lift aircraft (...) They've learned a lot of lessons about safety, maintenance, and how to manage their fleets. And those are things that we absolutely need to tap into." - OEM Manufacturer

			"We've seen and again investors asking the same questions ' What's your power system?' 'Where are you going to get your batteries? 'Are this a hybrid electric?' Nowadays, a lot of more sophisticated questions coming from the investors. So, I see the industry maturing from that perspective."
			"We have developed a very important knowledge of advanced air mobility, really looking at a commercial business within Gol." - Aircraft Operator
			"It was as ironic that the FAA's helicopter flying handbook does not mention the word safety area at all. So, we're not teaching pilots what good infrastructure is supposed to look like in the first place (...) We don't talk about what the hell design (...)What's the overall length and the rotor diameter have and what's the impact of the sizing of the infrastructure on the heliport? So, we've never gone out of our way as an industry for years to tell pilots 'Hey, this is what it's supposed to look like, you know'. We need to make sure that we account for that." - Consultancy Firm
L/L	Trial-by-error strategy S	Doing something until one finds the most successful output to resolve the IE-related uncertainty.	*"Lo perfecto, es enemigo de lo bueno. No puedes empezar perfecto, te vas a equivocar, lo tienes que asumir, el tema es no equivocarte poniendo en riesgo a nadie, pero dentro de eso podrás cometer errores. Pero si no empiezas, no vas a evolucionar, sino evolucionar, no vas a encontrar otras formas de hacer luego el tema de la visión"*
			He tested things, broke things, measured things, and converged to something that the point that I met him was already flying in a very, very efficient way. And again, one of the take-outs is to try because we, as humans, we tend to try and formalize or look for formulas, let's say that describe reality. And then we tend to mix the formula with the reality. And this is what happens here.
L/L	Playing by the rules (Adaptative strategy) S	Understand the design of the ecosystem that has already been mapped and designed and how to fit into this scenario	*"If you mix "autopiloted" with "urban" in "Madrid" (this will probably not work in the short run). But if you put "rural" and "with pilot" maybe in 2024 you can do some flights and get ready." - Infrastructure Operator*
			"We think that actually makes quite a lot of economic sense. (...) there is an argument that a two-seat aircraft is used to bring people into cities actually scales really well. So the economics are fantastic (...)" - Research and Innovation Center
			"(When) we started, we didn't know whether there would be a regulatory framework to work on. Now we already have it that provides you some confidence on the solutions you want to work on as soon as they are aligned with the regulations."
L/L	Learning by Borrowing S	Apply acquired knowledge and skills by taking ideas from traditional aviation, helicopters, drones, and other related markets to solve	*"Embraer's KC 390 (...) is a heavy military freighter that we have certified. It had two or three experimental units. So, the foundations, the start of operations, the certification process, it's made possible with these mechanisms, you know?" - National Regulator*
			"There I saw something where people got in an Uber, passed by with their cell phone and got into the helicopter (...) passed through an inspection channel, an autonomous system. (...) Very clean, and the business worked very well. I think we still have to develop a similar structure to make this perception of public acceptance viable." - Aircraft Operator

		uncertainties in the EVTOL innovation ecosystem	*"We know the tower and we know what we need. A company without this experience wouldn't be able to see that our systems are connected here. What we've identified needs to be adapted to suit this architecture here." - ATC Operator*
			"How do I do a simulation? Let me take the model that comes closest to this, which is a helicopter model, okay? And then I work with that model to try to get closer." - ATC Operator
			"They asked me for an estimate of the price. I said I can't give you any information in that sense, it hasn't been decided. The most I can tell you is that we've even talked to our boss here about the helicopter operation." - Aircraft Operator
			"And therefore, you look at what's existing in helicopters. But how can we change or adapt it in the best way, according to our performance of the aircraft is how we steer us." - OEM Manufacturer
			"So, we need to either attract young pilots or pilots that flight currently planes or helicopters to convert."
			"When we've done a lot of studies, it looks like an airplane. It looks like a helicopter. It looks like something you might have flown in, or you surely see flying every day." - OEM Operator
L/L	Being Conservative strategy S	Look carefully and rationally at the information disclosed	*"We looked at the market reports the big consultancies were putting out the Roland Berger, the McKinsey's (...) we went into their assumptions to rethink their assumptions "were right?" or "did we should rethink their assumptions?", "were optimistic?", you know, "maybe too conservative?". And based on that, we tried to tailor their numbers. -Research and Innovation Center*
			It is not a typical aircraft configuration like a helicopter or like a light plane that is super studied that says 'look, this is how it works'. So. We have to give hours of flight, you have to continue his theoretical studies and you have to be very cautious in what you do so as not to get any surprises."
			"And we said if the world makes about 500 to 700 helicopters a year, you know, how realistic is it that will end up making 10.000 thousand a year, for example? And then what's going to drive that?
L/L	Doing Nothing and Wait Strategy S	Do not make decisions before others in scenarios where there is high uncertainty.	*" We are part of pilot training and member of regulations' committees, where we try to minimize uncertainties by talking to EASA. (...) staying in contact with them to see how this marlet evolves."- OEM Manufacturer*
			"And so, what do we do? We just made some plans for infrastructure. We made some plans for air spacing. We did transport processes, but all of those are just plans. We have them ready whenever that comes to certification or at a time when your regulators and authorities say 'OK, right now we are confident that we can offer you a certificate, then we are ready to go.' But right now, it's just, you know, we can't do anything anymore." - Groundhandling Operator - Airport
			"Getting up to the rooftop, you know, is a choke point. You've got to wait for an elevator that wasn't designed to service people getting up and off the roof. Fire codes don't support the use. Building codes don't support the use. Electrical codes don't support use. So, you know, for all of those reasons, we're like, Well, that's not a problem we want to go after ." - OEM Manufacturer
			"So, the wingspan of an EVTOL, almost all of them, is around 13 to 15 meters. In the case of the VX4 as well as the Archer that will be operated by United, it's a 15-meter aircraft. 50 feet is 30 meters on one side of a landing point. If I look at the helipads that exist in São Paulo, we did a quick

			calculation - do you know how much of the helipad infrastructure is capable of receiving an EVTOL if Anac adopts the American model? It's less than three percent."
			"I would expect that by next year, half of the companies working on that might be close because. and those that survive will need a fast-growing approach. My guess is that this ecosystem will not start in 2040. So, we are kind of waiting a little bit." - Engineering consultancy firm
			"We're not actually building SkySports at this stage. That would be premature to be building anything."
			"I don't know if they have anything ready, but it's probably in development. And that it's unanimous, not specific (...) that it works for everyone. Which is great." -
			"We're not actually building SkySports at this stage. That would be premature to be building anything. What we're doing is securing existing landing sites and creating approvals for new landing sites and having them perform together as a network so that when the time is right and hopefully they have a Joby or a Volocopter or a Lilium wants to come into Australia, SkySports will be able to say, Well, here are 20 landing sites and we're ready to start operating and we have investment partners who will now build out what you need and be ready to operate so." - Groundhandling operator
L/L	Being an Outlier strategy S	Searching for uncertainty resolution by investing in contradictory ideas based on particular opinions and guesses that go unlike other IE actors playing the same role.	*"Learning all the lessons that are necessary for us to be a successful and certifiable vehicle, and that's not the approach that generates the flashiest marketing videos right away, but it is an approach that I think in the long run will be much more efficient path to certification." - OEM Manufacturer.*
			"That was really the gap that we wanted to solve. Like, let's first focus on educating people and getting everybody on the same page that hydrogen is viable, it's feasible, it's safe. (...) Some people don't really understand, (...) hydrogen fuel cells are electric. They function very similar to a battery." - Private Association
			"What that means is that everything from performance to safety optimization on a standard automotive has to be on the vehicle because they can't guarantee the automotive supply, can't guarantee where it is going to be charging it ."
H/L	Students competition strategy S	Regional, national, or global student events are usually sponsored by an IE actor to collectively design and address solutions to complex IE uncertainties.	*"We've for several years that we did a motor vehicle student competition. We've now evolved that into actually a larger aircraft as part of a design-build flying competition (...) schools around the world." - OEM manufacturer*
H/L	Being enthusiastic strategy	Having an active and motivated attitude	*"I started seeing a lot of predictions for the future that are quite impressive regarding (...). It became evident to me (...) that this would definitively take place. There's no stopping it! (...) It's such a great market to be in." - IE complementor*

	S	instead of a passive one	*"Being able to see the grounded as a general aviator, you know, I've flown it, you know, 20 feet above the ground, 5000 feet cruising. And you just get to see so much more. You get to experience it!" - OEM Manufacturer*
			"My personality is that I'm attracted to large paradigm shifts (...) so I see this transition to EVTOLs as one of the largest market opportunities of our lifetimes. So, I might as an entrepreneur, I look at that clearly as an opportunity. (...) that's going to be enormous, it's very exciting." - OEM Manufacturer
H/L	Planning next alliances strategy S	Study the actors and new entrants of the ecosystem, their capabilities and resources, and possible cognitive, technological, and financial dependencies that can be created with these actors.	*"So, it's important to already start the engagement and possible agreements today or at the latest two years before the operation than to actually start an agreement in the operation or wait for the helipads to be built." - Aircraft Operator*
			"In order to get funding for this project (...) across collaboration with other companies might be useful to get some funding." - 1st tier Supplier
			"One of the things I think we really need to do as an organization and more importantly as an industry, is to be proactive and engage in these groups and lay that foundation for the long-term partnerships that will make this successful." - 1st tier Supplier
			"We also participate in various events where we can meet with companies and new institutions when we can extend our network of stakeholders. We participated in Amsterdam, in the World ATM Congress, for example." - Infrastructure Operator
H/L	Risk Assessment S	Tools to identify, analyze, and mitigate a wide range of risks	*"These kinds of meetings already usually use some risk assessments to see how you usually get things done." - OEM Manufacturer*
			"Comprehensive Safety Management Systems (SMS) identify, analyze, and mitigate a wide range of these risks. Threats include failures in avionics, navigation, and communication. They can also include bad weather or pushing an aircraft beyond its capabilities. Depending on the capabilities of the aircraft, its path, and the other aircraft in the area, the flight will have a different risk assessment." - Aircraft Manufacturer
H/L	Regression Analysis ST	Application of statistical techniques to reduce uncertainty	*"We developed a relationship between aircraft price per seat and MTOW per seat through regression analysis of the available price data as shown in the previous slides. Our analysis assumes that MTOW and aircraft price varies linearly with the number of seats (as typically observed in commercial aviation) " - Market Report*
H/L	Economic models/foresig ht ST	Calculations to measure future scenarios using known variables from other sectors as a basis	*"PRICING MODEL- The team expects taxi operators to first price their services based on the buyer's perceived value of the service followed by bundle pricing and other cost-based methods. - Assumptions available in the report" - UAM Market Study (2018)*
H/L	Survey ST	Application of statistical techniques to reduce uncertainty	*"We're doing several surveys. We're doing composite surveys; we're doing experience surveys". - Brand Agency*
			"We've done surveys and talked to people who think -Urban Air Mobility experts in urban planning and system integration." - Groundhandling Operator

H/L	Simulations ST	Close imitation of reality, operation of a process or system that represents its operation over time.	*“We carried out some simulations (...) a nice collaborative effort. We brought together various representatives, and the package also included an energy company. So, they did a study, and based on the energy capacity of Rio de Janeiro, they were able to see that the operations could take place up to a certain point (...) We take the information and study it, analyze it, simulate it, use the simulator and we draw some conclusions and it's all a bit of a ballgame.” - National Regulator*
			"Ellos tienen unas instalaciones hace un impacto de pájaro, una similitud en parte por el impacto de pájaro sobre la estructura de la aeronave y emite un informe (...) Y ese informe y este ensayo es válido de cara a EASA para decir OK, esta prueba que te exigíamos está pasada o no esta pasada." - OEM Manufacturer
			“So, it seems to me that, in terms of technological uncertainties, it is a strategy to mitigate these uncertainties. The simulations.” - Research center
			“We want to find the answer will urban mobility be on demand or scheduled? Will it be, you know, within 15 kilometers, you know, within the city? Or will more be like connecting cities between or airport and the city center shot them? So, these are all the questions which simulator can help us figure it out so that we can plan?” - City Lab
H/L	Business Plan ST	Consolidation of a project through a formal structured but flexible document that details the strategy of a future business model, as well as the actions to execute the project and resolve the uncertainties.	*"There must be taken the strategic decision in our company about the direction for the further innovative E-mobility concept development and talking about the long-term vision and things to be done within next year. Next year. I think the most efficient step would be to prepare a solid and detailed business model that would already consider the input of potential business partners and secondly, prepare the specification for the design. Then, of course, the design process itself, the construction, and all of it finished with the certification process." - Infrastructure Operator*
			"Tenemos un plan de desarrollo, puesto que de aquí a 2028 con desarrollo de la aeronave con sus retos, sus fechas y sus inversiones, necesidades y resultados (...) Ese plan de desarrollo es lo suficientemente detallado como para marcar las directrices generales y lo suficientemente flexible como para poder adaptarse a las incertidumbres, los cambios y la evolución del proyecto." - OEM Manufacturer
			"We have different phases in the strategy. Of course, now we are in the lead, focusing our strategy around certifying and developing and then producing the aircraft." - OEM Manufacturer
H/L	Made Assumptions strategy S	Assuming/taking something for granted so that progress can be made in solving greater uncertainty.	*"So, I created premises. Starting from these premises that this exists, 'then it's good'. Then we built the next steps. That's the strategy we adopted.” - ATC Operator*
			"Since we're not flying yet extensively, we have to assume certain things and then we will just adjust when we have, you know, better weather data." - OEM Manufacturer
			"For initial operations, we assumed that current operational regulations for airplanes and helicopters (RBAC 91,119 and 135) will not change drastically but should be slightly adapted to enable the introduction of EVTOLs(...) We assume one full-time equivalent pilot per aircraft and one full-time equivalent ground crew member in the first few years of the analysis. We assume that the ground crew is expected to serve multiple roles including passenger check-in, security check, and any other customer-related service." - OEM Manufacturer

H and L/H	Knowledge omission strategy S	Not opening up information that is already available to create creative solutions to existing uncertainties.	*"Now we've been told about the size of the track, EVTOLs, how it moves, the distances between buildings, all this we have, which has an impact on the architecture. Now we don't have information about the equipment to supply it (...) according to our research, some sound and noise sensors are needed (...) they also need a control room, but we don't know what's in the control room, equipment, energy." - Architecture office*
			"We pleaded not to release anything to the market, but also not to leak information like this." - Aircraft Operator
			"We tend to be pretty thoughtful and careful with the things that we share publicly. (...) so putting timestamps on things doesn't seem fair and reasonable to all of those that are involved in this process ultimately." - OEM Manufacturer
	Run away - decline strategy S	Consciously resolve not to invest resources and focus on resolving uncertainty	*"It's a lot of risk and it's a lot of money and things are not certified. So many times, you say 'hey, maybe it's better to go to something that is already well proven.' - OEM Manufacturer*

Source: Author's Elaboration.

5.2.1 Adaptative Strategies

The first group that emerged from the data refers to the **adaptative strategies**. We inductively extracted from the data thirteen strategies: Partnering to build knowledge and co-create solutions, Passive Learning, Researching, Testimonials and good faith, Sharing Uncertainties, Breaking the problem into pieces, Lessons Learned, Trial by error, Playing by the rules (Adaptative strategy), Learning by Borrowing, Being Conservative, Doing Nothing and wait, Being an Outlier. This low level of control and low level of prediction strategies were cited eighty-eight times.

While decision-makers think that the future cannot be fully predicted or controlled, adaptative strategies allow them to survive. By buffering against potential uncertainties, leaders employ a couple of interorganizational learning strategies. The most cited ones are the *act of listening* (**Passive learning strategy)** which means fostering the discussion on relevant topics to address IE-related uncertainties through Forums, Seminars, Working Groups, and Communities. This strategy is closely linked to **Testimonials and a good faith strategy** that reflects members' openness to listen and accept new information shared. On the other side, the *act of speaking* by genuinely and altruistically sharing information to broaden others' knowledge base – we called this a **Testimonials and good faith strategy:**

> "The manufacturer who declares compliance and assumes all responsibility and authority evaluates whether that demonstration of compliance with the requirement is okay and if it fulfills it (...) It also involves tests and testimonies to prove compliance with a certain requirement." (National Regulator)."

The second most cited strategy is the *act of copying* using **Learning by Borrowing ideas** from traditional aviation, helicopters, drones, and other related markets to solve uncertainties in the EVTOL IE. They also employ *the act of remembering* when using their own previous experiences as support in resolving current uncertainties. We entitled this as a **Lessons Learned strategy.**

Decision makers also employ *the act of cocreating* by **Partnering to build knowledge and co-create solutions**. Sometimes they interact with ecosystem actors to integrate them into the discussion and discover insights that help reduce ecosystem uncertainties by employing **Researching and Trial by error strategies**. This interaction occurs like a volleyball game, where synergies and exchanges of resources and activities are constant between companies.

> "We are trying to engage the public in some proper discussion (...) So I've asked people, do you like it? Yes, no. It's not very useful as just the public has got no idea what they are." - Research and Innovation Center when explaining how they performed research in partnership with another firm.
>
> "The perfectionism is an enemy of the good. You can't start perfect, you're going to make mistakes, you have to accept it. The point is that you cannot make make mistakes putting anyone at risk. Besides that, you can make mistakes. But if you don't start, you won't evolve" - Vertiport operator explaining trial by error strategy.

In this sense, all learning strategies broaden the other player's view of uncertainty, increasing their absorptive capacity and allowing them to develop new ways of dealing with unknown topics.

In cases of high uncertainty, some decision-makers prefer to outline action routes and organize what needs to be done into smaller pieces of action. Thus, they *act by partitioning*. We called this uncertainty Breaking the problem into pieces. The *act of waiting* **(Doing Nothing)** is employed when decision-makers think the best thing to do is nothing. They might also *act as fitting by* **Playing the rules** and *act of contradicting by* **Being an Outlier strategy** meaning adopting counterintuitive, contradictory actions, consensually defined as "inappropriate" or "incorrect" by other members of the ecosystem.

5.2.2 Shaping Strategies

The second group that emerged from the data refers to the **Shaping strategies**. We inductively extracted from the data thirteen strategies: Bottleneck, Standardization and Modularity, Imaging, Pivoting, Opening a new company, Creating a cluster, Platform and Systems, Dictating trends, Partnering to shape the market, Educating, White papers, Standardization of Concepts, Nomenclatures and Key terms, Manuals-handbooks-reports. This high level of control and high level of prediction strategies were cited ninety-four times.

We named the **Educating strategy** the process of developing teaching and learning to broaden the community's knowledge of the ecosystem. This strategy helps to build the basis for community acceptance. We see OEMs employing this strategy to deal with Coalition of Social Groups uncertainty, for example.

Bottlenecks restrict ecosystem growth or performance. But they can also move, as depicted in the case of Hannah and Eisenhardt's (2018) nascent solar panel industry. In the paper, Hannah and Eisenhardt (2018) showed that successful companies adopted the bottleneck strategy by identifying bottlenecks in advance and positioned themselves in the center of the bottleneck. In the EVTOL case study, we saw some companies employing this strategy and positioning themselves in the middle of the groundhandling infrastructure bottleneck. These firms mapped the critical points of the ecosystem and positioned within them to design ways to resolve uncertainties.

The **Pivoting Strategy** is another shaping strategy used by the firms. They employed a search process for alternative paths to solve uncertainty. To do that, companies adapt some aspects of their core products or services to ensure that the business remains viable and profitable. For example, we observed that from the extensive list of OEMs entering this market, some of them pivoted the initial business model strategy from manufacturers to operators or even vertiport operators.

Imaging strategy (backing into the future) is when a firm envisions a desired future state and its possible IE-related uncertainties and then works backward to identify the steps needed to get there from the present. For example, they see a future with a high air traffic density and based on that start imagining how city infrastructure would deal with that.

Opening a new company is one of the most frequent strategies we found in our research. This strategy entails the opening of new spin-offs and startups focused on dealing with specific IE-related uncertainties. This is an interesting example extracted from an interview with a Digital Air Safety Engineer. In this excerpt, he explains his new startup's main value proposition focuses on data gathering for certification requirements achievement: “We are helping people with the certification. Engineers compile all this evidence and get it, you know, make it ready for EASA and the FAA to look at and pore over."

Creating a cluster is a strategy employed by firms to reduce uncertainty by building an entrepreneurial context dedicated to facilitating IE emergence inside a specific region. Decision makers that employ this strategy believe in geographical proximity as a proxy for ecosystem success. We cite below one project, in particular, the EVTOL Aviation Village:

> "The Aviation Village is really to create an environment and infrastructure for the development of various technologies required for the eventual sector. At the same time, manufacturing the aircraft in the same part and same place, also having residential for all of the people who are coming to work in India, in that village, in a modern area where there are all of the support facilities, including schools and museums, entertainments and the medical center, the hotels, you know, sports centers, all everything that a community would require and create a cluster of various sizes of companies to come and innovate, develop, but also manufacture and operate this type of aircraft next to a runway that could be used as one of the air taxi centers for this type. So, creating an environment creates synergy, and the collaborations within between the two companies and groups provide benefits for these companies, but also the outside suppliers and supply chain network for food for this sector."

Platform and Systems creation is a strategy focused on reducing ecosystem interoperability unknowns by starting new IT projects. For example, some actors are investing in new platforms to solve interface standardization and air communication uncertainties. EVTOL will demand an entirely new communication system, and, in some markets, there is even competition as to which will be the dominant system to support air traffic control management.

Dictating trends is a strategy adopted by some ecosystem members to disseminate knowledge inside the ecosystem. Usually, consultancy firms and actors playing the orchestration role employ this strategy. The main intention behind this is to outline the path for ecosystem evolution. For example, NASA dictates trends by writing white papers and being imperative and mentoring what actors should do to resolve uncertainties.

We know how partnerships are important in a wide variety of contexts. Some firms employ this strategy in a tentative for building predictions and controlling strategic information aiming to solve ecosystem uncertainties. In the example below, we see how a **partnership** can help a firm to shape the market:

> "With the FAA, we're working with the next-gen office and with the standards group and started taking this as a starting point for discussion to build the standards and the means of compliance for how to get operational approval to do this. It will take some changes in the air traffic side to implement this minimal voice communication activity."

Players that already have control over the ecosystem's resources and strategic activities might seek to define IE-related- nomenclatures, key terms, and concepts to create a common knowledge base for uncertainty resolution. This is a strategy that helps to reduce alignment uncertainty, for example.

As we don't have a vehicle, ground handling, and air system dominant design yet, the **standardization and modularity strategy** adopted to reduce interoperability-related uncertainties has become increasingly popular in the ecosystem. With a modular approach, systems and products are divided into discrete, interchangeable components that can be mixed and matched as needed. In the EVTOL ecosystem, actors create standardized connection points between aircraft modules providing flexibility, customizability, and scalability to the ecosystem. Modular interfaces enable components to be swapped out or added on without rebuilding entire systems from scratch. Whether for versatility, upgradeability, maintainability, or cost-efficiency, modular design allows for more agile and iterative development. The overall complexity is reduced by dividing a system into self-contained, loosely coupled modules that have defined roles. This modularity and standardization are crucial for enabling large, collaborative development efforts and the continuous evolution of the ecosystem.

Producing manuals, handbooks, and reports can be an effective way to explain complex situations and mitigate ecosystem uncertainties by providing a systematic framework to logically organize and present information step-by-step. This facilitates understanding of ecosystem blind spots and reinforces or clarifies understandings. Some manuals are very visual, allowing the incorporation of illustrative visuals like diagrams, flowcharts, and photos that can connect explanations to real-world examples. In the EVTOL ecosystem, these documents are usually co-created to provide troubleshooting guides and solutions to common ecosystem problems that readers can readily implement. Reports, for example, convey research insights, data, and conclusions in a meticulous, comprehensive way that ensures accuracy and credibility. This strategy is a way to build institutional knowledge in the ecosystem as well.

In this sense, **white papers** are a subset of this strategy. They leverage expert insights to provide readers with an in-depth investigation of complex ecosystem-related uncertainties and propose strategic solutions or recommendations for decision-makers. Usually, writers have deep knowledge of the topic and draw on statistics, research, case studies, and domain expertise.

5.2.3 Transformative Strategies

The third group that emerged from the data refers to the **transformative strategies**. Actors that employ this set of strategies accept unpredictability as inherent and focus on what they can control. We inductively extracted from the data twelve strategies: Making it simple, Selecting uncertainties to focus on, CONOPS (Concep of Operation) and consortiums, Spreading Information, Commitment, Triangulation and redundancy, Refining and Validating, Compliance Demonstration test, Agile Methods, Proof of concept (POC) / Business Case, Get your hands dirty, Bricolage, Adapting to current systems. This low level of control and high level of prediction strategies were cited fifty-nine times inside the database.

Make it simple strategy is to act and do things in an easy-to-understand way, avoiding excessive bureaucracy. This strategy is used by decision-makers when they want to find practical solutions for IE-related uncertainties by resolving small parts of large unknowns. Traditional aviation is well known for large bureaucratic operational processes and the idea of simplifying operations is the strategy employed by some actors. Below we see the strategy employed in practice.

> “The EVTOL has a weight limit (...) how are we going to know the passenger's weight? It's a somewhat tricky question to ask. So, for digital check-in, you need to be within the frame to take your photo. However, no one mentions that inside the frame is a scale automatically linked to your photo. It's brilliant because it captures your weight automatically." (Aircraft Operator)

We can depict from this excerpt one example of how decision makers try to deal with user experience uncertainty by simplifying the checking process- the fact that they don’t know how the passenger will react to the checking process (being questioned about their weight) made them employ this strategy (attach an automatic weighing scale in the ground handling structure)

Selecting uncertainties to focus on strategy is to make a judgment about whether or not to expend energy to resolve an uncertainty based on the analysis of several factors. We know that there is a huge number of unknowns in this ecosystem and sometimes decision-makers have to take one step back, think, and precisely choose what uncertainty they want to focus on. We saw this strategy mainly used to deal with existing ground handling infrastructure adaptations uncertainty- i.e. decision-makers reviewed the pros and cons related to infrastructure changes and decided to focus on other uncertainties at that moment.

CONOPS (Concep of Operation) and consortiums strategy is maybe the most famous strategy employed by managers. A CONOPS connects technical design to real-world operations by bridging ATC system capabilities and user requirements. It serves as an evolving reference for system implementation, user training, evaluation, and improvement. An inclusive approach to capture the assumptions and tradeoffs made via multiple UAM stakeholders by defining clear operational boundaries for UAM and capturing the needs and desires of the many different stakeholders of the National Airspace System.

Spreading Information strategy is when managers communicate findings extracted from first-order data to the IE community through different communication channels. This strategy differentiates from other previously cited ones – for example, the "white papers" and "producing manuals, handbooks, and reports" strategies – since it can be raw data collected firsthand and thrown outside the firm's boundaries. In this type of strategy, the information spread is not always the creation of collective knowledge. Often, it is just information coming from companies' internal knowledge bases. The data is usually presented to other members of the ecosystem through seminars and sector events.

Commitment is a behavioral strategy employed by decision-makers when they show devotion and dedication to resolving an ecosystem's uncertainty. The strategy adopted by actors means showing commitment to the other actors in the ecosystem and adopting a proactive behavior when facing uncertainties.

Triangulation and redundancy is a strategic technique employed by decision-makers when they use a variety of data sources, including time, space, and persons to deal with uncertainty. Triangulation leverages a diversity of actor's perspectives to gain an accurate, multi-dimensional representation of the ecosystem uncertainties. This strategy increases the validity and reliability of the information that circulates in the ecosystem by cross-verifying what they read, see, and listen to. This strategy usually combines the strengths of qualitative and quantitative data, surveys, interviews, and docs.

Agile Methods strategy is the use of a set of processes, practices, and tools to resolve uncertainties.

Compliance Demonstration test means trials and tests to demonstrate that the method, technique, tool, and software effectively fulfills previous requirements to resolve uncertainties. In the EVTOL ecosystem, this is a strategy of testing whether a product/system meets specific mandatory standards, regulations, and laws that have been set by an external governing body. The key focus of this strategy is to verify conformity to those prescribed requirements.

Proof of concept (POC) and Business Case strategy evaluate technical and commercial viability, respectively. For example, a POC tests the feasibility of the ecosystem's new technologies and system in a real-world scenario aiming at determining if the concept works and has merits for further pursuit. If compared to the former strategy, we mentioned (Compliance Demonstration test). POC focuses on technical validation more than compliance. A business case analyzes the projected costs, benefits, risks, and rewards of implementing the EVTOL's operation. Includes sales projections, cost analysis, ROI modeling, and resources assessment. This strategy can help decision-makers mitigate financial uncertainties - affordability, fundability, operational costs, and value capture uncertainties.

Get your hands dirty strategy occurs when decision makers act proactively to resolve uncertainty by executing some actions. The focus of this strategy is on the action itself - regardless of what it is. Decision makers who executed this strategy were more concerned with executing tasks to resolve uncertainties than with planning the actions before their execution:

> "For us to really understand the market we had to launch. We had to step into the pool (...) It wasn't something that we could just do paper studies. And just sitting at a desk, you had to get your hands dirty and understand." - 1st tier Supplier

Bricolage is a strategy used by the IE actors when they creatively rearrange and improvise available resources (technological, financial, human, infrastructure resources, partner's resources, etc.) to obtain solutions that reduce ecosystem uncertainties. Thus, the bricolage strategy allows decision-makers – "Skillful bricoleurs"- to adapt and improvise solutions to challenges using limited resources on hand. The ecosystem still presents major uncertainties, and many actors are cautious when deciding whether to invest in this market or not. Therefore, bricolage becomes a less costly while effective strategy to deal with unknowns.

Adapting to the current systems strategy means the activities employed by decision makers in an attempt to accommodate EVTOL 's new idea – i.e., tools, softwares, technologies - inside traditional aviation systems as a way to deal with the IE-related uncertainties. This strategy is specifically applied by ecosystem actors who believe that EVTOL's success depends on its adaptation to the traditional aviation business model.

For example, an OEM manufacturer employed this strategy by creating an aircraft design similar to what the user already knows: *"It looks like an airplane. It looks like a helicopter. It looks like something you might have flown in, or you surely see flying every day." Another interesting example is the regulator, who commented about adapting the regulations: "Current operational regulations for airplanes and helicopters (RBAC 91,119 and 135) will not change drastically but should be slightly adapted to enable the introduction of EVTOLs".*

5.2.2 Planning Strategies

The fourth group that emerged from the data refers to the planning strategies. We inductively extracted from the data ten planning strategies: Students' competition, Being enthusiastic, Planning next alliances, Risk Assessment, Regression Analysis, Economic models/foresight, Survey, Simulations, Business Plan, and Made Assumptions. This high level of control and low level of prediction strategies were cited Forty-one times inside the database. Besides all of that, we found two other strategies we considered outliers: Knowledge omission strategy and run away-decline strategy.

The first strategy we want to mention is the **Planning Next alliance strategy**. We heard from a wide number of interviews a vast list of criteria they employ when selecting partners to share resources and activities in the ecosystem. **They define criteria** based on a study of the actors and new entrants of the ecosystem, their capabilities and resources, and possible cognitive, technological, and financial dependencies that can be created with these actors. We also observed that as relationships become more solid, enterprises begin to formalize agreements into contracts:

> "We will renew this MOU until November this year because we cannot proceed to an LOI (Letter of Intent), to something a little more committed in terms of values, as we understand that we can make a lot of mistakes when it comes

> to pricing and several other things due to having some difficulties. Here, we are already talking about some uncertainties that have arisen, including uncertainty in pricing." - Aircraft Operator

Students competition is a strategy employed by decision-makers when they invite students to help them design and address solutions to complex IE uncertainties. These regional, national, or global events are usually sponsored by an IE actor and provide opportunities for young people to showcase and develop their talents in aviation.

Being enthusiastic is a behavioral strategy that decision-makers employ when they want to motivate others to pursue uncertainty resolution. The positive attitude cultivates creativity and possibility-thinking to handle uncertainty. This positive energy gets actors working proactively and inspires passion in others, thus strategy fuels excitement about overcoming challenges.

Some strategic tools help to identify, analyze, and mitigate a wide range of uncertainties. Some of them employ statistical techniques to reduce uncertainty like **Regression Analysis, Survey, Risk Assessment, and Economic models**. **Economic models** measure future scenarios using known variables from other sectors as a basis. Other strategies imitate the reality, through **simulation** of process or system that represents aircraft operation over time.

Business Plan formulation is another well-known and traditional strategy used by actors dealing with macro uncertainties – for example, unknowns related to city infrastructure plans. The consolidation of a project through a formal structured but flexible document that details the future business model, as well as the actions to execute the project and resolve the uncertainties. A well-crafted business plan helps decision-makers reduce uncertainties by guiding them, securing funding, and assigning resources.

Made Assumptions is one very common strategy employed by a large number of decision-makers. This strategy involves explicitly stating assumptions up front by making educated guesses to move forward in situations of uncertainty or limited information. Managers assume/take something for granted in advance of the action. The goal is to eventually replace assumptions with facts. As you learn more, continue refining the solution to rely more on actual data points rather than guesses. In general, we see that this strategy is usually associated with complex uncertainties like weather and New Air Communication system design.

Figure 18 splits all strategies we found in our database inside the Wiltbank et al. (2006) matrix. We summarized the frequency of times that managers cited each strategy inside the database. As we can see, shaping and adapting strategies are almost equally employed in the ecosystem. The figure ranked them from the most to the last cited ones. To rank them inside the figure, we considered the frequency of citations. The frequency was measured by the number of times that every strategy - meaning how they did/ what tools and methods they employed to deal with uncertainties during the emergency of the IE – was mentioned on the database.

Besides all the strategies we identified and explained above, we also found the Knowledge omission strategy and Run away - decline strategy**.** We didn't want to frame these strategies inside one specific category because we understand that they might apply to multiple high/low prediction and control scenarios. **Knowledge omission** is one strategy employed by decision-makers when they want to block knowledge and information flows in the ecosystem. This strategy might apply in high control and high/low prediction scenarios. On one side of the coin, actors complain about the lack of access to information in the ecosystem, resulting in data-sharing information uncertainty previously known as data-issue uncertainty. On the other side, information owners apply the strategy of not disclosing it. So, we see that this strategy positively boosts the growth of data-issues uncertainty:

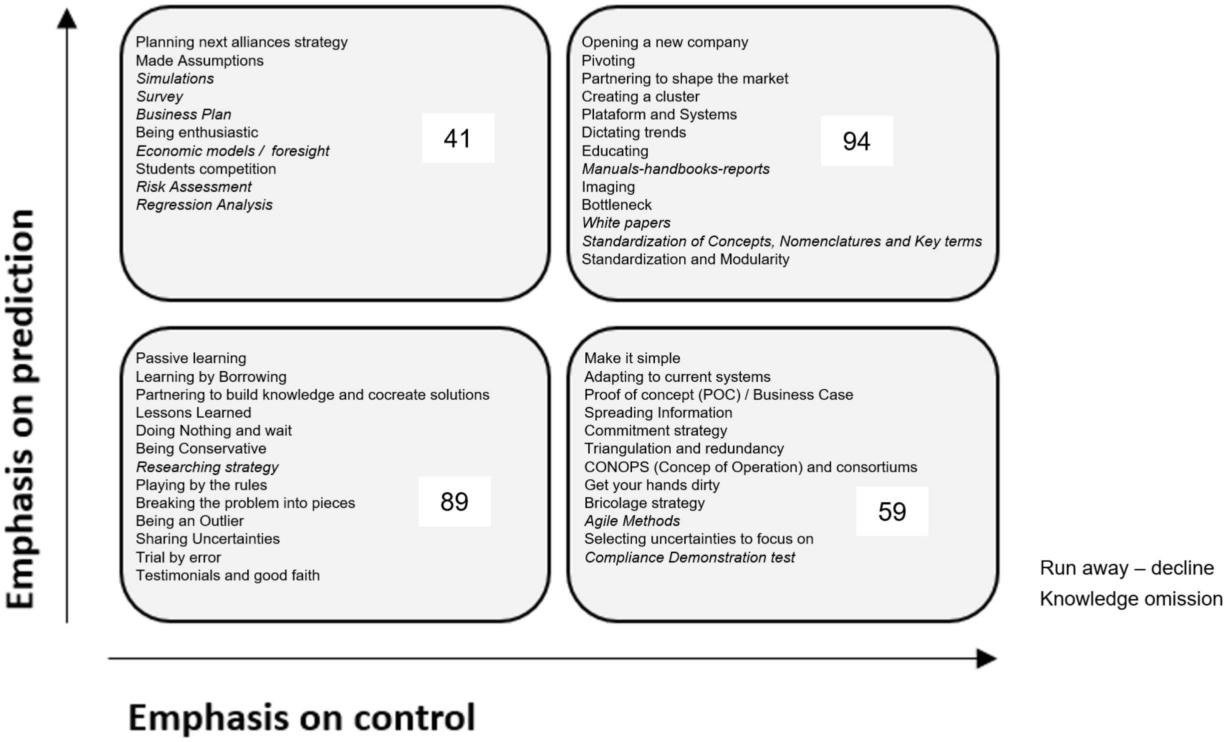
> "Now, some things regarding sizes, all this information was passed on: the size of the runway, EVTOL, how it moves, the distances between buildings—everything that impacts architecture. However, we do not have information about the refueling equipment (...) from our research, some sound sensors, and noise (...) are required. They also need a control center, but what is in the control center, equipment, power supply, we do not know." - Architectural office

Runaway - decline is a strategy that applies when decision-makers consciously decide not to invest resources to resolve uncertainties they face. As one Manufacturer said: *"Es mucho riesgo y es mucho dinero y las cosas no están certificadas. Entonces muchas veces dices 'oye, a lo mejor es mejor ir a algo que está muy probado.'"*

To summarize, actors playing these two previously mentioned strategies might think that for big uncertainties the best way to go is to not be part of the resolution. However, these strategies can encumber or even feedback and increase some of the uncertainties in the ecosystem itself. Another example:

> "I would expect that by next year, half of the companies working on that might be close because. and those that survive will need a fast-growing approach. My guess is that this ecosystem will not start in 2040. So, we are kind of waiting a little bit." - Engineering consultancy firm

Figure 18 - Strategies ranked by Strategy Formation Process Quadrants



Source: Authors elaboration based on Wiltbank et al. (2006) matrix.

5.3 SUMMARY OF DISCUSSION AND PROPOSITIONS

We start this section by presenting the main findings of the study in Table 25. This table shows all the thesis's specific goals, main findings, and discussion related to these findings. hen, we discuss the propositions of this thesis. First, we identified an emerging ecosystem based on multiple criteria. We identified an emerging ecosystem, mapped, and explained all its components, actors, and roles according to the ecosystem, and presented the results in Tables 10 and 11. We followed previous authors (Adner, 2017; Jacobides et al., 2018; Shipilov and Gawer, 2020) and framed the uncertainties into 11 ecosystem elements (Thomas and Autio, 2021; Gomes et al., 2021; Talmar et al., 2020).

We understood that this phenomenon that we analyzed can be theoretically considered as an IE in an emergent stage. We employed a process-based approach with multiple sources of analysis (Langley, 1999; Yin, 2004) and found 262 main events in a 7-year global trajectory evolution of the ecosystem and grouped them into 6 phases. We found that the vertical flight vehicle trajectory had its periods of ups and downs in history (see Table 15) and since 2010, the market started to be shaped mainly due to technological advancements in electric propulsion systems and energy storage solutions.

Based on the study of previous literature and case analysis, we inductively identified, named, and ranked (by degree of intensity) uncertainties and strategies that emerged from the data and inductively framed them into phases of the emergent ecosystem. The first phase of the ecosystem was predominantly related to IE technology uncertainties (subphase 1.1), followed by uncertainties on certifications (subphase 1.2), air traffic control, and ground handling infrastructures (subphases 2.1 and 2.2). Although this ecosystem has not emerged yet, we could also capture uncertainties related to city infrastructure (subphase 3.1). and with general issues regarding the scalability of the ecosystem (subphase 3.2). In the next section, we present the analysis of the data followed by a set of propositions.

Table 25 - Summary of the Main Findings of the Thesis

Specific Goal	**Findings**		**Discussion**	**Authors**
a) To identify, map, and describe an innovation ecosystem, pointing its main events along its growth trajectory	We identified an emerging ecosystem based on multiple criteria	Section 3.1	We performed exploratory interviews and decided to focus on the EVTOLs IE after a couple of analyses; We described all criteria we took into account in section 3.1;	Adner (2017); Jacobides et al. (2018); Shipilov and Gawer (2020).
	We mapped and explained all its components according to ecosystem theory	Table 10 - section 3.1.1	We performed some exploratory interviews and described the EVTOL IE's main components in Table 10;	Gomes et al. (2018, 2019).; Gomes and da Silva Barros (2022).
	We mapped and explained all its actors and roles according to ecosystem theory	Table 11- section 3.1.2	- We mapped the main players using snowball techniques and then we abstracted this info into roles that these actors played on the ecosystem. Then we describe the EVTOL IE's main components in Table 11;	Adner (2017); Jacobides et al. (2018); Shipilov and Gawer (2020)
	We found 262 main events in a 7-year global trajectory evolution of the ecosystem and grouped them into 6 phases	Section 4.1 - Table 16 to 21	- The vehicle design changed a lot over time (from the 1910s until now); - We see that the vertical flight vehicles' trajectory had its periods of ups and downs in history (see Table 15); - Since 2010, the market has been shaped mainly due to technological advancements in electric propulsion systems and energy storage solutions; - The phases of the ecosystem are: vehicle development, certification, aircraft traffic operation, ground handling infrastructure, city embeddedness, and scaling;	Langley (1999); Yin (2004)
b) To identify, name, and frame types of **uncertainties** perceived by decision-makers in the formation of an ecosystem over time;	We inductively identified, named, and ranked (by degree of intensity) 45 uncertainties that emerged from the data.	Table 22	- The uncertainties we found are: alignment, ecosystem identity, market experience, lack of knowledge, coalition of social groups, security and right to privacy, user full journey experience, city visual impact, auditive (noise) impact, natural resources impact, biotic beings impact, fundability, operational costs, value capture, social equity, affordability, battery, vehicle reliability, vehicle performance efficiency, controllability, vehicle design, traffic density, (micro) weather peculiarities, complex geographic and urban design, energy infrastructure, groundhandling infrastructure design, existing groundhandling infrastructure adaptations, certification/ regulation process, data sharing, new air communication system, expected strategic move, flexibility and dynamicity in changes, training, interface standardization and interoperability, vehicle maintenance, overlaps and blurry frontiers -	Davis et al. (2009); Furr and Eggers (2021)

			ecosystem roles, collaboration with the right players, interference in current systems - air cybersecurity safety, interference in current act systems – communication, air disorder and unexpected interferences, consistency and regularity when scaling, chicken and egg problem, ecosystem emergence and design, market sensibility, autonomous vehicles time-to-market; - We presented in Table 26 a Summary of the intensity of the uncertainties allocated by Strategic Group. An uncertainty can range from “Very High intensity” to “Very Low intensity; - Sixteen (36%) uncertainties are very high or high uncertainties; - Twenty (44%) of them are medium-intensity uncertainties; - Nine (20%) of them are low or very low-intensity uncertainties; - Uncertainties are usually related to one another, intensifying the effect of other uncertainties in the ecosystem;	
	We inductively framed the 45 uncertainties into 6 phases of the ecosystem	Section 4.1 and Figure 16	- Phase 1.1 presents the highest number of uncertainties compared to the other phases and has three classes of uncertainties (aircraft design, developing and prototypes, and aircraft testing); - Phase 1.2 is smaller compared to others and presents uncertainty related to the aircraft certification process; - Phase 2.1 presents uncertainties related to the Design and Implementation of a new or redesigned Air Traffic Operation space - uncertainties related to air traffic city climate issues, pilot training, air system design, and tools; - Phase 2.2 presents uncertainties related to the Design and Implementation of new or redesigned Groundhandling infrastructures; - Phase 3.1 embraces uncertainties related to the embeddedness of the EVTOL IE in the urban context; - Phase 3.2 has unknowns related to persistence and consistency needed by actors to continue to operate in a nascent ecosystem over time; - Phase 1.1, 1.2, 2.1, 2.2, and 3.1 have uncertainties mainly faced by OEMs, regulators, airspace operators, and designers, groundhandling operators and designers, and city representatives respectively; - Phase 3.2 in a broader context, has uncertainties mainly faced by all IE inner perimeter actors; - We found that uncertainties related to noise and weather drive complex sets of other uncertainties. (see section 4.2);	Langley (1999)

			- Uncertainties related to noise and weather drives complex sets of other uncertainties;	
	We inductively framed the 45 uncertainties into 11 ecosystem elements	Section 5.1	- We grouped all uncertainties inside IE elements - value proposition, ecosystem identity, value creation, value capture, systemic innovation, design and structure, IE configuration, activities, complementarities, competition level, collaboration level, competition outside IE, ecosystem emergence and design; - We found that the highest number of uncertainties were allocated to the IE Design and Structure and IE Value Creation;	Thomas and Autio (2021); Gomes et al. (2021); Talmar et al. (2020)
c) To identify, name, and frame types of **strategies** perceived by decision-makers in the formation of an ecosystem over time;	We inductively identified, and named 50 strategies that emerged from the data acting enablers of uncertainty management	Table 24	- The strategies we found are: Bottleneck, Pivoting, Imaging (backing into the future), Opening a new company, Creating a cluster, Platform and Systems, Dictating trends, Partnering to shape the market, Standardization of Concepts, Nomenclatures and Key terms, Standardization and Modularity, Manuals-handbooks-reports, White papers, Educating, Make it simple, Selecting uncertainties to focus on, CONOPS (Concep of Operation) and consortiums, Spreading Information, Commitment, Triangulation and redundancy, Refining and Validating, Compliance Demonstration test, Agile Methods, Proof of concept (POC) / Business Case, Get your hands dirty, Bricolage, Adapting to current systems, Partnering to build knowledge and cocreate solutions, Passive Learning, Researching, Testimonials and good faith, Sharing Uncertainties, Breaking the problem into pieces, Lessons Learned, Trial by error, Playing by the rules, Learning by Borrowing, Being Conservative, Doing Nothing and wait, Being an Outlier, Students competition, Being enthusiastic, Planning next alliances, Risk Assessment, Regression Analysis , Economic models/ foresight, Survey, Simulations, Business Plan, Made Assumptions; - The set of strategies that emerged from the data varies from very proactive sets of strategies to very reactive ones; - Shaping and adapting strategies are almost equally employed in the ecosystem by decision-makers;	Alchian (1950); Gomes et al. (2021c)
	We inductively framed the strategies into 6 phases of the ecosystem (vehicle development, certification, aircraft traffic operation,	Section 4.1 and Figure 16	- Phase 1.1 presented a mix of different strategies; - Phase 1.2 is smaller compared to others and presents a greater variety of adaptive strategies; - Decision makers equally use shaping and adapting strategies to deal with 1.1 (Vehicle Development) and 2.1 (Air Traffic Operation) phases;	Langley (1999)

	ground handling infrastructure, city embeddedness, scaling)		- Decision makers use more adapting strategies to deal with 1.2 (Certification Process phase); - transformative and adapting strategies are used to deal with 2.2 (Groundhandling Infrastructure phase); - In 3.1 (city embeddedness phase), more shaping strategies appeared; - Multiple strategies to deal with the uncertainties of the 3.2 (scaling) phase emerged The greatest diversity of sources of uncertainty was identified in this phase; - As the ecosystem advances in its emergence process (the phases progress in the evolutionary trajectory), we observe that the number of uncertainties reduces;	
	We inductively framed the 50 strategies into 4 high/low predictive and controllable strategic logics behind uncertainty management that influence the way entrepreneurs deal with uncertainty (planning, adaptative, transformative, and visionary logics)	Section 5.2 and Figure 18	- Some strategies can be used to mitigate risks, while others might help to reduce some more profound uncertainties (unknown unknowns); - We found 10 types of strategies linked to high prediction and low control, 13 linked to low prediction and low control, 13 linked to high prediction and high control, and 12 linked to low prediction and high control logic; - Other strategies we found outside Wiltbank's matrix: Knowledge omission, Run away, and decline;	Wiltbank et al. (2006)
d) To analyze the **relationship** between uncertainties and strategies employed by decision-makers, identifying patterns of	We created a visual map that represents how the uncertainties and strategies evolved over time	Figure 16	- This figure had some layers. The external layer shows the 6 phases of ecosystem evolution in a counterclockwise direction. The second inner layer shows the uncertainties most strongly associated with each phase. The third layer shows the strategies associated with the uncertainties of each phase (divided by colors according to their nature). Finally, the innermost layer of the circle shows the relationships between the uncertainties;	Langley and Tsoukas, (2016)
	We identified patterns of uncertainties as the ecosystem evolves	Figure 16 and P1,	- There are high uncertainties at the beginning of the emergence of the ecosystem; - As the ecosystem advances in its emergence process, the diversity of sources of perceived uncertainty reduces;	
	We identified patterns of uncertainties shared by a	P2	- Actors playing identical roles within an innovation ecosystem tend to perceive the same uncertainties;	Furr & Eisenhardt, (2021); Kapoor & Klueter, (2021)

uncertainty management	group of actors as the ecosystem evolves			
	We identified interconnectedness between uncertainties.	Figure 20, P3a and P3b	- There is a cascade effect of uncertainties with positive or negative effects on the IE emergence;	Gomes et al. (2018)
	We classified patterns of proactive and reactive strategies	4a and P4b	- IE actors need a high diversity of strategies (belonging to proactive and reactive mindsets) to deal with uncertainty in the IE emergence process; - Decision makers employ a reactive mindset to deal with uncertainties in innovation ecosystems – i.e. Passive Learning, Playing by the rules, Learning by Borrowing, Being Conservative, Doing Nothing and waiting, Being an Outlier; - Decision makers employ proactive strategies to deal with uncertainties in innovation ecosystems – i.e. Bottleneck, Opening a new company, Creating a cluster, Platform, and Systems, Dictating trends, Partnering to shape the market, Educating, Getting your hands dirty, Bricolage, Partnering to build knowledge and co-create solutions;	Huchzermeier and Loch (2001); Bhidé, 1999; Mcgrath and Macmillan, (2000); Shane and Venkataraman, (2000); Ross et al. (2018)
	We identified patterns of strategies as the ecosystem evolves	Figure 21 and P5, P6	- High amounts of strategies are needed to deal with each uncertainty in the ecosystem. - On average, decision-makers employ six different strategies to deal with each uncertainty in the ecosystem; - In practice, the OEMS group applies 92% of its proactive strategy to deal with the uncertainties of the first phase. These percentages reduce as the ecosystem advances through its phases. In other words, the best proactive strategies optimization level is related to product development (Phase 1.1) ; - Shaping strategies are more often employed (35% of frequency) to deal with the "value creation" uncertainty group than other types of strategies;	Gomes and da Silva Barros (2022); Gomes et al., (2021); Adner, (2017); Adner & Kapoor (2010)
	We identified patterns of strategies that occur within and across each group of uncertainties	Table 28	- Decision makers employ a greater number of proactive strategies (shaping and transformative) in the first levels of ecosystem development; - Most relevant uncertainties related to the ecosystem design, structure, and configuration uncertainty groups stem from high adaptive strategies (36% of frequency). - When dealing with the Innovation system" uncertainty group (i.e., vehicle design, performance efficiency, reliability, and battery uncertainties), we found low planning strategies and more action-based strategies employed,	

			like effectuation and adaptative strategies (38% and 33% of frequency, respectively); - 42% of all adaptive strategies are allocated to deal with ecosystem design uncertainties (i.e., Configuration 15%, Ecosystem Emergence (16%), and Design and Design and Structure (11%);	
	We counted and analyzed the uncertainty's frequency of citations by Strategic Group	Table 29	- There is a smaller diversity of uncertainties allocated to the H/L group (planning strategies). Even though, we see the uncertainties here seem to be more complex, in terms of the number of players allocated to resolve them and the possible effects of interdependencies that exist between them for resolution; - Effectuation (L/H group) strategies are usually performed in collaboration or competition with other players in the market; - There is a bigger diversity of uncertainties allocated to L/L group - Adaptative Strategy followed by H/H and L/H groups;	-
	We grouped uncertainties by degree of Intensity (High/Low) and allocated them by Strategic Group	Table 30	- Sixteen (36%) uncertainties are very high or high uncertainties; - Twenty (44%) uncertainties are medium-intensity uncertainties; - Nine (20%) uncertainties are low or very low-intensity uncertainties;	-
e) To analyze how uncertainties and strategies coevolved along its growth trajectory;	We presented a final Framework	Figure 23 32, P7a, P7b and P7c	- We present a proposal Framework that relates uncertainties and strategies;	Gomes et al. (2018) Gomes and da Silva Barros (2022) Kapoor and Klueter (2021) Rice et al. (2008) Milliken (1987) Gomes (2013) Furr and Eisenhardt (2021) Thomas and Ritala (2021) Gomes et al. (2021a) Adner (2006; 2012) Dattée et al. (2018) Talmar et al. (2020 Adner and Kapoor (2016)

Source: Author's Elaboration.

5.3.1 Uncertainties at IE Emergence

In this session, we combine theory and practice to defend the idea that there are high uncertainties at the beginning of the emergence of the ecosystem. Uncertainties related to the ecosystem permeate all elements that are essential for its development - concept generating and product planning, product design, process design production, and consumption process. When we first started to write this thesis, the main idea was that nascent ecosystems are permeated by high uncertainty (Kapoor and Klueter, 2021) and characterized by incomplete or fleeting structures and that, when it comes to ecosystem emergence, stakeholders are still organizing and discovering the best ways to create and capture value as new regulations are being implemented.

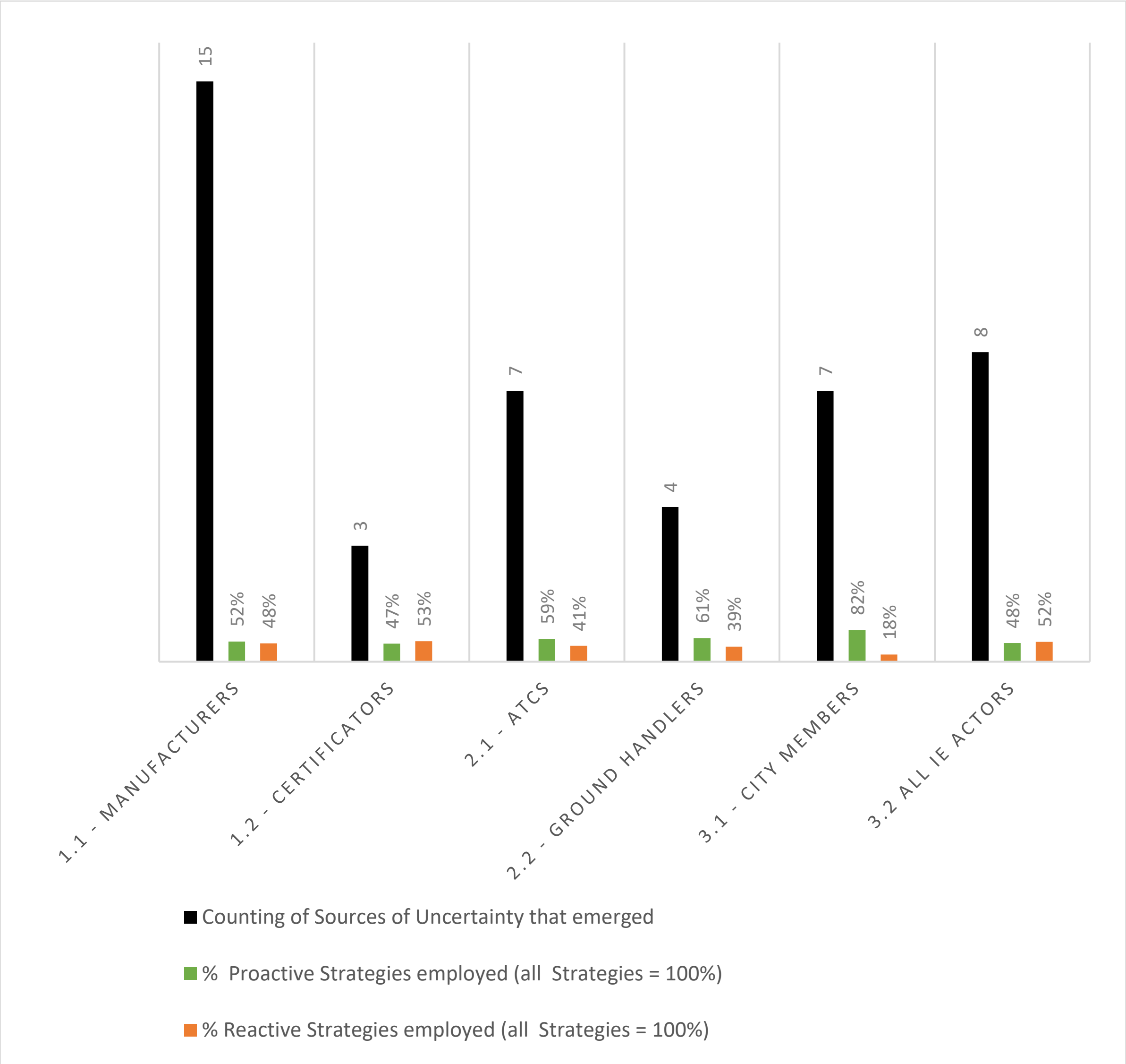
Considering the super volatile and complex character of the changes that occur in nascent ecosystems, the heterogeneity and intensity of uncertainties are meaningful. During the early stages of an ecosystem, information about the future is incomplete, unknown, or unavailable (Furr & Eggers, 2021), so actors face more decisions under uncertainty than under risk (Dattée et al., 20218). Uncertainty is always high in the emergence phase of IE, especially if the technologies underlying the ecosystem are new (Kapoor & Klueter, 2021; Furr & Eisenhardt, 2021).

Based on the database, as we can depict from Figure 19 we confirmed the theory by showing that uncertainties are higher in phase one. There was a high level of uncertainties linked to “vehicle development” - aircraft design, aircraft development and prototypes, and aircraft testing- if compared to other groups of uncertainty (15 different types of uncertainties that emerged, twice the number of uncertainties that appeared during the other phases of ecosystem evolution.

Uncertainties related to technology is a topic well addressed in previous literature (Kapoor & Klueter, 2021; Rice et al., 2008). We saw plenty of events that captured this idea[2, 22, 86, 191] and corroborated this previous literature. These findings converge with recent studies (Furr & Eisenhardt, 2021) that show that technological interdependencies are a key point to address when building an ecosystem (Talmar, 2020). These firms searched for one another to develop systems, apps, motors, and electric propulsion systems and share the “weight of the unknown” with each other.

As the ecosystem advances in its emergence process, the diversity of sources of perceived uncertainty reduces. These findings corroborate the literature by showing that managers can perceive and assimilate the uncertainties that present themselves in the short term (Mousavi & Gigerenzeret, 2014).

Figure 19 - Uncertainties that Emerged by Phase



Source: Author's Elaboration.

As the ecosystem advances in its emergence process (the phases progress in the evolutionary trajectory), we observe that the number of uncertainties reduces. These ideas lead us to the first proposition of this study.

Proposition 1 – Nascent innovation ecosystems face a high level of uncertainty during the early stages of their formation process.

5.3.2 Uncertainties Shared by Actors Playing the Same Roles

In this session, we combine theory and practice to defend the idea that cognitive alignment among actors leads to the sharing of uncertainties. As we explained in the introduction section, we see an IE as a set of interconnected activities and resources between actors playing different roles (Ader, 2017; Adner and Kapoor, 2010). The group of actors can seek cohesion of opinions and attitudes as a way of dealing with the uncertainties that arise. They share the same cognitive structures (i.e., the collective of actors adopts a reducing mindset or a recognition mindset). For example, Nenonen and Storbacka (2020) exemplified that even leading competitors can agree to cooperate for the greater benefit of reducing marketing uncertainties.

According to the results of our database, the uncertainties that were allocated within each ecosystem's phases are generally perceived by the same group of ecosystem actors. It means that decision-makers playing the same role share the same uncertainties in the ecosystem.

Phases 1.1, 1.2, 2.1, and 2.2 have uncertainties mainly faced by OEMs, regulators, airspace operators, designers, groundhandling operators, and designers, respectively. For example, this is not new to the literature that institutional governments have the power to start movements and impact the growth of ecosystems (Gomes et al., 2021; Adner, 2017. Adner & Kapoor, 2010) so it makes sense to see they appear as a relevant group of actors discussing certification issues at the first phase of the ecosystem emergence.

However, phases 3.1 and 3.2 embraced uncertainties related to city rearrangements in infrastructure and the design of the ecosystem as a whole. For these phases, we did not find a specific pattern, maybe because these are broad-level sets of exogenous uncertainties spread all over the entire ecosystem (they are more generic and embrace multiple actors' engagement to solve them).

In this sense, these findings corroborate Gomes et al. (2018) who defined collective uncertainty, which refers to uncertainties that affect a group of actors in an IE, affecting the performance of a group of actors and, in some cases, the performance of the whole IE. Cognitive alignment refers to the synchronization or harmonization of mental processes, perceptions, and attitudes among individuals or groups. It denotes a shared understanding, mindset, or perspective regarding ecosystem issues. This alignment often leads to coordinated actions, improved communication, and better decision-making within teams or organizations.

Proposition 2 – Actors playing identical roles within an innovation ecosystem tend to perceive the same uncertainties.

5.3.3 Interrelated Uncertainties

In this session, we combine theory and practice to defend the idea that there is a cascade effect of uncertainties with positive or negative effects on the IE emergence. Based on our database, we saw that there is an interrelation between the different types of uncertainties in the ecosystem. Uncertainties are usually related to one another, intensifying the effect of other uncertainties in the ecosystem. Below we see in Table 26 some examples of sets of relationships between uncertainties based on the data we collected. These findings demonstrate the complexity involved in resolving uncertainties in ecosystem environments.

Table 26 - Examples of Interrelated Uncertainties

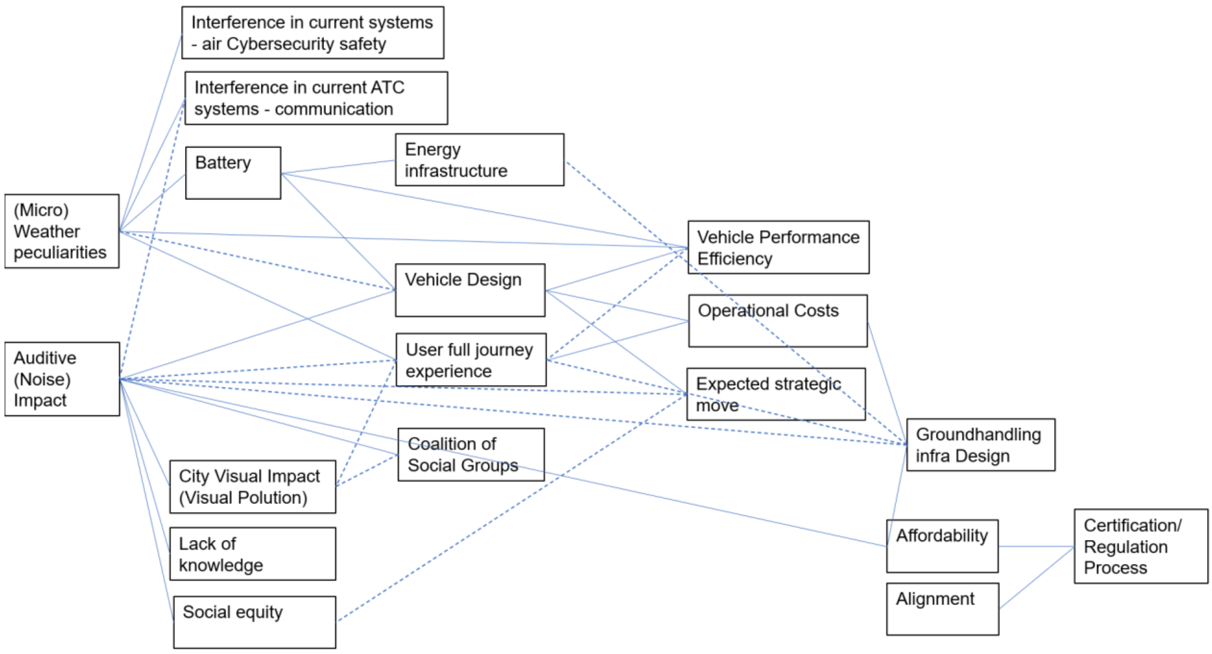
Interrelated Uncertainties		**Citation examples**
Nº	Type	
2	Aircraft Design Expected strategic move	*"The wingspan of an EVTOL, almost all of them are around 13 to 15 meters (...) If I look at the helipads that exist in São Paulo, we did a quick calculation, do you know how much % of the helipad infrastructure is capable of receiving an EVTOL if Anac adopts the American model? It's less than three percent."*
3	Alignment Certification/Regulation Process	*" A bit of uncertainty is the availability of suppliers who are able to offer products adapted to the EVTOLs and who are, let's say, friendly or who are certified or certifiable (...)The issue of component quality is complex, it is an issue of uncertainty and it is complex (...)You have to meet a series of requirements to be able to live real life."*
3	Groundhandling infrastructure Affordability	*"The choice of vertiports also influences the total volume of the population served by VTOLs as well as their desirability relative to other transportation options." – Uber Report (2016)*
4	Battery Vehicle Design Vehicle Performance Efficiency Energy infrastructure	*"The big thing that makes designing practical EVTOLs so hard is that batteries have a very low energy density. Basically, they're really heavy compared to jet fuel, which is bad for aircraft that need to be light to fly. What this means is that a lot of clever design decisions need to be made to get an all-electric aircraft to achieve practical payload capacity, endurance, and range."* *"To achieve more range, you need to carry more batteries and more batteries means the EVTOL is heavier, which means you need more batteries to carry those batteries. So, from that sense are energy storage, I think is the main bottleneck right now for is Very high energy density (…) I would say energy storage is the is the main limitation for any aircraft."*
7	Noise City Visual Impact (Visual Pollution) Lack of knowledge Vehicle Design Social equity Affordability Coalition of Social Groups	*"Vehicle noise and cabin acceptability will impact public adoption and acceptance." - NASA CONOPS* *"A more sophisticated measure of "noise" is required to properly characterize the impact of vehicle sound on a community. Electric propulsion will be critical for this objective, as well: it enables ultra-quiet designs, both in terms of engine noise and propulsor thrust noise. (…) special attention must be paid to addressing the fact that noise can also be a proxy for other concerns, such as visual pollution or safety worries." (NASA CONOPS)* *"We need to come up with a new way of measuring it (…) the psycho-acoustic aspects of that noise, and we need to be able to communicate to people because it is social acceptance that's going to allow it because the people will just put so much pressure on local authorities to say no because of noise and the fact that they can't afford to access the service, that you just won't get the planning applications through for the infrastructure (…) So that's about noise helping people understand what the noise issue is."*
8	(Micro) Weather peculiarities Interference in current systems -	*"A lot of heat is going to create a problem for a certain weight for the aircraft that will not be able to take off."*

	air Cybersecurity safety Battery User full journey experience Operational Costs Groundhandling infrastructure Design Interference in current ATC systems - communication Vehicle Performance	*"The micro weather affects the operation much more in the metropolitan urban area (...) it affects the entire air flow (...) we have to think of a sensing network to serve this segment."* *"Weather can influence many components of UAM, creating a variety of potential barriers. Operations: Reduction or cessation of operations during adverse conditions may occur due to safety concerns. Service Supply: Conditions may extend trip distance or reduce battery life. Passenger Comfort: May be impacted due to conditions such as extreme temperatures and turbulence. Community Acceptance: This could lead to passenger apprehension toward flying in certain conditions. Infrastructure: Consistent adverse weather may increase wear and reduce the viability of vertiports. Traffic Management: Conditions such as wind shear and thunderstorms could disrupt flow patterns and structure." - UAM Market Study*

Source: Author's elaboration

According to our database, we found that uncertainties related to noise and weather drive complex sets of other uncertainties. These findings corroborate the literature on state uncertainty (perceived environmental uncertainty) (Milliken, 1987) once it related to the inability to assign probabilities to states of nature and the difficulty of predicting how an environment is changing (Milliken, 1987). In the EVTOL case, few strategies were dealing with these uncertainties. Figure 20 shows some of the interrelationships we found in our database. As we can see, this complexity may lead to cascading effects.

Figure 20 - Interrelation of Uncertainties



Source: Author’s Elaboration.

The interplay of different uncertainties within an IE can have a positive or negative influence on IE growth. For example, depending on the nature of interrelated uncertainties, innovation may be either accelerated or delayed.

From a positive perspective, uncertainty might open opportunity scenarios for firms (Bhidé, 1999; Mcgrath & Macmillan, 2000; Shane & Venkataraman, 2000; Ross et al., 2018) allowing them to create value (Huchzermeier & Loch, 2001). In the case they are interlinked, there might be a positive synergy. Uncertainties might also thrive on an opportunity mindset to solve other related uncertainties. For example, in the EVTOL case study, one example of positive impact in the case of uncertainty regarding the high-efficiency Battery level needed for vehicles to fly[q]. This unknown increased uncertainties on Vehicle Reliability[r]. Teams merged mindsets, sharing unknows and perceiving that solutions to one uncertainty could also impact solving other uncertainties. Battery uncertainty[q] increased levels of interest and attention of the population for the Natural resources impact[j] and attention of the government for the Energy infrastructure[z] uncertainty as well.

In a negative perspective, interrelated uncertainties may increase the complexity of the operations and blurry predictions and speculations about ecosystem emergence. For example, in the EVTOL case study, actors didn't know what would be the standards in terms of sound level (the Auditive Impact[i]) and started speculating that this unknown could lead the population to complain about the noise of the vehicle, forming retaliation groups (Coalition of Social Groups[e] uncertainty). This movement also increased uncertainties related to Groundhandling infrastructure Design[ab] and adaptations[at] once actors didn't know if they should invest and develop infrastructures under the center of the big cities or if they should change to the building of new structures under the seacoast.

In summary, while the interrelations of uncertainties in an innovation ecosystem pose challenges, they also present opportunities for positive synergies and collaborative problem-solving.

Proposition 3a – Multiple sources of interrelated uncertainties can positively impact the ecosystem emergence process.

Proposition 3b – Multiple sources of interrelated uncertainties can negatively impact the ecosystem emergence process.

5.3.4 Proactive and Reactive Mindsets

Traditionally, the greater the degree of uncertainty, the lesser the degree of prediction. But could a decision-maker (or a collective of decision-makers) possibly manage uncertainties at the ecosystem level? In this session, we combine theory and practice to defend the idea that IE actors employ a high diversity of strategies (belonging to proactive and reactive mindsets) to deal with uncertainty in the IE emergence process. Although Porterian Planning School is a static and sectoral-focused perspective, with a focus on bargaining power relations between actors rather than the dynamic of interrelationships among them, we cannot deny the fact that this theoretical perspective contributed to IE studies. However, based on the previous subsections, we see that both Porter's (planning) and Mintzberg's (adaptative) ideas were developed in a period when changes were not as fast-paced as they are today. In 1990, we barely talked about spin-offs and startups and complementarity relationships, for example.

In our database, we inductively identified, and named 50 strategies that emerged from the data-acting enablers of uncertainty management and presented them in Table 22. We also framed the uncertainties into 4 high/low predictive and controllable strategic logics (planning, adaptative, transformative, and visionary logics). We found that the set of strategies that emerged from the data varied from very proactive sets of strategies to very reactive ones. We found 10 types of strategies linked to high prediction and low control, 13 linked to low prediction and low control, 13 linked to high prediction and high control, and 12 linked to low prediction and high control logic besides other strategies that went off Wiltbank's matrix (Knowledge omission strategy, Run away and decline strategy).

Table 27 presents a summary of uncertainties and strategies by IE Phase. Some of the strategies were used to mitigate risks, while others helped to reduce some more profound uncertainties (unknowns).

Table 27 - Number of Uncertainties and Strategies by IE Phase

Subphase	Events	Uncertainties	Reactive Mindset			Proactive mindset		
			H/L	L/L	TOTAL	L/H	H/H	TOTAL
1.1	173	15	7	11	18	13	12	25
1.2	34	3	1	8	9	3	5	8
2.1	19	7	3	6	9	4	9	13
2.2	17	4	3	6	9	7	5	12
3.1	12	7	2	0	2	1	7	8
3.2	7	8	6	8	14	7	8	15

Source: author's elaboration.

Both proactive and reactive mindsets were important and helped the EVTOL IE to emerge. Managing is a word interchangeably related to control. Entrepreneurs' theorists like Foss et al. (2019) following Knight (1921) defined a firm as the sum of an entrepreneur plus the alienable resources/ assets the entrepreneur owns and controls. If an ecosystem is an extension of the firm (Adner, 2017; Shiplov & Gawer, 2020), then the ecosystem is the sum of firms that work together to deliver a value proposition to the market plus the alienable resources/ assets this firm owns and controls.

In this sense, we call low-control schools as reactive mindsets grounded on Planning and Adaptative schools. This idea sees uncertainty as something to be reduced or transferred to another one because it is a threat to our survival (Mintzberg, 1990; Hedley, 1977; Porter, 1985; Andrews, 1976). Some actors of the ecosystem employed these strategies viewing uncertainty as a problem to solve and relying on learning processes (often guided by mental models) to create strategies, corroborating the literature.

> It is not a typical ship configuration like a helicopter or a light plane that is super studied that says 'look, this is how it works.' So, this is why you have to continue his theoretical studies and you have to be very cautious in what you do so as not to get surprises. (OEM Manufacturer)

Reactive mindsets focus on uncertainty reduction strategies for the achievement of organizational effectiveness (not equilibrium) through the accumulation of resources (Jauch & Kraft 1986). It means that uncertainty reduction is a means of acquiring knowledge (a major resource). So, decision-makers performed strategies to resolve the uncertainty as much as possible before judgments were made (Packard et al., 2017) by building, renewing, owning, controlling, and leveraging resources (Furr & Eisenhardt, 2021) inside this environment. For example, in the EVTOL case study, decision-makers use more adapting strategies to deal with the 1.2 (Certification Process) (Gomes et al., 2021; Adner, 2017. Adner & Kapoor, 2010).

The learning experimentation process already proved to be an essential weapon to reduce the uncertainty during IE emergence, as shown by Mahmoud-Jouini and Duboc (2017). In the EVTOL case, actors employed reactive mindsets to deal with ecosystem uncertainties related to the design, structure, and configuration of the IE (Gomes and da Silva Barros, 2022).

We also found that some decision-makers purposefully employed reactive mindsets in cases where they were exposed to some uncertainties. In some cases, they did not want to broaden their perspectives, share, and learn about some uncertainties. They prefer to be ambiguous (Weick, 1995) and this behavior triggered proactive attitudes that helped the ecosystem to solve other uncertainties. For example, consumers were not able to discern the probability of a Helicopter crash or risks related to their takeoff and landing procedures. Even so, they flew in these vehicles for many years. One part of these customers are now open to take a ride in an EVTOL experience. Their continuous participation as prosumers of this ecosystem was an important part of the success of the proof of concept strategy (among all of them, we can cite the POC in Rio de Janeiro[g], for example).

Previous research on the IE shows that reactive mindsets can either increase the actor's knowledge of the problem situation or reduce uncertainty. As decision-makers become more aware and broaden their perspectives, this expansion process might induce reactive behaviors as more alternatives become visible. In other words, by exchanging ideas and becoming aware of the uncertainties, decision-makers might start a "sensemaking process" that might result in an impulse to escape and jumping off the boat. According to our database, this impulse became tangible through the strategies they employed. We found some strategies employed by decision-makers that exemplify this situation: Doing Nothing and Waiting, Being an Outlier, running away, and declining. Therefore, the actor's expanded knowledge can be negative for the ecosystem, by triggering reactive behaviors

Proposition 4a – Decision makers employ reactive mindset to deal with uncertainties in innovation ecosystems – i.e. Passive Learning, Playing by the rules, Learning by Borrowing, Being Conservative, Doing Nothing and waiting, Being an Outlier

On the other hand, shaping strategies usually emphasize flexibility, cognition, and shaping markets (Furr & Eisenhardt, 2021) and sees human action as a primary factor in the creation of reality and uncertainty as an opportunity to exploit. Decision-makers rely on the imagination to invent a new and favorable market order and processes like storytelling and wielding soft power (e.g., cooptation, diplomacy) to achieve it.

In the EVTOL case, we also identified that decision makers employed proactive experimentation-oriented strategies mainly due to the lack of resources and the difficulty of forecasting and controlling at the beginning of the ecosystem demanded, corroborating the literature (Packard et al., 2017). For example, Next, when analyzing the 3.1 (city embeddedness) phase, more shaping strategies appeared due to the lack of resources available for transforming an entire city project (Complex Geographic and Urban Design[y] uncertainty)

As Packard et al. (2017) commented: “If one or more options have an unknown outcome probability distribution, the decision requires human imagination, intuition, and estimation in a judgment process.” During periods of discontinuous technological change, recent papers show that initial resource constraints can be a blessing in disguise that drives a firm to seek new alliances for ecosystem emergence (Pushpananthan & Elmquist, 2022).

We identified that shaping strategies are more often employed to deal with the “value creation” uncertainty group than other types of strategies. Value creation is an ecosystem dimension established early on in its emergence process (Dattée et al., 2018; Thomas & Autio, 2014). As the value proposition is still very incipient at this stage, shaping strategies are employed (Flaig et al., 2021; Furr & Eisenhardt, 2021).

Proposition 4b – Decision makers employ proactive strategies to deal with uncertainties in innovation ecosystems – i.e. Bottleneck, Opening a new company, Creating a cluster, Platform, and Systems, Dictating trends, Partnering to shape the market, Educating, Getting your hands dirty, Bricolage, Partnering to build knowledge and co-create solutions

5.3.5 Multiple Strategies to Deal with each Uncertainty

In this session, we combine theory and practice to defend the idea that high amounts of strategies are needed to deal with each uncertainty in the ecosystem. We found that decision-makers employ multiple strategies over time. Given the complex nature of the uncertainties, multiple strategies are necessary to deal with highly complex uncertainties. On average, decision-makers employ six different strategies to deal with each uncertainty in the ecosystem.

In this sense, in some cases, these multiple strategies are of the same nature - for example, they use imaging, creating a cluster strategy, educating (three shaping strategies) to deal with a coalition of social groups uncertainty [e]. In other cases, these multiple strategies are not of the same nature - for example, in the case of Battery uncertainty [q], they use shaping (imaging and pivoting), adaptive (partnering to build knowledge and co-create solutions, passive learning, being an outlier, researching) and transformative (get your hands dirty) strategies.

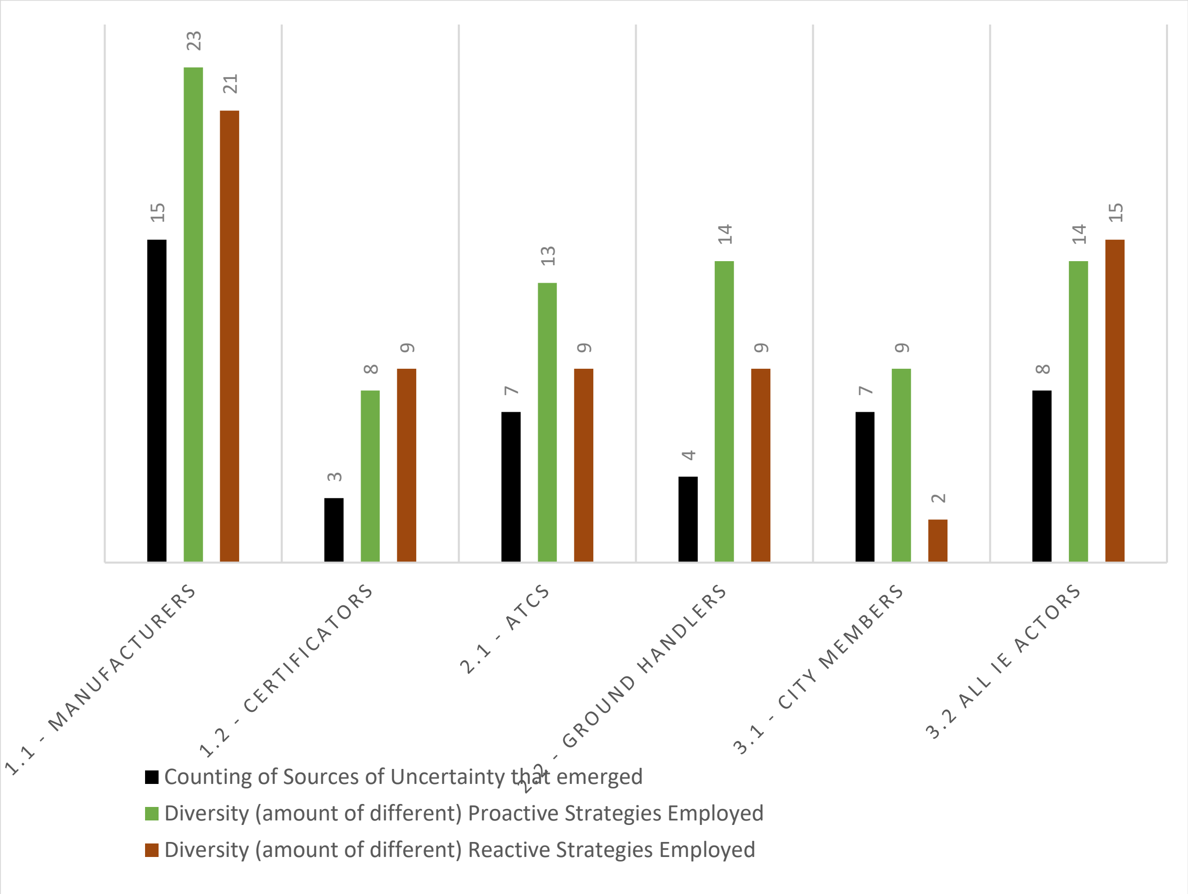
There is an imbalance between the number of uncertainties and strategies for dealing with them. For example, while multiple strategies have been mentioned to deal with the uncertainties of noise [i], no strategies have been found to deal with other uncertainties, such as the impact of natural resources [j] and n biotic beings [k]. This finding shows us that environmental concerns are not yet a prioritized topic in business.

Figure 21 shows the variety of types of strategies (green and brown bars) employed to deal with uncertainty (black bars) in the ecosystem. This applies to all phases of the ecosystem (Phase 1.1 we found 44 strategies to deal with 15 sources of uncertainty. Phase 1.2 = 17 strategies to 3 uncertainties. Phase 2.1 = 22 strategies to 7 uncertainties. Phase 2.2 = 23 strategies to 4 uncertainties. Phase 3.1 = 11 strategies to 7 uncertainties. Phase 3.2 = 29 strategies to 8 uncertainties).

On average, decision-makers employ six different strategies to deal with each uncertainty in the ecosystem. We see that the most complex uncertainties are the **Certification/ Regulation Process.** On average, decision-makers use seventeen different types of strategies to reduce this uncertainty. They also use fifteen, fourteen, and thirteen strategies to deal with other complex uncertainties – named **new Air Communication system, Interface standardization and Interoperability,** and **Groundhandling infrastructure Design** uncertainties, respectively.

On the other extreme, we see that decision-makers have few or no strategies employed to deal with **Biotic beings impact**, **Expected strategic move** and **Controllability**, **City Visual Impact**, **Flexibility and dynamicity in changes**, **Air disorder and unexpected Interferences** and **Energy infrastructure** and **Natural resources impact**. The fact that there are a small number of strategies is critical since few firms might be looking into the unknowns and this might be a blind spot to the ecosystem's emergence and growth.

Figure 21 - Strategy Making Under Uncertainty Counting – Proactive x Reactive



Source: Author's Elaboration.

Proposition 5 – Multiple types of strategies in ecosystems can be interrelated and employed to deal with uncertainties.

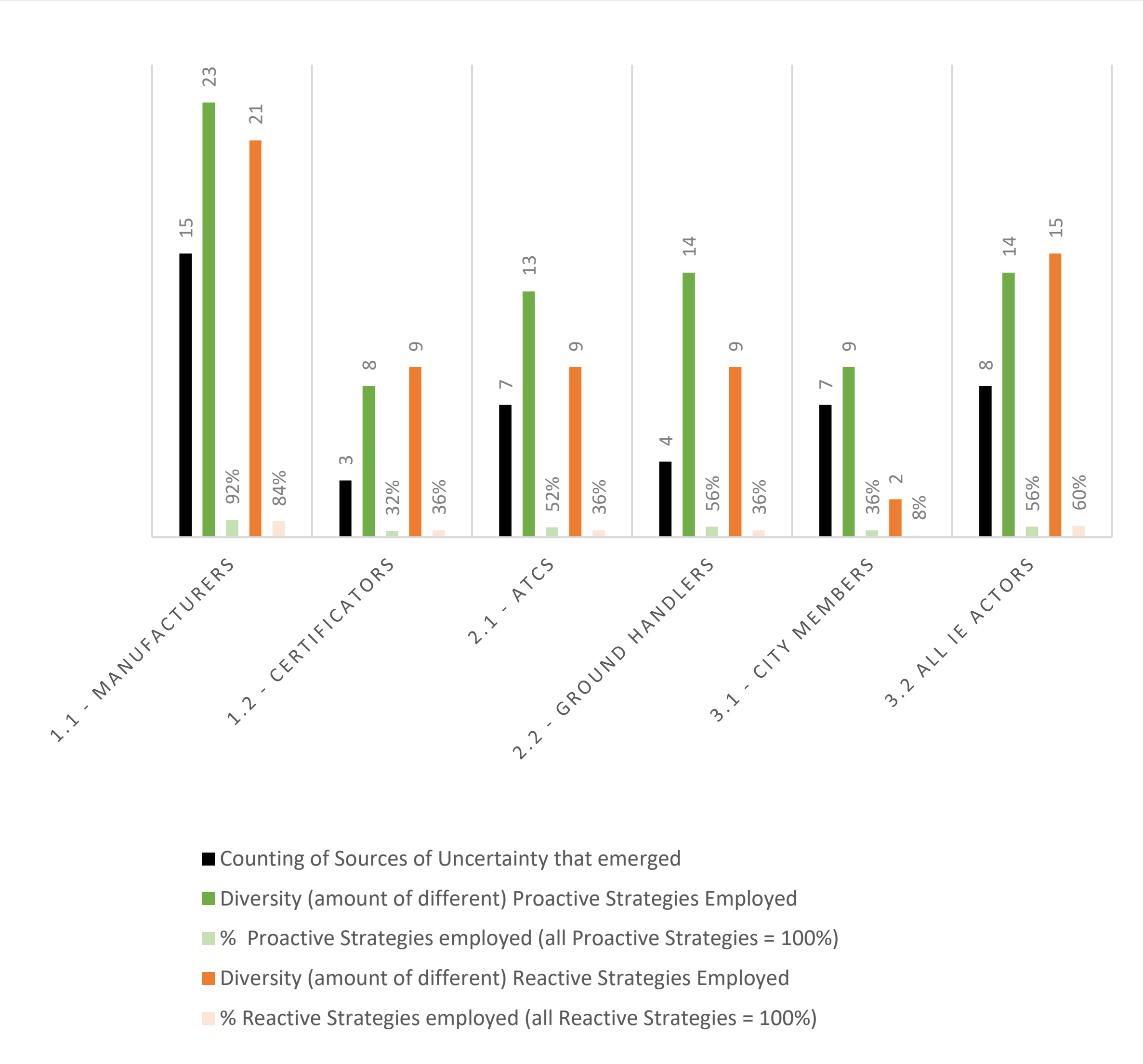
In this sense, if went deep into this analysis to understand the level of use of each strategy per phase of ecosystem development. In other words, considering all the possible strategies to be adopted by the actors in each phase of the ecosystem, we calculate the real percentage used in practice by the actors. Figure 22 shows the strategy making under uncertainty counting by group of strategies where n represents the percentage of all possible strategies to be adopted by the actors in each phase of the ecosystem (i.e., n = 100% in the case they apply all strategies we identified to solve uncertainties by each phase). p^{used} represents the total percentage of strategies employed in practice by the actors of the ecosystem by phase. Then, we can use the following formula to calculate p:

$$\boldsymbol{p} = (\frac{\boldsymbol{P\ used}}{\boldsymbol{n}})\ \boldsymbol{x}\ \mathbf{100}\%$$

In practice, the OEMS group applies 92% of its proactive strategy to deal with the uncertainties of the first phase. These percentages reduce as the ecosystem advances through its phases. In other words, the best proactive strategies optimization level is related to product development (Phase 1.1).

By the end of section 2.3 we presented Table 7 “The main ideas Behind the Four Schools” and defended the idea that during the ecosystem emergence, proactive strategies would be more and that this logic will “switch” to reactive strategies when the ecosystem enacts its resonance. If we consider these contrasting viewpoints from a timeline perspective, during the EVTOL ecosystem emergence, decision-makers collectively employed a larger number of shaping strategies if compared to reactive strategies, acting by pushing beyond the boundary conditions of the traditional strategic logics of reacting to uncertainties (planning and adaption logic) to the opportunity logic where ecosystems can be shaped.

Figure 22 - Strategy Making Under Uncertainty Counting – By Group of Strategies



Source: Author's Elaboration.

We also performed an analysis of the ecosystem uncertainties (in light of the theory of the IE) by each strategy school (adaptative, shaping, effectuation, and visionary schools). Table 28 presents the distribution of ecosystem uncertainties by strategy.

We can depict two sets of analyses based on this table. The first analysis is **horizontal** where we seek to find patterns of strategies that occur **within** each group of uncertainties. The second analysis is **vertical** where we seek to find patterns of strategies that occur **across** all groups of uncertainties.

We calculated the percentage (%) of distribution of each group of strategies by ecosystem uncertainty element. In other words, how many percentages of each strategy (planning adaptation, effectuation, and shaping) does each uncertainty group employ? Here are some interesting findings based on this analysis:

- In the “activities” uncertainty group, the most used strategies are adaptive (50% frequency);
- In the “coopetition” uncertainty group (that contains the sum of collaborative, outside, and insider coopetitive uncertainties), the most used strategies are shaping (41% frequency). The same occurs for the “Complementarities” uncertainty group (59% frequency allocated to shaping).
- Another interesting finding was that the most relevant uncertainties related to the ecosystem design, structure, and configuration uncertainty groups stem from high adaptive strategies (36% of frequency). This group contains all unknowns related to Energy/ Traffic/ Groundhandling/ Air systems Infrastructure and design and other sets of complex uncertainties based on collective movements like Vehicles time-to-market, Consistency and regularity when scaling, Market Sensibility and Data sharing uncertainties;
- When dealing with the Innovation system uncertainty group (i.e. Vehicle Design, Performance Efficiency, Reliability, and battery uncertainties), we found low planning strategies and more action-based strategies employed, like effectuation and adaptative strategies (38% and 33% of frequency, respectively);
- In general, we also see that there are more strategies related to the value creation uncertainties (thirty-seven strategies) if compared to value capture uncertainties (twenty-nine strategies), being Shaping strategies the more intently employed (35% of frequency) to deal with the “value creation”. We also analyzed how the entire group of shaping strategies is distributed by each ecosystem uncertainty group and found that the biggest concentration of shaping strategies (20%) is inside the value creation uncertainty group too.

Table 28 - % Distribution of Ecosystem Uncertainties by Strategy

Uncertainty			Strategies to Deal with the Uncertainty								
Element	**Subgroups**	**Intensity**	**H/H (shaping)**		**L/L (adapting)**		**(H/L) transformative**		**(H/L) planning**		**Total**
Activities	Expected strategic move	Medium	0		1		0		0		1
	Training	Low	2		1		1		1		5
	Flexibility and dynamicity in changes	Low	0		2		0		0		2
% distribution of each ecosystem uncertainty element by each group of strategy			*2*	*2%*	*4*	*4%*	*1*	*2%*	*1*	*2%*	*8*
% distribution of each group of strategies by ecosystem uncertainty element				*25%*		*50%*		*13%*		*13%*	*100%*
Collaboration level	Collaboration with the right players	Medium	1		0		1		3		5
Competition level	Overlaps and blurry frontiers - Ecosystem roles	Medium-High	4		1		0		1		6
Competition outside IE	Interference in current ATC systems – communication	Medium	2		2		3		0		7
	Interference in current systems - air Cybersecurity safety	Medium	3		2		2		0		7
	Air disorder and unexpected Interferences	Medium-Low	1		0		0		1		2
% distribution of each ecosystem uncertainty element by each group of strategy			*11*	*12%*	*5*	*6%*	*6*	*10%*	*5*	*12%*	*27*
% distribution of each group of strategies by ecosystem uncertainty element				*41%*		*19%*		*22%*		*19%*	*100%*
Complementarities	Vehicle Maintenance	Very Low	2		0		1		0		3
	Interface Standardization and Interoperability	High	8		3		1		2		14
% distribution of each ecosystem uncertainty element by each group of strategy			*10*	*11%*	*3*	*3%*	*2*	*3%*	*2*	*5%*	*17*
% distribution of each group of strategies by ecosystem uncertainty element				*59%*		*18%*		*12%*		*12%*	*100%*
Design and Structure	Energy infrastructure	Medium-High	0		0		0		2		2
	Complex Geographic and Urban Design	Low	1		0		1		1		3
	(Micro) Weather peculiarities	High	1		1		0		2		4
	Traffic Density	High	2		1		0		0		3
	Existing Groundhandling infrastructure adaptations	Medium	1		3		3		0		7
	Groundhandling infrastructure Design	High	4		5		3		1		13
% distribution of each ecosystem uncertainty element by each group of strategy			*9*	*10%*	*10*	*11%*	*7*	*12%*	*6*	*15%*	*32*
% distribution of each group of strategies by ecosystem uncertainty element				*28%*		*31%*		*22%*		*19%*	*100%*
Ecosystem Emergence and Design	Autonomous Vehicles time-to-market	Medium	1		1		0		1		3
	Consistency and regularity when scaling	Medium	2		1		0		2		5
	Market Sensibility	Very High	0		3		1		0		4

	Chicken and egg problem	High	3		3		2		1		9
	Ecosystem Emergence and Design	High	5		6		1		3		15
% distribution of each ecosystem uncertainty element by each group of strategy			*11*	*12%*	*14*	*16%*	*4*	*7%*	*7*	*17%*	*36*
% distribution of each group of strategies by ecosystem uncertainty element				*31%*		*39%*		*11%*		*19%*	*100%*
IE Configuration	New Air Communication system	Medium-Low	5		4		4		2		15
	Certification/ Regulation Process	Very High	5		8		3		1		17
	Data Sharing	Medium	2		1		0		0		3
% distribution of each ecosystem uncertainty element by each group of strategy			*12*	*13%*	*13*	*15%*	*7*	*12%*	*3*	*7%*	*35*
% distribution of each group of strategies by ecosystem uncertainty element				*34%*		*37%*		*20%*		*9%*	*100%*
Ecosystem Identity	Ecosystem Identity	Low	1		2		0		0		3
	Market Experience	Low	0		3		0		0		3
% distribution of each ecosystem uncertainty element by each group of strategy			*1*	*1%*	*5*	*6%*	*0*	*0%*	*0*	*0%*	*6*
% distribution of each group of strategies by ecosystem uncertainty element				*17%*		*83%*		*0%*		*0%*	*100%*
Value Proposition	Alignment	Medium	6		3		1		1		11
% distribution of each ecosystem uncertainty element by each group of strategy			*6*	*6%*	*3*	*3%*	*1*	*2%*	*1*	*2%*	*11*
% distribution of each group of strategies by ecosystem uncertainty element				*55%*		*27%*		*9%*		*9%*	*100%*
Systemic innovation	Controlability	Low	0		1		0		0		1
	Vehicle Design	Medium-High	3		2		4		2		11
	Vehicle Performance Efficiency	High	3		3		4		1		11
	Vehicle Reliability	Medium-High	1		5		4		0		10
	Battery	Very High	2		5		2		0		9
% distribution of each ecosystem uncertainty element by each group of strategy			*9*	*10%*	*16*	*18%*	*14*	*24%*	*3*	*7%*	*42*
% distribution of each group of strategies by ecosystem uncertainty element				*21%*		*38%*		*33%*		*7%*	*100%*
Value Capture	Affordability	Medium	2		0		1		1		4
	Fundability	High	0		2		1		1		4
	Operational Costs	High	2		2		2		0		6
% distribution of each ecosystem uncertainty element by each group of strategy			*4*	*4%*	*4*	*4%*	*4*	*7%*	*2*	*5%*	*14*
% distribution of each group of strategies by ecosystem uncertainty element				*29%*		*29%*		*29%*		*14%*	*100%*
Value Creation	Social equity	High	3		0		1		2		6
	Value Capture	High	0		3		1		5		9
	City Visual Impact	Medium-Low	1		0		0		0		1

	Coalition of Social Groups	Medium-Low	3		0		0		0		3
	Auditive (Noise) Impact	Very High	4		0		0		0		4
	User full journey experience	High	0		1		5		2		8
	Safety or right to privacy	Low	1		3		4		1		9
	Lack of knowledge	Medium-Low	5		4		2		1		12
	Natural resources impact	Medium-Low	2		0		0		0		2
	Biotic beings impact	Low	0		0		0		0		0
% distribution of each ecosystem uncertainty element by each group of strategy			*19*	*20%*	*11*	*12%*	*13*	*22%*	*11*	*27%*	*54*
% distribution of each group of strategies by ecosystem uncertainty element				*35%*		*20%*		*24%*		*20%*	*100%*
Total			**94**		**89**		**59**		**41**		**282**

These findings showed us how revelant is the proactive strategies for the beginning of the ecosystem's development. Based on this, we present the following proposition:

Proposition 6 - Decision makers employ a greater number of proactive strategies (shaping and transformative) in the first levels of ecosystem development.

Table 29 shows us that 42% of all adaptive strategies are allocated to deal with ecosystem design uncertainties (i.e. Configuration 15%, Ecosystem Emergence (16%), and Design and Design and Structure (11%).

The next two sets of analyses (Table 29 and 30) counted for the number of citations we found in our database. The first subset of analysis (Table 29) shows the citation quantification we found on the databases by each uncertainty that emerged from the data. It means that every time we heard a respondent talk about a strategy adopted, we counted a point. From this analysis, we can depict that:

- We counted a smaller number of uncertainties allocated to the group of planning strategies (H/L group) since eighteen different types of uncertainties were mentioned within this group. Even though it is a group with a smaller variety of allocated uncertainties, we see the uncertainties here seem to be more complex, in terms of the number of players allocated to resolve them and the possible effects of interdependencies that exist between them for resolution;
- There is a bigger diversity of uncertainties allocated to the other groups (H/H and L/H groups) - Twenty-five subgroups allocated in both. Shaping Strategies (H/H group) are the most frequent uncertainties. This group seems to have a pattern of "always depending on the other". A possible explanation for that is that as the actors don't know the other's movement, they adopt a shaper position to control the game;
- In this sense, Effectuation (L/H group) is more aligned with movements (actions) made in collaboration or competition with other players. How the ecosystem adjusts, and organizes itself within a much larger big picture;

- On the other extreme, thirty-one subgroups were allocated to the L/L group meaning that the Adaptative Strategy has a greater diversity of types of uncertainties, very heterogeneous in their natures.

In the table, we kept in bold the uncertainty subcategories that had the highest frequency of citations from the database.

Table 29 - Number, Types and Counting of Uncertainties Allocated by Ecosystem Elements and Strategic Groups

Uncertainty Group	Uncertainties Subgroup		Frequency of citations	Strategy
Coopetition	*1*	*Outside competition -Air disorder and unexpected Interferences*	1	H/L
Complementarities	*2*	*Interface Standardization and Interoperability*	2	
Design and Structure	***3***	***Complex Geographic and Urban Design***	**5**	
	4	***Groundhandling infrastructure Design***		
	5	***(Micro) Weather peculiarities***		
	6	***Energy infrastructure***		
Ecosystem Emergence and Design	***7***	***Chicken and egg problem***	**8**	
	8	***Consistency and regularity when scaling***		
	9	***Ecosystem Emergence and Design***		
IE Configuration	*10*	*Certification/ Regulation Process*	3	
	11	*New Air Communication system*		
Systemic innovation	*12*	*Vehicle Design*	3	
Value Capture	*13*	*Fundability*	3	
	14	*Value Capture*		
Value Creation	*15*	*Lack of knowledge*	4	
	16	*Security and right to privacy*		
	17	*User full journey experience*		
Value Proposition	*18*	*Alignment*	1	
Sum	*18*		30	
Activities	*1*	*Training*	1	H/H
Complementarities	*2*	*Interface Standardization and Interoperability*	7	
	3	*Vehicle Maintenance*		
Coopetition	*4*	*Outside competition - Interference in current systems - air Cybersecurity safety*	2	
	5	*Inside Competition- Overlaps and blurry frontiers - Ecosystem roles*		
Design and Structure	*6*	*(Micro) Weather peculiarities*	7	
	7	*Groundhandling infrastructure Design*		
	8	*Traffic Density*		
	9	*Chicken and egg problem*	7	

Ecosystem Emergence and Design	*10*	*Consistency and regularity when scaling*		
	11	*Ecosystem Emergence and Design*		
Ecosystem Identity	*12*	*Ecosystem Identity*	1	
IE Configuration	***13***	***Certification/ Regulation Process***	**9**	
	14	***Data Sharing***		
	15	***New Air Communication system***		
Systemic innovation	*16*	*Battery*	7	
	17	*Vehicle Design*		
	18	*Vehicle Performance Efficiency*		
	19	*Vehicle Reliability*		
Value Capture	*20*	*Operational Costs*	2	
Value Creation	***21***	***Coalition of Social Groups***	**10**	
	22	***Lack of knowledge***		
	23	***Auditive (Noise) Impact***		
	24	***Security and right to privacy***		
Value Proposition	*25*	*Alignment*	7	
Sum	*25*		60	
Systemic innovation	*1*	*Battery*	2	L/H
Ecosystem Emergence and Design	*2*	*Chicken and egg problem*	1	
Activities	*3*	*Expected strategic move*	2	
	4	*Training*		
Complementarities	*5*	*Interface Standardization and Interoperability*	2	
	6	*Vehicle Maintenance*		
Coopetition	***7***	***Collaboration - Collaboration with the right players***	**9**	
	8	***Outside competition -Interference in current ATC systems - communication***		
	9	***Outside competition - Interference in current systems - air Cybersecurity safety***		
	10	***Collaboration - Collaboration with the right players***		
Design and Structure	*11*	*Complex Geographic and Urban Design*	7	
	12	*Existing Groundhandling infrastructure adaptations*		

	13	*Groundhandling infrastructure Design*		
Ecosystem Emergence and Design	*14*	*Ecosystem Emergence and Design*	2	
	15	*Market Sensibility*		
IE Configuration	*16*	*New Air Communication system*	7	
	17	*Certification/ Regulation Process*		
Systemic innovation	***18***	***Vehicle Performance Efficiency***	**10**	
	19	***Vehicle Reliability***		
	20	***Vehicle Design***		
Value Capture	*21*	*Operational Costs*	2	
	22	*Value Capture*		
Value Creation	***23***	***Security and right to privacy***	**8**	
	24	***User full journey experience***		
	25	***Lack of knowledge***		
Sum	*25*		52	
Activities	*1*	*Flexibility and dynamicity in changes*	2	L/L
	2	*Training*		
Complementarities	*3*	*Interface Standardization and Interoperability*	3	
Coopetition	*4*	*Collaboration - Collaboration with the right players*	6	
	5	*Outside competition -Interference in current ATC systems - communication*		
	6	*Outside competition - Interference in current systems - air Cybersecurity safety*		
Design and Structure	***7***	***Traffic Density***	**10**	
	8	***(Micro) Weather peculiarities***		
	9	***Existing Groundhandling infrastructure adaptations***		
	10	***Groundhandling infrastructure Design***		
Ecosystem Emergence and Design	***11***	***Autonomous Vehicles time-to-market***	**12**	
	12	***Consistency and regularity when scaling***		
	13	***Chicken and egg problem***		
	14	***Ecosystem Emergence and Design***		
Ecosystem Identity	*15*	*Ecosystem Identity*	3	
	16	*Market Experience*		
IE Configuration	*17*	*New Air Communication system*	8	

	18	*Certification/ Regulation Process*		
Systemic innovation	***19***	***Vehicle Design***	**10**	
	20	***Vehicle Performance Efficiency***		
	21	***Vehicle Reliability***		
	22	***Battery***		
Value Capture	*23*	*Operational Costs*	5	
	24	*Fundability*		
	25	*Value Capture*		
Value Creation	***26***	***Lack of knowledge***	**10**	
	27	***Security and right to privacy***		
	28	***User full journey experience***		
	29	***Security and right to privacy***		
	30	***Lack of knowledge***		
Value Proposition	*31*	*Alignment*	2	
Sum	*31*		71	

Source: Author's Elaboration.

The second subset of the analysis (Table 30) shows the intensity of the uncertainties allocated by Strategic Group. Here we measured the degree of intensity of uncertainty based on the frequency with which interviewees commented/ emphasized that. In other words, the more players shared a specific uncertainty, mention it, and commented on it during the interviews, this counted for the intensity of this uncertainty in the ecosystem. We also considered secondary reports to triangulate this information.

An uncertainty can range from “Very High intensity” to “Very Low intensity”. Here are some of the main insights based on this analysis:

- The Very High-level intensity group has Ecosystem Emergence and Design uncertainty (i.e. Market Sensibility uncertainty), IE Configuration uncertainty (i.e. Certification/ Regulation Process uncertainty), and Systemic innovation uncertainty (i.e. Battery uncertainty);
- The High-level intensity group has Complementarities (Interface standardization and Interoperability uncertainty), Design and Structure (Weather peculiarities, Traffic Density, Groundhandling infrastructure Design), Ecosystem Emergence and Design (Chicken and egg problem), Systemic innovation (Vehicle Performance Efficiency), Value Capture (Fundability, Value Capture and Operational Costs), Value Creation (Social equity and User full journey experience);
- The Low of very low-level intensity group has Complementarities Activities (Training and Flexibility and dynamicity in changes), Ecosystem Identity, Systemic innovation (Controllability), Value Creation (Safety or right to privacy), Complementarities (Vehicle Maintenance), Complex Geographic and Urban Design and Biotic beings impact.
- All other uncertainties are in the middle inside the Medium-level intensity group.
- Sixteen (36%) uncertainties are very high or high uncertainties. Twenty (44%) of them are medium-intensity uncertainties and nine (20%) of them are low or very low-intensity uncertainties.

Table 30 - Summary of Intensity of the Uncertainties Allocated by Strategic Group

Uncertainty	**Strategy Group**					
Intensity	**Total (Counting of citations)**	**shaping**	**adapting**	**effectuation**	**planning**	
Very High	34	32%	**47%**	18%	3%	100%
High	102	**30%**	29%	21%	20%	100%
Medium-High	29	28%	28%	28%	17%	100%
Medium	53	**38%**	26%	21%	15%	100%
Medium-Low	35	**49%**	23%	17%	11%	100%
Low	26	19%	**46%**	23%	12%	100%
Very Low	3	**67%**	0%	33%	0%	100%
	282					

Source: Author's Elaboration.

5.3.6 Towards an Uncertainties-Strategy Model to Unlock Ecosystem Emergence

This subsection presents the final analysis and propositions of the thesis. We present Figure 23 which reduces uncertainties into three groups: Relationships-related Uncertainties, Design-related Uncertainties, and Dynamicity of growth-related Uncertainties. These three groups are an abstraction of uncertainties that emerge from the data (45 uncertainties), from the data related to the IE theory (11 grouped uncertainties), and from the data related to uncertainty management (9 grouped uncertainties). Table 31 summarizes all uncertainties.

Table 31 - Uncertainties

Uncertainties that inductively emerged from the data analysis	**Uncertainties in light of the theory of IE**	**Uncertainties in light of the theory of uncertainty management (IE-level)**
Database EVTOL case study	*Furr and Eisenhardt (2021)* *Thomas and Ritala (2021)* *Adner (2017)* *Gomes et al. (2021a)* *Adner (2006; 2012)* *Dattée et al. (2018)* *Adner and Feiler (2019)* *Shipilov and Gawer (2020)* *Talmar et al. (2020* *Adner and Kapoor (2016)*	*Gomes et al. (2018)* *Helfat and Teece (1987)* *Williamson (1985)* *Gomes and da Silva Barros (2022)* *Kapoor and Klueter (2021)* *Rice et al. (2008)* *Milliken (1987)* *Gomes (2013)* *Dosi and Egidi (1991)*
Lack of knowledg[e] Coalition of Social Groups[e] Security and right to privacy[f]	1- Value Proposition Uncertainty 2- Identity Uncertainty 3- Value Creation Uncertainty	1- Collective Uncertainty 2- Behavioral or secondary Uncertainty

User full journey experience[g] City Visual Impact[h] Auditive (Noise) Impact[i] Natural resources impact[j] Biotic beings impact[k] Consumer is willing to pay[p] Social Equity Expected strategic move[af] Market Experience[c] Training[ah] Collaboration with the right players[al] Interface Standardization and Interoperability[ai] Interference in current systems - air Cybersecurity safety[am] Interference in current ATC systems – communication Air disorder and unexpected Interferences[an] Fundability[l] Operational Costs[m] Value Capture[n] Traffic Density[w] (Micro) Weather peculiarities[x] Complex Geographic and Urban Design[y] Energy infrastructure[z] Groundhandling infrastructure Designa[b] Existing Groundhandling infrastructure adaptations[at] Certification/ Regulation Process[ac] Data sharing[ad] New Air Communication system[ae] Vehicle Maintenance[aj] Overlaps and blurry frontiers - Ecosystem roles[ak] Battery[q] Vehicle Reliability[r] Vehicle Performance Efficiency[s] Controllability[t] Vehicle Design[u] Ecosystem Identity[b] Consistency and regularity when scaling[ao] Chicken and egg problem[ap] Autonomous Vehicles time-to-market[as] Alignment[a] Flexibility and dynamicity in changes[ag] Market Sensibility[ar]	4- Value Capture Uncertainty 5- System Innovation Uncertainty 6- Design and Structure Uncertainty 7- Configuration Uncertainty 8- Activities Uncertainty 9- Complementarities Uncertainty 10- Coopetition Uncertainty 11- Emergence and Design Uncertainty	3- Affiliation Uncertainty 4- Interdependence Uncertainty 5- Configurational Uncertainty 6- Technological Uncertainty 7- Response or Procedural Uncertainty 8- State or perceived environmental Uncertainty 9- Effect uncertainty

Source: Author's Elaboration.

Relationships-related uncertainties are a set of uncertainties related to collaborative issues: uncertainties they share (collective uncertainty), their unknowns regarding other's behavior (behavioral uncertainty), who they should affiliate with (Affiliation uncertainty) or to create interdependence (interdependence uncertainty), and compete (coopetition uncertainty). Below we explain the five second-order categories that integrate this construct.

Collective Uncertainties affect the performance of actors in the ecosystem (Gomes et al., 2018). We did not find any uncertainties in our database to sustain this second-order category. **Behavioral uncertainty** is the difficulty in predicting the actions of other relevant actors, particularly because of the potential for opportunistic behavior. because actors might act with 'self-interest seeking with guile'. The lack of knowledge about the actions of other economic actors might affect a firm's investment decisions because of the possibility of ex-ante or ex-post opportunism on the part of the exchange partner firm (for example, actors may use self-disbelieved statements and misinformation to profit at the expense of the exchange partner (Helfat and Teece, 1987; Williamson, 1985). This construct relates to plenty of uncertainties we found on the database [ge, e, f, g, h, i, j, k, p, af, o].

Affiliation uncertainty is the difficulty in predicting whether the right actors would engage in a particular ecosystem to produce a coherent focal sustainability value proposition (Gomes and da Silva Barros, 2022). This construct relates to plenty of uncertainties we found on the database [c, ah, al].

In this sense, another category we define is the **Interdependence uncertainty**, meaning the difficulties in predicting whether and how mutual dependencies would emerge and strengthen a new market (Gomes and da Silva Barros, 2022). This idea is also anchored in on EVTOL uncertainty [ai]. Lastly, **Coopetition uncertainty** means unknowns of other ecosystems that compete to deliver the same focal value proposition to the market. What will the relationship be like with other traditional industries and markets that are being disrupted? We found on or database two uncertainties enlightening this idea [am, an].

In summary, this group concerns collaboration among diverse ecosystem actors. Relationships-related uncertainties are key to hinder the progress of ecosystem emergence. Decision-makers might try to increase control by searching for support from ecosystem actors mostly through proactive mindsets (more precisely, shaping strategies) as we can depict in Figure 23. That interaction generates exchanges of knowledge, consequently broadening actors' understanding of exogenous uncertainties. They broaden their knowledge base through the sharing of different perspectives, increasing a collective and holistic understanding of the uncertainties they face. In our database, we found a couple of collaborative strategies corroborating this idea (i.g. Partnering to shape the market strategy, and creating a cluster strategy). Below we present the following propositions that summarize these ideas.

Proposition 7a – Relationships-related Uncertainties unlock ecosystem emergence.

"Design Related Uncertainties" are a set of uncertainties related to the key attributes of the ecosystem: unknowns of the value they will capture (value capture uncertainty), the rules and mechanisms that allow the ecosystem to emerge (Configurational uncertainty), and the lack of clearness and alignments regarding technology developments (Technological uncertainty). We found similar sets of proactive and reactive strategies that managers employ to deal with these uncertainties in IE emergence in general. Below we explain the three second-order categories that integrate this category.

Uncertainty related to the **economic viability** of the IE funding raising, resource allocation willingness and also the lack of knowledge regarding whether the costs and cons related to the development of EVTOL will be fairly split. We an find evidence of this category inside the database [l, m, n].

Configurational uncertainty is the difficulty in predicting what are the boundaries of the ecosystem in terms of structure/actors/activities exchanged among them We also found evidence in the literature (Gomes and da Silva Barros, 2022) and in the database [w, x, y, z, ab, at, ac, ad, ae, aj, ak] to sustain this category idea. Lastly, **technological uncertainty** means the unpredictability surrounding the development, performance, and adoption of new technologies or technological innovations (Kapoor and Klueter, 2021; Rice et al., 2008). In the database, we can depict this category too [q, r, s, t, u]. The following proposition representing these ideas is:

Proposition 7b – Design-related uncertainties unlock ecosystem emergence

The last group of uncertainties is quite new to the literature, and we believe that is one of the main contributions of this thesis. We called this second-order category “Dynamicity of growth-related Uncertainties”. This group gives pace, flow, and dynamicity to the ecosystem's emergence. The high level of uncertainty might retain this emergence process. This category is composed of a set of unknowns related to crystallization, consistency, and regularity when scaling, synchronicity, and response times. We will briefly explain them below. We found similar sets of proactive and reactive strategies that managers employ to deal with these uncertainties in IE emergence in general too. Below we explain the four second-order categories that integrate this category.

Coalescence uncertainty means unknowing the odds of consolidation of the ecosystem in the long run. Actors don't have an idea of the pace of the ecosystem's solidification - if the ties will endure, shared activities and resources will persist. They don't know if the implementation might persist consistently over time. This is an uncertainty of consistency and regularity when scaling. Will the ecosystem grow consistently over the long term?

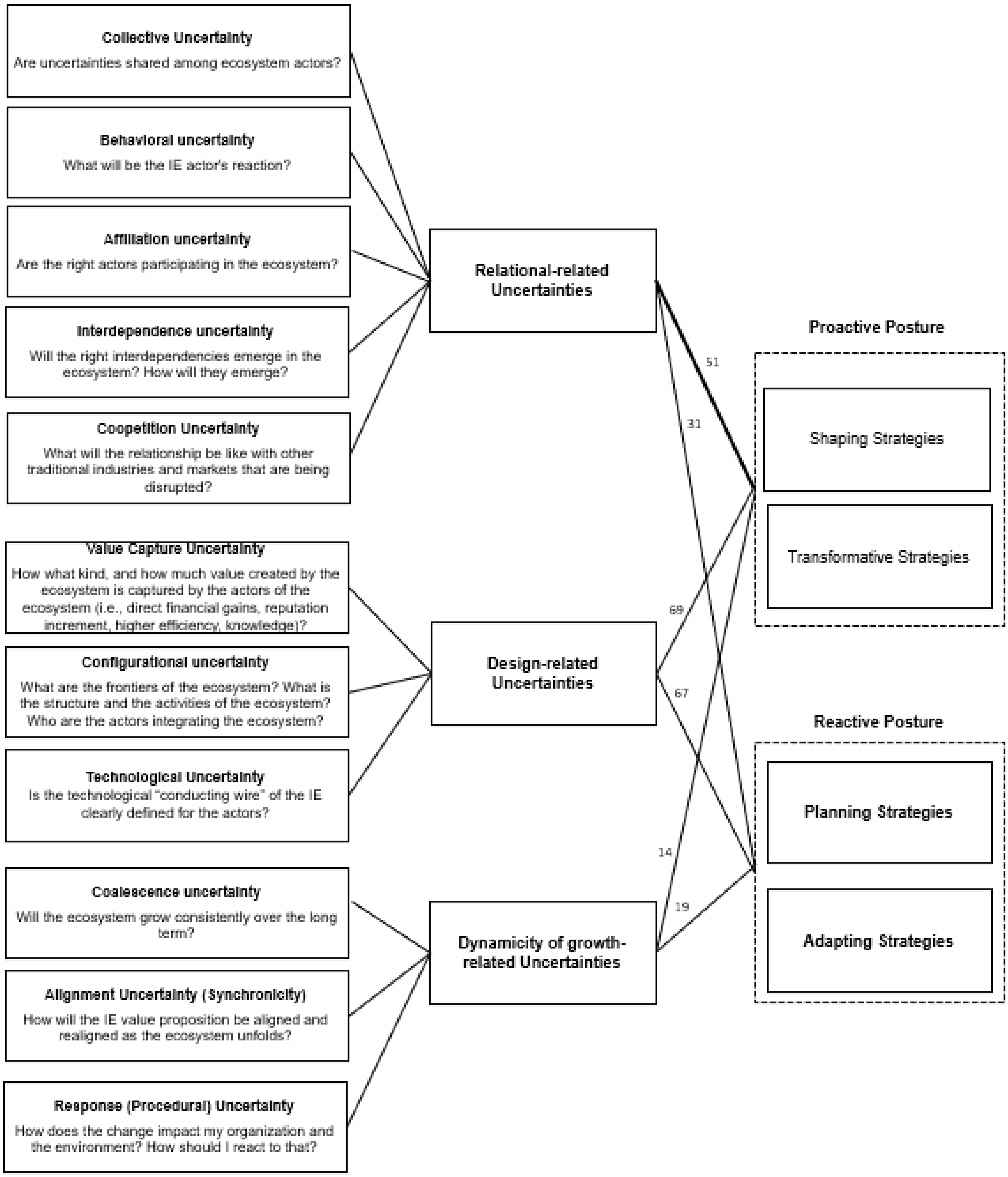
Alignment Uncertainty (Synchronicity) refers to the uncertainty of alignment and realignment of the value proposition as the ecosystem unfolds. In terms of realignment, it means the uncertainty of whether ecosystem rules and regulations will be flexible enough to quickly incorporate changes and improvements over time. We found only two uncertainties in the case studied to corroborate this category idea [a, ag].

Lastly, **response (Procedural) uncertainty** means the doubt about the “how to react” question. It means the inability to predict the outcomes of decisions and predict what the consequences of each choice will be. This typology deals with the computational and cognitive limitations of agents in pursuing their goals, even if the information is available. Arising from human cognitive limitations, i.e., bounded rationality (Milliken; 1987; Gomes, 2013; Dosi and Egidi, 1991). We found evidence in the database to support this category [ar].

Proposition 7c – Dynamicity of growth-related Uncertainties unlock ecosystem emergence

Figure 23 shows a summary of these main ideas. We also present Table 32 located inside “Theoretical Contributions” which summarizes these ideas.

Figure 23 - Theory Building - Strategy and Uncertainty Relationships



Source: Author’s Elaboration.

6 CONTRIBUTIONS

This section describes the contributions of this study. We make clear, well-founded contributions by filling gaps, providing utility, and pushing boundaries of the research on uncertainty theory, ecosystem theory, and strategic formation theory.

6.2 THEORETICAL CONTRIBUTIONS

The way theorists in strategy deal with uncertainty has changed over the past 40 years. Business success metrics have also evolved, as well as the way firms interact with each other. In the early 70s and 80s, business success metrics were generating revenue growth and profitability, respectively. Strategy research has sought to manage uncertainties by using market-based relationship strategies based on purchase/sale contracts or vertical integration models (Williamson, 1985) and planning future scenarios (Hedley, 1977; Levitt, 1965; Henderson, 1979). As time evolved, in the 90s, firms started to spin off their growing businesses to tap funding from external capital markets and changed their corporate goals to value creation. Strategy research has sought to manage uncertainties by employing a vast majority of tests (see, for example, attractiveness test, cost-of-entry test, better-off test).

After 2000, firms changed focus to long-term corporate advantage (Barney, 1991) and managed uncertainties by investing in economies of scope and sharing risks between multiple business units and partners through different types of alliances (long-term contracts, spot sales purchases, franchises, joint ventures, value-adding vertical partnerships, agency agreements, etc) (Möller & Halinen, 2017). Theorists addressed different models of arrangements between firms. Today, alliances have become more complex than ever (we see for example, new forms of interorganizational relationships between firms and complementors, for example, that involve attracting, influencing, and coordinating companies without the use of contracts) (Shipilov and Gawer, 2020).

Along with this movement, firms started to take their social impact more seriously than ever (Gomes & da Silva Barros, 2022). Their focus is reconciling revenue and impact and redefining success in the economy so that not only financial success is considered, but also the well-being of society and the planet. More than a long-term corporate advantage, they seek now to deliver a meaningful value proposition to the market through co-creation, co-selling, and co-producing complex solutions with other firms (Adner, 2017). Companies are still learning how to deal with these shared and decentralized resources and capabilities (Gomes et al., 2022).

Nowadays, firms with value-oriented goals and embraced complex interorganizational relationships must deal with different classes of uncertainties (Furr & Eisenhardt, 2021). The literature on uncertainty management still needs to be further refined to explain the types of uncertainties that occur in these environments (Kapoor & Klueter, 2021).

Uncertainties at the company level, and the level of collaborative projects, cannot explain what happens at the ecosystem level. At the project level, studies show the lack of knowledge that hinders the execution of specific time-framed projects, not looking at the possible uncertainties that might emerge when giving regularity to the value creation and capture process. The focus is on understanding uncertainties in a defined and limited scope of actors, often actors that relate to the first layer of the proximity of the value proposition (see Rice et al. 2008; de Vasconcelos Gomes et al., 2019). At the organizational level, previous literature showed an ego-centered view of uncertainties (i.e. Jauch & Kraft, 1986), without looking at the causes and impacts that they can generate in a larger scope and the effect on the delivery of the value proposition to the market as a whole (i.e. Loch et al., 2008 and Milliken, 1987).

In such an ecosystem context, this specific time-framed logic (projects uncertainty) and self-centered logic (organizational uncertainty) do not apply. At the ecosystem level, firms with value-oriented goals embraced by complex interorganizational relationships must deal with different classes of uncertainties (Gomes & da Silva Barros, 2022; Gomes et al., 2018). At the ecosystem level, some uncertainties have already been addressed in previous works - Response (procedural) uncertainty, behavioral uncertainty (secondary uncertainty, configurational uncertainty, and affiliation uncertainty. The literature on uncertainty management still needs to be further refined to explain the types of uncertainties that occur in these environments. We added to this literature by discovering new types of uncertainties.

Below we present a table (Table 32) that shows the uncertainties we aggregated t the literature. This thesis identified families of uncertainties and strategies to deal with them at the ecosystem level. We add to the literature by offering a dynamic framework for uncertainty management to understand uncertainty and its implications for entrepreneurial behavior when participating in a nascent ecosystem.

Table 32 - Theoretical Contributions

Name	**Descriptions (Theory)**	**Author**	**Key question(s)**	**Thesis evidence found in the database (Name of the Uncertainty)**
State uncertainty (perceived environmental uncertainty)	Inability to assign probabilities to states of nature. The difficulty of predicting how an environment is changing	Milliken (1987)	How does the environment change?	No evidence
Effect uncertainty	Inability to predict outcomes of managerial action. Lack of knowledge about cause-effect relationships, in particular, how states of nature will affect the organization (how these changes will impact the individual or firm).	Milliken (1987)	How does the change impact my organization?	No evidence
Collective uncertainty	Uncertainties that “affect a group of actors in an innovation ecosystem, affecting the performance of a group of actors and, in some cases, the performance of the whole innovation ecosystem	Gomes et al. (2018)	Ecosystem uncertainties are shared and propagated by the actors.	No evidence
Response (Procedural) Uncertainty	Is the doubt about the “how to react” question. It means the inability to predict the outcomes of decisions and predict what the consequences of each choice will be. This typology deals with the computational and cognitive limitations of agents in pursuing their goals, even if the information is available. Arising from human cognitive limitations, i.e., bounded rationality.	Milliken (1987); Gomes (2013); Dosi and Egidi (1991)	How does the change impact my organization and the environment? How should I react to that?	Market Sensibility[ar]
Behavioral uncertainty (secondary uncertainty)	Is the difficulty in terms of predicting the actions of other relevant actors, particularly in view of the potential for opportunistic behavior because actors might act with ‘self-interest seeking with guile’. The lack of knowledge about the actions of other economic actors might affect a firm’s	Helfat and Teece (1987) and Williamson (1985)	What will be the IE actor's reaction?	Lack of knowled[ge] Coalition of Social Groups[e] Security and right to privacy[f] User full journey experience[g] City Visual Impact[h] Auditive (Noise) Impact[i] Natural resources impact[j]

	investment decisions because of the possibility of ex-ante or ex-post opportunism on the part of the exchange partner firm (for example, actors may use self-disbelieved statements and misinformation with the intention of profiting at the expense of the exchange partner.			Biotic beings impact[k] Affordabiity[p] Expected strategic move[af] Social Equity[o]
Configurational uncertainty	Difficulty in predicting what are the boundaries of the ecosystem in terms of structure/actors/activities exchanged among them),	Gomes and da Silva Barros (2022)	What are the frontiers of the ecosystem? What is the structure and the activities of the ecosystem? Who are the actors integrating the ecosystem?	Traffic Density[w] (Micro) Weather peculiarities[x] Complex Geographic and Urban Design[y] Energy infrastructure[z] Groundhandling infrastructure Design[ab] Existing Groundhandling infrastructure adaptations[at] Certification/ Regulation Process[ac] Data sharing[ad] New Air Communication system[ae] Vehicle Maintenance[aj] Overlaps and blurry frontiers - Ecosystem roles[ak]
Affiliation uncertainty	Difficulty in predicting whether the right actors would engage in a particular ecosystem to produce a coherent focal sustainability value proposition	Gomes and da Silva Barros (2022)	Are the right actors participating in the ecosystem?	Market Experience[c] Training[ah] Collaboration with the right players[al]
Interdependence uncertainty	Difficulties in predicting whether and how mutual dependencies would emerge and strengthen a new market).	Gomes and da Silva Barros (2022)	Will the right interdependencies emerge in the ecosystem? How will they emerge?	Interface Standardization and Interoperability[ai]
Tecnological Uncertainty	Unpredictability surrounding the development, performance, and adoption of new technologies or technological innovations.	Kapoor and Klueter (2021); Rice et al. (2008)	Is the technological “conducting wire” of the IE clearly defined for the actors?	Battery[q] Vehicle Reliability[r] Vehicle Performance Efficiency[s] Controllability[t] Vehicle Design[u]

Value Capture Uncertainty	Uncertainty related to the economic viability of the IE funding raising, and resource allocation willingness (l, m, n). Uncertainty whether the costs and cons related to the development of EVTOL will be fairly split (o)	New to the literature on IE	How what kind, and how much value created by the ecosystem is captured by the actors of the ecosystem (i.e., direct financial gains, reputation increment, higher efficiency, knowledge)?	Fundability[l] Operational Costs[m] Value Capture[n]
Alignment Uncertainty (Synchronicity)	Uncertainty whether the companies in the ecosystem will align their goals and times	New to the literature on IE	Will companies act synchronously?	Alignment[a] Flexibility and dynamicity in changes[ag]
Cristalization	Uncertainty regarding which identity will be crystallized in the ecosystem	New to the literature on IE	Will all actors share the same meaning of the ecosystem?	Ecosystem Identity[b]
Uncertainty of coopetition	Other ecosystems that compete to deliver the same focal value proposition to the market.	New to the literature on IE	What will the relationship be like with other traditional industries and markets that are being disrupted?	Interference in current systems - air Cybersecurity safety[am] Interference in current ATC systems – communication Air disorder and unexpected Interferences[an]
Uncertainty of Consistency and regularity when scaling	Uncertainty if the ecosystem will grow consistently over the long term	New to the literature on IE	Will the ecosystem will grow consistently over the long term?	Consistency and regularity when scaling[ao] Chicken and egg problem[ap] Autonomous Vehicles time-to-market[as]

Source: Author’s Elaboration.

First, this study contributes to the entrepreneurial strategies to deal with uncertainty at the ecosystem level studies. The dominant theme in organization theory and research has been uncertainty reduction strategies (planning and adaptative schools). Other strategic options seem to be underrepresented in the literature (transformative and visionary schools). Both Porter's (planning) and Mintzberg's (adaptative) ideas were developed in a period when changes were not as fast-paced as they are today, and collaborative relations were not deeply explored in the ecosystem logic, which started to be more explored in Moore's work (1993). For example, in 1990, authors barely talked about spin-offs, startups, and complementarity relationships. On the other hand, Courtney et al. (1997), and Rindova and Fombrun (1999) approaches seem to be more suitable for dealing with this complex ecosystem environment because these strategies recognize uncertainties and don't necessarily want to reduce them. They see uncertainty not as a problem to solve but as an opportunity to shape the garden of change, develop novel value propositions, design new business models, or even create a new ecosystem. Recognizing uncertainty means not committing to formulating ex-ante plans to resolve uncertainties because they believe things will change. There will be many costs for altering those plans as new information is obtained in low prediction and highly controllable environments. This research advances the understanding of strategies adopted by decision-makers in the context of perceived uncertainty related to nascent IEs. This study advances the theory showing the existence of other strategies besides those proposed by the previous author (Gomes et al., 2021c).

Second, researchers ask for studies that deal with uncertainty in environments characterized by rapid technological change (Kapoor & Klueter, 2021, Furr & Eisenhardt, 2021). This research also contributes to the literature on ecosystems (Adner, 2017; Ganco et al., 2020; Shipilov & Gawer, 2020). Ecosystems, by their nature, are surrounded by uncertainties; therefore, managing uncertainties is crucial for technological evolution (Gomes et al., 2019). Uncertainty might undermine ecosystems, interfering in their growth, leading to ruin, business bankruptcy, partnership disintegration, and people's deprivation to access technologies that positively impact their lives. Nascent ecosystems are permeated by high uncertainty (Kapoor & Klueter, 2021) and characterized by incomplete or fleeting structures. So, enacting the ecosystem's resonance is a challenge (Thomas & Autio, 2021), especially for those developing an ecosystem around a path-breaking innovation.

So, this study is on the intersection of uncertainty management and strategy formation in entrepreneurial settings and has multiple contributions to the literature on ecosystem-as-a-structured research (Adner, 2017; Ganco et al., 2020; Shipilov & Gawer, 2020) by refining uncertainty families at the ecosystem level (Gomes et al., 2022; O'Connor & Rice, 2013; Packard et al., 2017). This work advances the configurational view of IE (Thomas & Autio, 2020; Cennamo & Santaló, 2019; Gomes et al.,2021b) by showing its dynamics of operations (Shi et al., 2021; Dattée et al., 2018; Kapoor & Klueter, 2021) in terms of uncertainty management as one important driver for unlocking nascent ecosystem emergence (Thomas & Ritala, 2021; Gomes et al., 2022). More precisely, we discovered new types of uncertainties at the IE level (Table 32).

If we know how to manage uncertainties in these environments, we can understand how to enable a nascent ecosystem to overcome its liability of newness. All the efforts to initiate the ecosystem will not have been "in vain", and the nascent technologies developed will be able to be more quickly absorbed by the market to enable VP solidification and growth.

6.3 MANAGERIAL CONTRIBUTIONS

Firms are constantly challenged to rethink the levels of formalization and commitment they want to invest in their network of partners, to decide about the resource and capability strengths they really possess and the ones they do not; and to critically think about the goals they want to pursue without forgetting the strategic orientation that guides their DNA. In the case of the development of new solutions that challenge traditional market structures, companies cannot evolve without sharing uncertainties to reduce the obstacles to ecosystem emergencies. Collaboration in larger groups is the key to the survival of enterprises and to reducing ecosystem uncertainties. Cooperation with market players to enable the emergence of innovations allows us to deliver a value proposition to the market.

First, this work contributes to practitioners working on firms that take on ecosystem orchestration roles. We contribute to them by showing them strategies they might undertake to deal with uncertainties in these ecosystems, making them seek to remain in central positions in the ecosystems they lead.

Orchestrators or "ecosystem developers" (Dattée et al., 2018; Shi et al., 2021) are an important role a firm might take on in IEs. This role embraces defining rules, designing ecosystem architecture, and influencing other actors (Dattée et al., 2018; Souza Luz et al., 2024; Adner & Kapoor, 2010). In the case of the Airbus A380 IE orchestrated by Airbus, the orchestrators have successfully managed the uncertainties associated with the ecosystem (Adner & Kapoor, 2010). This research instrumentalizes orchestrators in broadening their views of uncertainties they might face in a way they can establish dynamic control over the creation process (Dattée et al., 2018) by drawing on influencing, monitoring, and ensuring that the emerging VP will evolve in such a way value created is appropriately captured by the members.

Second, companies specializing in specific niches possess deep knowledge and expertise in certain areas. They play the role of complementors in IEs by providing products, services, or technologies (i.e. APIs) that often enable the delivery of the value proposition to the market (Jacobides et al., 2018; Shipilov & Gawer, 2020). Understanding uncertainties and strategies for managing them can help them unlock interoperability issues and enable the technology to reach the market, contributing to the ecosystem's emergence.

Third, this work contributes to public policymakers. Policymakers are key in this process. They interact with managers of all types of corporations (providers, complementors, big firms, small firms, and also other policymakers) to help them have a clear understanding of environmental uncertainties, risk, or ambiguity (Packard, et al., 2017). These agents work simultaneously with a huge portfolio of IEs. We must instrumentalize policymakers with frameworks that help them depict elements that inhibit IEs' emergence. Here is a long path between the development of technology and its delivery to the consumer. This path is not always clear and needs to be formatted with the support of different companies.

7 CONCLUSION

In this study, we analyzed how uncertainties and strategies coevolved along an IE growth trajectory. To reach this goal, we investigated uncertainties, strategies, and how decision-makers managed them over time in an emerging IE. We first identified, mapped, and described an IE, pointing out its main elements, actors, and events along its growth trajectory. Then, we identified, named, and framed the types of uncertainties perceived by decision-makers in the formation of an ecosystem over time. Third, we identified, named, and framed types of strategies perceived by decision-makers in the formation of an ecosystem over time. Fourth, we analyzed the relationship between uncertainties and strategies employed by decision-makers, identifying patterns of uncertainty management. Table 25 presents the main findings of the study.

7.1 LIMITATIONS AND FUTURE STUDIES

This work has some limitations. We know that "uncertainties", and "ecosystems" are abstractions of the real-world challenges faced by decision-makers. We employed some efforts to operationalize these categories following previous literature.

This work does not address uncertainties that were not perceived by the interviewees or mentioned in the secondary data we analyzed. We focused on "Perceived Uncertainty" – i.e., what were the ecosystem's uncertainties based on the decision-makers perspective. For example, we know that macroenvironmental factors might interfere with the ecosystem. However, they were not mentioned in the databases, so we did not analyze them. IE uncertainties is a topic little discussed in the literature, and there is still much room for discussion. As we commented on 2.2 – Uncertainty Section, few studies approach uncertainty in IEs. This thesis showed 50 uncertainties that emerged from the data. We believe that other types of ecosystems might present different sets of uncertainties.

Moreover, this work does not address the entire decision-making process. We focused on judgments or outcomes of the decision-making process, as we explained in Figure 10 (Unit of analysis). This means we analyzed the uncertainty perceived by the decision maker and the actions employed by them to deal with the uncertainties they perceived.

This thesis had no intention to analyze the entrepreneurial or knowledge context in which the IE may be embedded. IE may be interlinked with (or embraced by) a knowledge or entrepreneurial ecosystem (Xu et al., 2018) once they present a combination of broad and narrow focuses (Scaringella & Radziwon, 2018). To some extent, the IE value proposition needs to be adapted/ redesigned for specific regional contexts. Thus, IE as a strategy is being affected and affects a series of IE as communities. Moreover, this study does not look at the development of science and technology ecosystems (Xu et al., 2018) but at the IE that allows this nascent technology to be applied and disseminated to the final user. We did not bring to this thesis any literature related to entrepreneurial ecosystems, clusters, or other forms of interorganizational coalitions. We understand that these theories could add new insights and perspectives. Future studies could perform a multi-level analysis and approach entrepreneurial ecosystem-level uncertainties and their possible interactions/ interrelations with IE-level uncertainties (Scaringella and Radziwon, 2018; Gomes & da Silva Barros, 2022).

Another limitation of this thesis is that we did not employ a narrative strategy (Langley, 1999). We intend to build a data result section following the logic of “situation” *(“event description”) “complication” (“uncertainties”) and “resolution” (“strategies”) merging subsections into one fluid narrative that tells the history of the data for next publications. For future studies, we intend to analyze the chronology of the EVTOL ecosystem in more depth, clarify sequences across levels of analysis, suggest causal linkages between levels, and establish early analytical themes (Pettigrew,1990).

In this sense, we also know that processes-based methodology using a retrospective approach to data gathering has certain limitations, as people forget some points as we explained in subsection 3.2.4.1 - Validity and reliability. We reduce this limitation by following some steps described in this chapter. Future studies could explore Qualitative Comparative Analysis (QCA) as a methodological approach to examine uncertainties in IEs. As ecosystems involve multiple uncertainties, QCA allows modeling these uncertainties in a set-theoretic approach where different combinations of uncertainties can lead to an outcome like IEs emergence. Unlike regression methods that determine the net effect of predictors, QCA can identify various causal factors for IEs emergence. QCA also integrates well with mixed methods by formalizing systematic cross-case comparisons. Its configurational nature moves beyond individual factors and can uncover equifinality, where alternative and equal combinations of elements enable ecosystems to foster emergence. Finally, we also suggest testing the propositions of this study.

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9 GLOSSARY

Vertiports: VTOL hubs with multiple takeoff and landing pads, as well as charging infrastructure. Large multi-landing locations that have support facilities (i.e., rechargers, support personnel, etc.) for multiple VTOLs and passengers.

Vertistops: Single vehicle landing locations where no support facilities are provided, but where VTOLs can quickly drop off and pick up passengers without parking for an extended time. An example of a Verti stop includes small helipads that are atop high-rise downtown buildings today.

Autonomy: Autonomy refers to the ability of the vehicle to make these adjustments itself; pilot inputs are limited to commanding a desired trajectory rather than the means to achieve it.

Commuter: A person who regularly travel between home and work.

Evtol: An electric, zero-emission aircraft that takes off vertically. Typically, these aircraft will carry up to 6 passengers on short hops across the city.

Urban Air Mobility: The use of aircraft to travel across a large urban area. Historically, UAM has used helicopters, but EVTOLs will introduce a zero-emission, low-noise, and accessible mode for urban flights.

10 APPENDIX

10.1 APPENDIX A – RESEARCH PROTOCOL

Context	Innovation Ecosystem		
Research Question	How do innovation ecosystem members resolve uncertainty challenges as they evolve?		
General Goal	This study aims to analyze what response patterns exist for uncertainty in a nascent ecosystem.		
Specific Goal	a) To identify, map, and describe an innovation ecosystem, pointing its many events along its growth trajectory		
Methodological Step	Interviews with specialists and researchers who know the entire ecosystems		
Justification	To ensure that we have an ecosystem that matches all the prerequisites essential to performing this research		
Before start	Systematic Literature review on "EVTOL " inside Web of Science Database. Send an e-mail with an invite to all the authors.		
	For the ones who accepted the invitation, read the technical paper they published and search for the professional and scientific trajectory of the interview (prior occupations and positions, publications)		
Topic	**Question**	**Notes**	**Authors**
Beginning	Revision of the Research goals (PDF File)		
	Ask the respondent if the meeting can be recorded		
	Send by e-mail the Confidence Agreement Contract and ask the respondent to sign (through the Contractor platform) and present the research website		
	Please tell me a little about yourself. What is your background?		
Middle	Please tell me about EVTOLs' technology evolution. How did it start and what came next? In your opinion, what were the bottlenecks?	These are exploratory questions just to understand and get familiar with the phenomenon of analysis	
	What challenges did the technology face?		
	What uncertainties or knowledge gaps or unanswered questions did EVTOL 's ecosystem members have? How did it progress? How did it evolve?		

	How did EVTOL 's ecosystem members deal with these knowledge/information gaps and doubts at that time?		
	What uncertainties, in your opinion, existed in the past and have already been resolved?		
End	Ask if the respondent has any questions or wants to ask something.		
	Do you know anyone else I could speak to about this topic? Could you please send me a recommendation e-mail?		
	Do you have some data to send me (any interview, report, information that may help to better understand the things you told me)		
	Is that okay if I come in contact with you again at some point in the future?		
Procedures after the interview	Transcribe the interviews		
	Analyze them using open coding on the NVIVO		
Specific Goal	a) To identify, map, and describe an innovation ecosystem, pointing its many events along its growth trajectory		
Methodological Step	Interview with main players of the ecosystem (suppliers, complementors, orchestrators) with deep knowledge about the trajectory of the ecosystem		
Justification	To ensure that we have an ecosystem that matches all the prerequisites essential to performing this research. To ensure that the phenomenon analyzed is really an IE in which various partners are involved in the development, commercialization, and complementation of innovation.		
Procedures before the interview	Search for the professional and scientific trajectory of the interview (prior occupations and positions, publications, the main partners, and their eventual roles in the ecosystem.)		
	Search for firms' information on association, websites, technology news, international fairs.		
Topic	**Question**	**Notes**	**Authors**
Beginning	Revision of the Research goals (PDF File)		
	Ask the respondent if the meeting can be recorded		
	Send by e-mail the Confidence Agreement Contract and ask the respondent to sign (through the Contractor platform) and present the research website		
	Please tell me a little about yourself. What is your background?		
	Tell me about the business. What does your business do?		

Ecosystem Desing	Who are the customers?	Try to identify if the consumers have the power to buy the product (has an active role in the ecosystem (consumers' adoption of the solution and partners B2B's incentives to adopt the solution)	Adner, 2017
	Which markets are you targeting?	Try to identify if the firm's business model has some impact on positions of the traditional market business model, or changes in links that give rise to a new set of interactions.	Adner, 2017
	Why do you think your customers find your product valuable? What do customers find valuable?	Value proposition	
	No, let's backtrack to know your product or your service. Which companies or who do you work with to actually deliver this? Who do you work with to actually develop/ create the products, and who you're working with to deliver them? Is this a one-time relationship or a constant relationship?	Try to understand who the ecosystem members are and what kind of relationship they have (They are independent, they operate as separate businesses, and have adoption choices?). Try to understand the types of relationships, interdependencies (explore technological, cognitive, and economic interdependencies), and complementarities that exist in relationships	Ganco et al., 2020; Gomes et al., 2021a; Luo, 2018; Shipilov and Gawer, 2020; Talmar et al., 2020; Thomas and Autio, 2020
	How did you work with them?	Collaboration: Members may interact through routines to jointly create and capture value. Try to explore collaborative routines for co-creation, co selling, co production, and problem-solving. Try to find some examples of routines. Try to understand if they see that there is any type of combined effort between companies to achieve common goals and benefits.	Cao and Shi, 2020; Gawer, 2014; Hannah and Eisenhardt, 2018; Meng, Li, and Rong, 2019; Ranganathan, Ghosh, and Rosenkopf, 2018

	Why do you work with them?	Value addition: try to understand what is the value that each member adds to the ecosystem. Try to understand how much profit, knowledge, resources, and contacts are members adding. (list by member). What critical interactions exist among the actors?	Adner, 2017; Adner and Kapoor, 2010; Granstrand and Holgersson, 2020; Ritala et al., 2013; Walrave et al., 2018.
	How you and all these firms you told me make money with the ecosystem?	Try to understand what is the value captured by each of the ecosystem members (what type of profit, knowledge, benefits resources, and contacts are members capturing?) (list by member)	Acs, Stam, Audretsch, and O'Connor, 2017; Cennamo and Santaló, 2019; Gomes et al., 2018; Ritala et al., 2013.
	Do you know of any other place in the world where this same technology is being developed, tested, and validated in the market?	Competition outside IE: Try to understand another ecosystem that also delivers the same value proposition to the market. What would be the differentials of this ecosystem compared to other competitors?	Pombo-Juárez et al., 2017; Xu et al., 2018
	At the end of the day, why all of you are interested in working together? What beliefs do all of you share?	IE Identity: Investigate what is the shared meaning of the ecosystem that arises from the consciousness of its members.	Gomes et al., 2021b; Thomas and Autio, 2020
Changes in the ecosystem	Now that I understand a little bit about the flow of technology in your company and the roles you play in that ecosystem, I'd like to take a look back in more depth. How has this changed over the past year?	Observe the evolution. Try to understand how the ecosystem-building process happened. What year did you start and what was the initial idea you had about this ecosystem and what were the highlights in your trajectory? Is expected to characterize the business opportunity. Raise the stage of market and technology development at the time of business creation.	Talmar et al., 2020; Gomes et al., 2018; Adner, 2006; Gomes et al., 2018; Dattée et al., 2018; Kapoor & Klueter, 2021
Changes in the roles of actors	Has your network of relationships changed a lot over time? Tell me more about these changes. Have they always been there?	Map changes in actors, roles, and interdependencies	Ganco et al., 2020; Gomes et al., 2021a; Luo, 2018; Shipilov and Gawer, 2020;

			Talmar et al., 2020; Thomas and Autio, 2020
Changes in the Focal Innovation	How have your customer needs evolved over product generations?	Understand the user buy-in process regarding the new technology. Possible problems of non-acceptance of new technologies in the market.	Dosi, 1982; Fine, 1998
End	Ask if the respondent has any questions or wants to ask something.		
	Do you know anyone else I could speak to about this topic? Could you please send me a recommendation e-mail?		
	Do you have some data to send me (any interview, report, information that may help to better understand the things you told me)		
	Is that okay if I come in contact with you again at some point in the future?		
Procedures after the interview	Transcribe the interviews		
	Analyze them using open coding on the NVIVO		
	Try to understand what the leading ecosystem value chains are, which companies are the main innovators, and which ones may require complements (Systemic innovation:). Hierarchically independence: analyze if the firm is trying to coordinate the ecosystem, even when they have no formal hierarchy among them.		
	Write a text describing the main ecosystem attributes. Draw a focal IE Canvas based on previous literature insights to visually show how IE attributes present themselves in the field. The ecosystem has a collective value proposition that is the sum of these levels down.		
	Contact the net companies using the snow bowl technique (in order to map the ecosystem in the view of other members)		

Specific Goal	b) Identifying the sources of uncertainties and how they evolved along its growth trajectory		
Justification	To understand how each uncertainty source is related to ecosystem evolution. How do decision-makers frame the uncertainties (i.e., perceive them as opportunity vs. threat)?		
Specific Goal	c) To investigate how ecosystem members deal with uncertainty. Through what strategies do they respond to the uncertainties when managing their implications to the innovation ecosystem management?		
Justification	Understand strategies for dealing with uncertainty through the manager's decision-making process (i.e. the strategic creation processes)		
Methodological Step	Interview with main players of the ecosystem (suppliers, complementors, orchestrators) with deep knowledge about the trajectory of the ecosystem		
Before start	Revisit the map drawn at the previous meeting and bring it to the interview.		
Topic	**Question**	**Notes**	**Authors**

Beginning	Present the map drawn at the previous meeting, which shows the technological flow and main actors		Gomes et al. (2021)
	Revision of the Research goals (PDF File) (if necessary)		
	Ask the respondent if the meeting can be recorded		
Uncertainty	Have you ever wondered if participating in this ecosystem would really be the best thing to do? Do you think other members share the same opinion?	Map uncertainties in the innovation ecosystem's evolving structure	Alchian (1950); Gomes et al. (2013; 2018; 2019); Moeen et al. (2020); Saghaei et al. (2020); Li et al. (2021); Kapoor and Klueter (2021); Rice et al. (2008); Wernerfelt and Karnani (1987); Gomes and da Silva Barros (2022); Milliken (1987); Adner (2012)
	What challenges did you face? What uncertainties or knowledge gaps or unanswered questions did you have at that time? What decisions did you make?	Diagnoses uncertaintins that happened along the way. Investigate in which moments the respondent used shaping and adapting.	
	How did it progress/evolve? What uncertainties, in your opinion, existed in the past and have already been resolved?	Observe what were the milestones in the trajectory of evolution and the changes and evolution of the ecosystem's value proposition	
	Have you been looking for new information? What type of information?		
Strategies to deal with uncertainty	Did you use your power or influence to resolve this situation?	Observe the evolution, in which moments the respondent used shaping and adapting. Check if the interviewees did some kind of alignment and experimentation to solve the problems that arose.	Furr and Eggers (2021); Kapoor and Klueter, (2021); Wiltbank et al. (2006); Milliken (1987); Gomes et al. (2019); Gomes and da Silva Barros (2022)
	How did you deal with these knowledge/information gaps and doubts at that time?		
	How did you do to access this knowledge?		
	Did you write a business plan at some point in the development of the venture? Did you use any visual planning techniques: Canvas Business Model, Technology roadmapping, among others? Or go straight to action, getting your hands dirty?		
End	Ask if the respondent has any questions or wants to ask something.		
	(Complementary Question) Do you know anyone else I could speak to about this topic? Could you please send me a recommendation e-mail?		
	(Complementary Question) Do you have some data to send me (any interview, report, information that may help to better understand the things you told me)		
	Is that okay if I come in contact with you again at some point in the future?		

	Contact the companies using the snow bowl technique
Procedures after the interview	Transcribe the interviews
	Analyze them using open coding on the NVIVO
	Analyze their secondary data, and podcasts using open coding on the NVIVO
	1) Characterization of the company and entrepreneur and its trajectory, the business opportunity, the market, technology, product (or service), production process, business model, and the ecosystem
	2) Description of decisions and uncertainties
	2.1) To identify and describe the “decisions” of the entrepreneur.
	2.2) To identify and describe the context of the decisions.
	2.3) To identify, describe, and analyze the actor's actions to deal with the following individual uncertainties.
	2.4) To investigate actions taken to improve the structuring of the decision
	2.5) To investigate the origin, types, areas, and extent of uncertainties.
	2.5.1) These decisions must fill a table containing 1) market or technology 2)Entrepreneur 3) Ecosystem actor 4)Effect on the entrepreneur and effect on partners 5) context 6) actions 7) uncertainty types 8) uncertainty areas 9) uncertainty extension 10) managerial approach 11) decisions 12) Origin 13)When did uncertainty arise 14) Effect on the actor 15) Effect on other actors
	2.5.2) The same procedure must be done for the decisions of other actors in the ecosystem.
	2.6) To analyze the distortion of information across the ecosystem. This is due to the fact that knowledge and information are asymmetrically distributed. These knowledge and information gaps are related to uncertainties.
	The next step is to analyze the actions aimed at reducing uncertainties to represent the ecosystem as a network of uncertainties and to analyze how the actors deal with it.
	Create a visual map that shows how uncertainties advance as the ecosystem grows (Langlely, 1999; 2017). Write a text describing the phases. To identify the critical event that characterizes each of the stages of the ecosystem evolution and the sources of uncertainty associated with each of them, determine the decisions, uncertainties, and actions used to equate the uncertainties raised; raise new decisions, uncertainties, and actions.
	Categorize the data and check the patterns of similarities in the answers.

10.2 APPENDIX B – CONSENT TERM

Consent Letter

You have been invited to participate in the academic research entitled "Uncertainty Management Deconstructed: Strategies to Surpass the Liability of Newness of Innovation Ecosystems."

PURPOSE OF STUDY

This project focuses on what strategies can provide superior growth of a specific technology in the market. More precisely, this study aims to explain what response patterns exist for uncertainty in a nascent ecosystem. To do that, I will interview managers from technological companies related to a specific value chain. The specific goals of this study are a) to identify, map, and describe an innovation ecosystem, pointing its many events along its growth trajectory b) To reconstruct the nascent innovation ecosystem history since its inception, mapping and describing how that structure evolves c) Identifying the sources of uncertainties and how they evolved along its growth trajectory d) To investigate the manager's decision-making process to deal with uncertainties.

PRINCIPAL RESEARCHER

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STUDY PROCEDURES

- Your participation is very important in carrying out this research;
- Respondents will be invited to participate in a minimum of one and a maximum of 4 interviews;
- The script of questions will be sent to the participant in a separate document;
- Each interview will last one hour;
- Data collection intends to run between October and December of 2022;
- The interviews will be recorded, transcribed, and analyzed only for academic research purposes;
- All material analyzed will be reviewed by the interviewee to guarantee the reliability of the data collected.

BENEFITS

We hope that the information obtained from this study may help your company understand which strategies can be useful to help your company better navigate the innovation ecosystem in which it is embedded. From this study, you will understand the strategies to deal with uncertainties in this context.

CONFIDENTIALITY

For this research study, your comments will be anonymous. The researcher will make every effort to preserve your confidentiality, including the following:
- Information will not be shared with anyone other than those participating in this research;
- The names of the companies participating in the study can be mentioned in the scientific article to be published if it is of interest to the interviewee;
- Assigning code names/numbers for participants that will be used on all research notes and documents;
- Keeping notes, interview transcriptions, and any other identifying participant information in a locked file cabinet in the personal possession of the researcher;
- Participant data will be kept confidential except in cases where the researcher is legally obligated to report specific incidents. These incidents include, but may not be limited to, incidents of abuse and suicide risk;
- The writing of the final thesis document may contain acknowledgments to the research participants if this is of interest to the interviewee;
- Researchers are forbidden to perform any type of confrontation of information between the interviewees that could result in the identification of the sources interviewed.
- The researcher will delete parts of the interview if the interviewee wishes.

CONTACT INFORMATION

The researcher will be available to answer questions. If you have questions regarding your rights as a research participant, or if problems arise that you do not feel you can discuss with the Primary Investigator, do not hesitate to get in touch with the Institutional Review Board at Kadigia Faccin <kadigiaf@unisinos.br>

VOLUNTARY PARTICIPATION

Your participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you decide to participate in this study, you will be asked to sign a consent form. After you sign the consent form, you are still free to withdraw at any time and without giving a reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed.

CONSENT

I have read and understood the provided information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason or cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Brazil, September 2022

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Interviewee's Signature