Towards a Theory of Ecosystem Resilience: Actor Perceptions and Institutional Influence in the Small Satellite Ecosystem

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Supervisor: Yimei Hu

Group members and student numbers:

Kristoffer Lund Breil: 20203424

Larisa Nicoleta Ciocârlan: 20202954

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Kristoffer L. Breil & Larisa N. Ciocârlan

Aalborg University Business School, Denmark

ABSTRACT

In an era marked by geopolitical volatility, technological disruption, and mounting interdependence, the resilience of business ecosystems has become a critical concern, particularly in high-stakes settings such as the small satellite industry. While resilience is well-established at the firm level, little is known about how it emerges, is perceived, and is enacted at the ecosystem level. This thesis addresses that gap by investigating how ecosystem resilience is understood and operationalised by actors, primarily, within the European small satellite ecosystem. Employing a single embedded case study design, the study draws on twelve in-depth interviews across the small satellite ecosystem; spanning focal firms, suppliers, complementors, institutions and universities. The data is analysed using the Gioia methodology, enabling the identification of four aggregate dimensions: 1) subjective perceptions and practices of resilience, 2) interdependence and value co-creation, 3) institutional influence, and 4) vulnerabilities and adaptive strategies.

The findings reveal that ecosystem resilience is a layered and negotiated process; emerging not from top-down coordination but from the decentralised, often unintentional alignment of individual strategies and institutional structures. Actors perceive resilience as both a mindset and a practice, shaped by financial constraints, geopolitical dynamics, and shifting customer expectations. Institutions, particularly space agencies and national funding bodies, play a pivotal role in this process by legitimising technologies, allocating resources, and shaping the technical and normative frameworks within which actors operate. Their influence extends beyond stabilisation – they actively participate in the renegotiation of ecosystem balance in response to shocks, value migration, and technological change. The thesis contributes to ecosystem and resilience theory by offering a conceptual framework that integrates structural, behavioural, and institutional dimensions of collective adaptability. Ultimately, the study suggests that resilience in complex ecosystems depends less on insulation from shocks than on the ability to navigate interdependence. In doing so, it equips practitioners and policymakers with new tools for understanding and enhancing the systemic robustness of innovation- and technology-intensive industries.

Keywords: Ecosystem resilience, ecosystem, resilience, small satellite, critical realism, interdependence, institutional influence, innovation ecosystems, strategic resilience, supply chain, value chain, value co-creation, qualitative case study

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1. Introduction

In a time of accelerating geopolitical tension, rapid technological churn and ever-deeper reliance on space-borne services, small satellites have travelled from the margins of experimental engineering to the heart of commercial and security strategy. Falling launch costs and rising demand for live data are pushing both start-ups and industry giants to fill low-Earth orbit (LEO) with satellite constellations that deliver global connectivity, detailed Earth images, and real-time insights. The standardised CubeSat platform – a modular, miniaturised satellite format – along with commercial-off-the-shelf (COTS) electronics and an expanding rideshare market seem to democratise access to orbit; yet every promise masks a dependency whose failure can reverberate throughout the ecosystem. The ecosystem remains structurally dependent on its supply base: limited purchase volumes diminish bargaining power, leaving integrators vulnerable when a single board supplier fails or a precision machining partner ceases operations. Industry managers describe a 'small volume trap', cf. section 4.1.2, where flight proven parts are scarce, lead-times stretch into quarters and textbook dual sourcing becomes aspirational rather than achievable. In summary, the very forces that have enabled the growth of New Space have also rendered its ecosystem acutely sensitive to disruption – making collective resilience perhaps not merely desirable, but indispensable for firms, governments and institutions alike.

The small satellite ecosystem exemplifies both the promise and the challenges of this evolving landscape. Standardised CubeSat architectures have lowered the threshold for market entry, yet mission success continues to depend on the seamless coordination of an ecosystem that spans component suppliers, platform integrators, launch brokers, and other key actors.As recent studies detail, this ecosystem's vitality rests on dense complementarities, fragile supply lines and the implicit coordination provided by institutional hubs such as the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA). The same attributes that power collective innovation can therefore propagate bottlenecks. The prior work of the authors offered an early glimpse of these tensions. By treating a European small satellite manufacturer as a focal lens, Breil & Ciocârlan (2025) showed that ecosystems may both enable and constrain firm-level resilience: flight proven modules, shared legitimacy and agency funding insulated the company from certain shocks, while single-source dependencies, launch congestion and policy realignments exposed new vulnerabilities. That project, however, stopped at the organisational boundary. It traced how one actor drew strength – or suffered weakness – from the wider ecosystem constellation, but it did not ask whether the ecosystem itself might display, or lack, a capacity to bend without breaking. This unaddressed issue therefore at least constitutes the point of departure for the present study – an extension already signalled in the earlier project as a priority for future research.

The broader literature tells a similar story. Resilience is now a staple of strategic management discourse, yet empirical and conceptual treatments still gravitate toward the firm as the unit of analysis. Only a handful of scholars have begun to probe resilience as an emergent, multiscalar property of business ecosystems, cf. chapter 2, and their efforts remain piecemeal, often limited to game-theory models or to case studies of a single industry. As a result, one has remarkably limited knowledge about how ecosystem participants interpret the idea of collective resilience, negotiate its costs and benefits, or enlist institutional frameworks to strengthen – perhaps unintentionally – the system in which they operate.

This absence motivates the present thesis. The problem confronted is the absence of an integrated explanation for how ecosystem-level resilience is conceived, enacted and mediated in practice. Without such an explanation, managers risk over-investing in proprietary buffers that solve past threats while ignoring interdependencies that will determine future survival; institutions, for their part, lack the evidence base to design governance instruments that reinforce, rather than inadvertently erode, systemic robustness. The objective, therefore, is to unravel the foundations and drivers of ecosystem resilience in the small satellite ecosystem. Concretely, this thesis seeks to demonstrate how individual actors' perceptions and behaviours co-evolve with structural interdependencies and with the rules, resources and legitimising signals issued by institutional hubs. The overarching goal is to advance a nascent theory of ecosystem resilience that transcends firm-centric pathologies and foregrounds the relational, negotiated and politically inflected character of adaptive capacity. In these circumstances, this study poses two inter-related research questions:

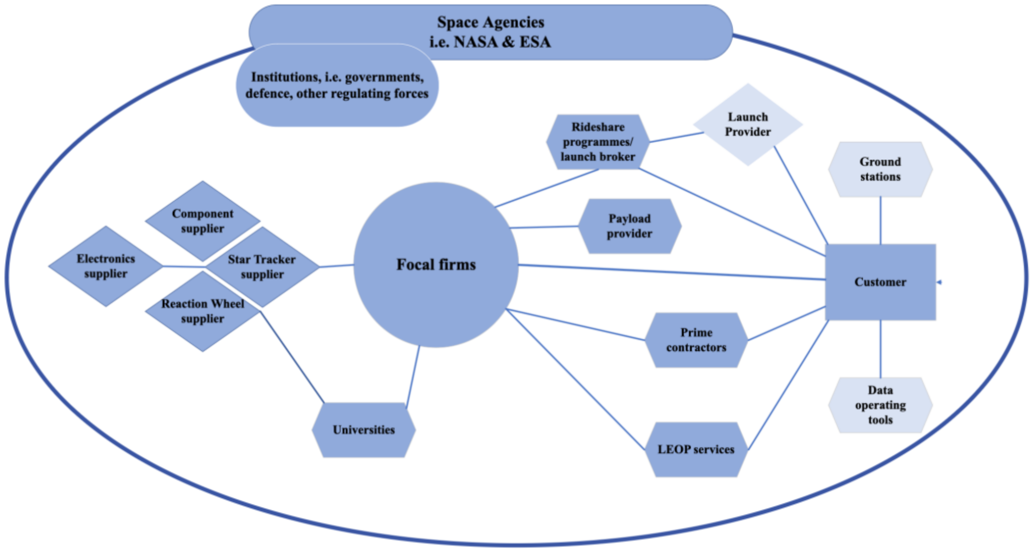
> *RQ1: How do different actors perceive and experience ecosystem resilience, and how does it affect their actions?*
> *RQ2: How may institutions impact the co-evolution and resilience of the ecosystem?*

By combining extensive qualitative data from twelve in-depth interviews within a single embedded case study, the aim is to make four contributions. To extend resilience theory beyond the organisational boundary, demonstrating that adaptive capacity is forged in the interaction of subjective mind-sets, structural complementarities and institutional guardrails. The thesis translates ecosystem theory into an actionable diagnostic for practitioners who must manage cooperation and competition under acute uncertainty. The thesis surfaces the under-appreciated role of institutional hubs as stabilisers – and sometimes as stressors – of technology ecosystems. Finally, the thesis furnishes policymakers with evidence that targeted governance may amplify positive spill-overs and mitigate systemic fragility. In doing so, the thesis seeks to shift the conversation from "how does a single firm survive the storm?" to "how may the entire constellation steer clear of the storm in the first place – and, if caught in it, emerge together on the other side?". Theoretically, the thesis contributes to an emerging dialogue on resilience in business ecosystems by introducing two interlinked constructs. First, it develops a stage perspective model of ecosystem resilience, showing how actors at different maturity levels perceive, enact and shape resilience in qualitatively distinct ways; from reactive survival to strategic orchestration. Second, it advances the concept of ecosystem balance as a continuously reconfigured condition, shaped by value migration, institutional intervention and actor repositioning.

1.1. The Small Satellite Ecosystem in a Snapshot

The empirical setting could scarcely be more suitable. The small satellite ecosystem is global in reach yet narrow in volume; it relies on a handful of specialised suppliers, is subject to mission-critical standards, and is increasingly marked by a paradoxical drift toward vertical integration that challenges the long-celebrated virtue of modular specialisation, cf. section 4.2.1. In this crucible, even modest perturbations can ripple through the entire ecosystem, amplifying or dampening resilience in unexpected ways. The model introduced here is a lightly revised version of the authors' earlier framework and serves as a concise snapshot of the whole small satellite ecosystem that the rest of this section will unpack.

Figure 1: Author depiction of the small satellite ecosystem



Source: *authors' revised framework from Breil & Ciocârlan (2025)*

At the centre of the ecosystem is the focal firm – the integrator – which brings together dozens of subsystems to deliver a unified, mission-specific satellite. Its legitimacy, in this context called flight heritage, hinges on a record of flawless execution in both launch and early orbit operations, as well as on the breadth of its supplier network; yet its bargaining power is often constrained by a low-volume reality that sometimes poorly positions the firm towards its suppliers, cf. section 4.1.2. These suppliers in turn sometimes support other, higher-volume ecosystems, such as automotive, telecommunications, or consumer electronics, where steadier demand for similar components can pull production capacity away from the small satellite ecosystem. Some integrators therefore internalise critical components to secure cost, schedule and quality, while still depending on external specialists for highly advanced payloads – the mission-specific instruments or sensors that delivers the satellite's service – deemed too unviable to replicate, cf. section 4.2.1. Upstream, the integrator depends on a set of specialised suppliers: avionics and power-electronics firms that build flight computers and battery-management units in small batches before returning their lines to larger medical or automotive orders; single-product companies that provide star trackers or reaction wheels for attitude control; propulsion firms that sell compact electric thrusters; and workshops that machine aluminium structures or apply thermal coatings (Williams et al., 2020; NANOSATS Database, ntd).

Surrounding the integrator, both upstream and downstream, is an array of complementors whose offerings either unlock or amplify the satellite's ultimate value proposition. Rideshare programmes its launch brokers bundle disparate payloads, translate interface requirements and allocate scarce fairing volume, smoothing access to orbit for small satellite firms that would otherwise be priced out of dedicated launches (Williams et al., 2020). Downstream, ground-station networks provide telemetry, tracking and command; software services seek to automate early orbit processes; data-analytics houses transform raw satellite data into usable data that defence ministries, weather services or venture-backed start-ups can monetise. Prime contractors sit one tier above the integrator as the single accountable partner that defence and space agencies demand. Drawing on strong balance sheets, security clearances and diplomatic links, they absorb legal liability, manage both spacecraft and ground segment, and handle export licences. Most focal firm satellite bus integrators lack this capacity, so they sell their standard satellite bus to the prime, which rebrands it, adds the payload and services, and earns a margin for carrying the risk and accessing markets the integrator cannot reach alone, cf. section 4.2.4.

Universities serve as long-term anchors of innovation and talent within the small satellite ecosystem. Unburdened by immediate commercial pressures, academic teams may pursue high-risk technologies and trial them on student-led satellite missions where setbacks are, comparatively, inexpensive lessons. Inadvertently, these projects also produce engineers who enter industry having already managed requirements definition, assembly-integration-test, and early-orbit operations, easing the ecosystem skills gap, cf. section 4.3.2. Moreover, academic successes often transition to the market through university spin-outs, seeding new supplier niches and expanding the ecosystem's technological variety. Because universities plan over decades and remain neutral in commercial rivalries, they also provide a stable forum for international collaboration, keeping knowledge flowing even when market or geopolitical conditions become volatile. Consequently, by supplying proven innovations and skilled labour, universities widen the ecosystem's technological options without upsetting its overall balance.

Customers, such as civil ministries, commercial constellation operators and defence agencies, sit at the end of the chain yet hold decisive influence. Many satellite components are considered dual-use, meaning the same hardware can support both civilian services, such as weather monitoring, and military or intelligence tasks, such as reconnaissance (OECD, 2023). The modular design of small satellite offerings lets them pair one firm's satellite bus with a launch broker of their choosing, choose whichever ground-station network fits their downlink plan, and add analytics or automation services as budgets or security rules allow. This freedom to mix and match complementors keeps interfaces open, prices competitive and the balance of power tilted toward the customer rather than any single provider, cf. section 4.2.3.

Encircling the ecosystem are institutional actors that function as hub firms, steering rather than merely supervising its evolution. Space agencies such as ESA and NASA channel grant funding, issue interface standards and couple awards to schemes like geographical return – rules that distribute contract spending back to member states in proportion to their financial contributions – thereby deciding which technologies progress and where work is placed across national industries (ESA, 2025). Their mandates give them agenda-setting power: by defining debris-mitigation rules or endorsing the CubeSat form factor they synchronise design choices far beyond their own programmes. Beside them are defence ministries, export-control offices and spectrum authorities whose clearances, licensing decisions and security demands can accelerate a launch campaign or halt it overnight, tightening or loosening the whole system's cadence. Together with institutional hubs, these actors help shape the architecture and tempo of the small satellite ecosystem. Firms succeed only to the extent that they align with the incentives, constraints, and forms of legitimacy conferred by these governing bodies.

2. Theoretical Background

The subsequent chapter on theoretical background covers the analytical foundation for the study. It reviews how business ecosystem research and resilience scholarship have evolved, clarifies the definitions and concepts the thesis will use, and pinpoints the gaps this work addresses. The chapter first traces the main streams of ecosystem theory, then shows how resilience has been modelled – mostly at the firm level – and why a shift to the ecosystem level is now needed. It closes by setting the study's definition of an ecosystem and the questions that follow from viewing resilience as a collective, co-evolving property rather than a purely organisational capability.

Resilience, in this thesis, is understood as the ability of a firm and the wider ecosystem in which it is embedded to absorb shocks, adjust to new conditions and continue delivering value. It is a multi-faceted construct that unfolds through two complementary logics: proactive strategies that anticipate and prevent disruption, and reactive strategies that adapt and recover once a disturbance has occurred.

While the extant literature has only recently begun to explore resilience as an emergent property of ecosystems, a prior empirical study by the present authors offers an early conceptual and practical bridge between ecosystem theory and resilience within the context of the small satellite industry (Breil & Ciocârlan, 2025). By examining a focal firm within the European small satellite ecosystem, the study demonstrated that ecosystems may serve as both enablers and constraints of organisational resilience. Notably, it extends resilience discourse beyond firm-level capabilities by identifying how structural interdependencies, actor complementarities, and institutional governance mechanisms shape the strategic options available to individual firms under conditions of uncertainty. The study introduced the notion of ecosystems as external determinants of resilience, where the degree of firm embeddedness and the availability of modular, flight proven components influenced both proactive and reactive resilience strategies. Key findings included the role of flight heritage as a source of performative legitimacy, and the identification of structural bottlenecks, such as supplier immaturity and constrained launch access, as systemic inhibitors of resilience. Furthermore, it highlighted how the focal firm's internal organisational choices, such as vertical integration and multi-role positioning, could either mitigate or exacerbate exposure to ecosystem vulnerabilities. The study also proposed a refinement of existing resilience frameworks by integrating ecosystem theory, arguing that organisational resilience cannot be meaningfully understood without accounting for the inter-firm structures and institutional actors that shape adaptive capacity.

2.1. The Evolution of Ecosystem Definitions and the Study's Conceptual Approach

Before delving into the debates that shape ecosystem research, this section first sets the basic vocabulary of ecosystems. Four central ideas – complementarity, interdependence, hub firm, and focal firm – recur across ecosystem literature and frame the arguments that follow. Table 1 sets out concise definitions and cites some of the sources often credited with developing each term, giving readers a clear reference point for the rest of the paper.

Table 1: Core Ecosystem Concepts and their Definitions

Concept	Definition	Key author(s)
Complementarity	The value of one component or actor rises when coupled with another, so that the joint offering exceeds the sum of standalone contributions.	Jacobides et al. (2018); Adner (2017)
Interdependence	Mutual dependence among ecosystem participants whereby the performance or survival of each party is contingent on the actions of others.	Iansiti & Levien (2004); Moore (1993)
Hub firm	A central actor that sets technical standards, orchestrates complementarities and invests in shared assets to maintain overall ecosystem health.	Iansiti & Levien (2004)
Focal firm	The organisation around which the ecosystem is built; its value proposition defines the problem to be solved and guides the orchestration of complementors and suppliers.	Adner (2017); Jacobides et al. (2018); Moore (1993)

Source: *authors' own table*

The seminal notion of a business ecosystem originates in Moore's (1993) portrayal of co-evolving capabilities and actors aligning around new innovations, cf. table 2. Much like a biological ecosystem, interdependence and mutual adaptation are considered vital to the ecosystem's survival. In a similar vein, Iansiti and Levien (2004) highlight that ecosystems consist of loosely interconnected but interdependent participants whose shared fate compels them to continuously recalibrate their roles and relationships. These foundational studies foreground an evolutionary perspective, viewing ecosystems as fluid, adaptive communities rather than fixed, static networks, thereby revealing the collective sense-making and continuous innovation that arise from co-evolving actor relationships.

Subsequent scholars sharpened the theoretical underpinnings by specifying the structural attributes of an ecosystem. Adner's (2017) seminal definition focuses on multilateral coordination, framing the ecosystem as an "alignment structure" wherein multiple partners must interact effectively for a focal value proposition to materialise. In parallel, Teece (2007) draws attention to the institutional underpinnings, arguing that these external actors do more than influence transactions: they actively shape the strategic latitude firms enjoy. Further refining ecosystem theory, Jacobides et al. (2018) propose the concept of complementarities, the idea that actors collectively create a higher-order offering through specialised, interlocking contributions, without any single entity exerting hierarchical control.

Alongside these conceptual advances, scholars such as Granstrand and Holgersson (2020) introduced a distinct emphasis on innovation ecosystems. Here, the analytical lens shifts toward how evolving sets of actors and artifacts, together with institutions and relations, drive or constrain innovative performance. While earlier works like Moore (1993) and Iansiti and Levien (2004) underscored co-evolutionary dynamics, Granstrand and Holgersson's perspective delves deeper into the technological undercurrents, intellectual property regimes, and knowledge flows that propel or impede innovation outcomes within an ecosystem.

Table 2: Popular ecosystem definitions

Source	**Type of ecosystem**	**Definition**
Moore, 1993	Business ecosystem	*"In a business ecosystem, companies co- evolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations."*
Adner, 2017	Ecosystem	*"The ecosystem is defined by the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialise."*
Iansiti & Levien, 2004	Ecosystem	*"...characterised by a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival."*
Jacobides et al., 2018	Ecosystem	*"An ecosystem is a set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled. "*
Granstrand & Holgersson, 2020	Innovation ecosystem	*"An innovation ecosystem is the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors*."
Teece, 2007	Business ecosystem	*"... the business 'ecosystem' – the community of organisations, institutions, and individuals that impact the enterprise and the enterprise's customers and supplies. The relevant community therefore includes complementors, suppliers, regulatory authorities, standard-setting bodies, the judiciary, and educational and research institutions."*

Source: *the authors own table*

Building on these convergent viewpoints, our thesis adopts a hybrid definition that situates the ecosystem as a:

> *"Multilateral structure of interdependent and complementary actors, and institutions, whose co-evolution and alignment dynamically shape the focal value proposition."*

This formulation draws directly from Adner's (2017) emphasis on alignment and complementarities, while also incorporating the broader institutional and evolutionary insights offered by Moore (1993), Iansiti and Levien (2004), Teece (2007), and Jacobides et al. (2018). Furthermore, it acknowledges innovation-specific nuances highlighted by Granstrand and Holgersson (2020), recognising that the pursuit and commercialisation of new knowledge is often the cornerstone of ecosystem functioning. Ultimately, the key contribution of our definition is underscoring that no single organisation can fully dictate value creation in isolation; rather, collective adaptability, emergent interdependencies, and shared legitimacy all become principal drivers of ecosystem health. It was observed that the small satellite ecosystem has evolved from a closed government-led domain into a dynamic and decentralised environment, where competition and cooperation coexist. This development suggests that the ecosystem is maturing, characterised by increasing interdependence and adaptability.

2.2. Measuring and Modelling Ecosystem Resilience

In bridging the existing theories of ecosystems and resilience, it is necessary to also consider how scholars have attempted to measure and model resilience at a collective rather than purely firm-specific level. A relatively small body of work has explored resilience within business ecosystems as opposed to individual organisations, suggesting that the conceptual development of ecosystem-level resilience is still in its infancy (Abdi et al., 2024; Gomes et al., 2023). Abdi et al. (2024), for instance, utilise agent-based modelling to capture the dynamic interactions within innovation ecosystems, illustrating how resilience may be measured through shifts in network structure and adaptive behaviours. Similarly, Gomes et al. (2023) propose performance measurement systems that integrate resilience metrics into firm decision-making processes, though their model is largely anchored in the interaction between firm-level outcomes and broader ecosystem conditions. Ultimately, these quantitative efforts, while valuable, indicate the challenge of defining resilience at a collective level, given that most existing research emphasises firm-level capabilities.

Resilience as a firm-level dynamic capability

Empirical and conceptual studies largely center themselves around resilience as a firm-level dynamic capability, examining how organisations adapt to disruption and exploit opportunities in their external environment (Bathke et al., 2024; Bughin, 2022; Heikinheimo et al., 2025; Iwu et al., 2023; Priyono et al., 2024; Tang et al., 2024; Zabel et al., 2023). In particular, Bathke et al. (2024) and Bughin (2022) focus on the processes through which firms develop foresight and agility, emphasising the path-dependent nature of resource reconfiguration while linking these capabilities to improved adaptive responses. Heikinheimo et al. (2025) and Priyono et al. (2024) examine how digital ecosystems facilitate the rapid sharing of information, thereby enhancing individual firms' capacity to respond to disruptions. In a similar vein, Zabel et al. (2023) introduce the importance of sensing capabilities in digital business ecosystems, pointing to the ways in which firms scan for emerging opportunities and threats, while Tang et al. (2024) demonstrate how IT firms modify their innovation ecosystems to improve adaptability. In a way, these studies frame resilience as an active rather than passive phenomenon, thus reinforcing the notion that firms play a proactive role in shaping the ecosystems upon which they depend. However, the emphasis remains largely on the firm-level perspective, often overlooking the extent to which resilience may potentially also emerge through broader ecosystem structures and relationships.

Interdependencies and structural vulnerabilities in ecosystems

A number of researchers address the ways in which interdependence within business ecosystems influences structural vulnerabilities, stressing that resilience is intrinsically tied to the networked nature of modern industries (Burford et al., 2021; Dong et al., 2022; Parente et al., 2019; Zang et al., 2022). Burford et al. (2021) and Dong et al. (2022) discuss how supplier networks and institutional contexts may shape both risk exposure and adaptive capacity, with each node in the network contributing to the overall resilience of the system. Parente et al. (2019) add an institutional dimension, illustrating how firms in unstable environments rely on collective mechanisms, such as shared norms and supportive regulatory frameworks, to strengthen their own resilience. One particularly noteworthy concept in this area is eco-embeddedness, introduced by Zang et al. (2022), which describes the deep integration of firms into their ecosystems. Specifically, eco-embeddedness is argued to be crucial for sustaining resilience, as it enables rapid information exchange, trust-building and coordinated responses to shocks, as by embedding themselves more deeply in their environments, firms not only sustain their own survival but also enhance the adaptive capacity of the entire ecosystem.

Ecosystems as resilience enablers

Further insight into the potential for resilience to exist as an emergent property of ecosystems is provided by research into platform and innovation ecosystems (Brink, 2017; Falcke et al., 2023; Floetgen et al., 2021; Heaton et al., 2024; Liu et al., 2024; Singal, 2022; Sun, 2025; Zabel et al., 2023). Floetgen et al. (2021) posit that platform-based relationships, characterised by co-creation and decentralised governance, possess innate resilience mechanisms. These include flexible network structures, diverse knowledge bases, and mutual dependence that incentivises rapid collective problem-solving. Zabel et al. (2023) and Singal (2022) focus on the role of governance within platform ecosystems, arguing that well-structured norms and rules may maintain legitimacy and stability, particularly in volatile environments. Sun (2025) addresses how small businesses leverage digital platform ecosystems to remain resilient in the face of economic fluctuations, underlining the value of ecosystem membership as an insulating factor for smaller, more resource-constrained organisations. Consequently, the notion that ecosystems inherently foster stronger resilience than traditional business models stems from their capacity for self-adaptation, where individual actors continuously reconfigure their roles in response to emerging conditions.

Complexity science and the emergence of resilience

The theoretical lens of complexity science furthers the understanding that resilience in ecosystems arises in a non-linear, coevolutionary manner rather than being a static attribute (Russell et al., 2018; Zang et al., 2022). Russell et al. (2018) argue that ecosystems self-organise in response to external pressures, with the patterns of interaction among firms influencing collective responses to disruption. Zang et al. (2022) connect the concept of coevolution with eco-embeddedness, suggesting that organisations strategically embed themselves to gain resilience advantages as the ecosystem evolves. Commonly, these perspectives emphasise the fluidity of organisational relationships and the importance of examining multiple levels of analysis to capture how resilience may shift over time.

Towards a theory of ecosystem resilience

Taken together, the existing literature indicates that resilience is far more developed as a firm-level concept than as an ecosystem-level phenomenon. Although several studies acknowledge the significance of the collective structure of an ecosystem and its interdependencies, there remains limited exploration of how resilience emerges from the interactions of multiple actors, particularly in dynamic or global contexts. The concept of eco-embeddedness provided by Zang et al. (2022) and Liu et al. (2024) points towards a relational conception of resilience, one that is anchored in deep integration within ecosystems rather than solely dependent on firm-specific capabilities, which is in accordance with the argument that resilience is best viewed as an emergent outcome of coevolutionary processes. As a result, a gap remains in our understanding of how the collective of ecosystems reorganise and adapt in response to crises. Much of the current discourse suggests that when firms act as proactive agents, they may bolster not only their own resilience but also that of the wider ecosystem. However, a holistic theory of ecosystem resilience that, among other things, accounts for interdependence, coevolutionary processes and eco-embeddedness is yet to be fully articulated. Consequently, the scarcity of theoretical integration at the ecosystem level stresses the need for research that systematically investigates how resilience manifests beyond firm boundaries.

3. Methodology

This chapter outlines the methodology employed covering: the single embedded case study research design grounded in critical realism; the retroductive research approach; data collection considerations; data analysis method; and lastly, considerations for ensuring qualitative rigour and validity.

3.1. Research Design

This research is grounded in the philosophy of critical realism (Bhaskar, 1975), as the study seeks to establish underlying mechanisms that shape ecosystem actors' contribution to overall ecosystem resilience. Assuming that reality exists independently of human perception – i.e. ecosystem roles, interdependencies, and regulations – how these actors collectively manifest to achieve an overall ecosystem resilience can only be understood through social construct. Before that it is important to identify their perceptions of ecosystems resilience to establish if the ontology is acknowledged or purely exists outside of ecosystem actors' perceptions.

Therefore, this paper adopts a single embedded case study using qualitative data, as it analyses a single ecosystem, namely the small satellite ecosystem. The reasoning behind an embedded case study is to enable an in-depth exploration of subunits embedded in the broader ecosystem context (Cresswell & Cresswell, 2018). These subunits are identified as the focal firm, suppliers (both upstream and downstream), complementors, institutions, and hubs.

The connection with critical realism will allow a multi-level exploration of the ecosystem: 1) individual actors' description of the ecosystem and perceptions of collective efforts, 2) individual actors' resilience strategies, 3) institutions impacting the ecosystem resilience. By integrating these levels, a deeper understanding of the complexity and comprehensiveness of an ecosystem's resilience can be provided.

The structure of this research is the following: 1) Firstly, the introduction covers research context, background, and research questions, while introducing readers to the small satellite ecosystem for clarity, 2) The theoretical background covers the evolution of ecosystem definitions, defining terms and concepts of ecosystem theory, and a small literature review that bridges the two theories/concepts: resilience and ecosystems, 3) Methodology showcases the research approach, strategy and design, discussing qualitative rigour, and presenting data collection and data analysis methods, 4) Findings are presented through the Gioia methodology, where dividing the chapter in correspondence to the four emerging aggregated dimensions, 5) In the discussion, core findings will be reflected on using theory, new theoretical contributions will emerge, and a theoretical framework will be theorised and presented, 6) Lastly, the conclusion chapter will cover core findings, practical considerations, limitations, and future research.

3.2. Research Strategy

Given the multi-level complexity that follows an embedded case study, an iterative research process is appropriate. As this paper seeks to identify underlying mechanisms and engage in theory-building, retroduction is employed as the research approach. This approach corresponds to critical realism accordingly, being quite valuable for uncovering the deeper domain. Additionally, this form of reasoning commences with the observable events and moves retrospectively to infer the causal mechanisms. Thus, retroduction involves stirring beyond observed events and explores how these events arose (Danermark et al., 2002).

Within the empirical layer, the authors are able to collect relevant data explicating the perceptions of ecosystem actors and their actions. While these address the first research questions, why they may have these perceptions or what makes their strategies possible warrants an unpacking of the deeper layers. An example of underlying mechanisms analysed in this paper is institutions and their influence on ecosystem resilience. Undoubtedly, retroduction will support the reveal of how institutions shape and impact ecosystem resilience, answering the second research question.

Both resilience and institutions are not observable, which calls for a more in-depth research approach to uncover how external mechanisms enable or constrains the overall ecosystem resilience. Hence, the retroductive approach is an appropriate reasoning logic for this paper, as it delineates with critical realism and the purpose of this paper.

3.3. Data Collection

The primary data was collected through semi-structured interviews of representative actors from each ecosystem role: suppliers (upstream and downstream), focal firm, complementor, institutions, and hubs. Additionally, interviewed representatives within the focal firm were government and institutional specialists, a part of the executive management team, and part of the upper-level management. Another focal firm interviewee covered the solution provider role, which is a new emerging space application. Consequently, by interviewing various representatives, the authors were able to contrast perceptions and actions. This type of data collection allows for deep exploration of how various actors perceive the overall ecosystem resilience. Additionally, this approach to data collection allowed the authors to explore the ecosystem actors' perception of their ecosystem, resulting in various perceptions, cf. chapter 4.

From an epistemological perspective, resilience itself cannot be directly observable; however, through actors' experiences, decisions, and strategies it can be inferred. To ensure robust results, the analysis cross-referenced these interview statements and perceptions with theoretical reasoning and secondary data, especially in sections 4.3 and 4.4. While sections 4.1 and 4.2 are mostly based on actors' perceptions, sections 4.3 and 4.4 emphasises on external and collective mechanisms impacting the ecosystem actors, thus justifying the use of secondary data as cross-references. Examples of secondary data used are ESA's Space Debris Charter, Technology Readiness Levels (TRL), and ESA official statements. Secondary data has especially been employed in the preliminary stage of this thesis to identify relevant participants and gain background knowledge regarding these actors; for example, through NANOSATS Database.

To minimise bias, representatives from various ecosystem roles were contacted and interviewed. Ensuring comparable results in exploring how different roles perceive and act in accordance with ecosystem resilience, a standardised interview guide was developed (Appendix E). This interview guide was systematically constructed to align with the two research questions. Firstly, the research questions were identified, followed by key topics within each research question, leading to the standard interview questions. While these standard questions were tailored to each participant's role and prior knowledge, they always reflected the relevant topics while ensuring clarity in terminology.

All interviews were recorded, transcribed, and subjected to thematic analysis, cf. 3.4. To encourage openness and transparency from ecosystem actors, participants were assured anonymity. Nevertheless, the following information about the interviews can be disclosed.

Table 3: Interview information

Interview	**Appendices**	**Duration**	**Role**
Focal Firm Rep. 1	Appendix F	1 hour	Executive Management
Focal Firm Rep. 2	Appendix G	1 hour 15 minutes	Executive Management
Focal Firm Rep. 3	Appendix M	1 hour	Upper-level Management
Solution Provider	Appendix N	40 minutes	Upper-level Management
Government Specialist	Appendix J	1 hour	Sales Director
Supplier A	Appendix H	1 hour	Executive Management
Supplier B	Appendix I	1 hour	Upper-level Management
Launch Provider (Downstream Supplier)	Appendix P	30 minutes	Key account manager
Institutions Specialist	Appendix K	1 hour	Business Developer
ESA Specialist	Appendix G	1 hour	Senior Project Manager
Launch Broker (Complementor)	Appendix O	45 minutes	Executive Management
University Rep.	Appendix Q	45 minutes	Faculty Strategic Project Manager

Source: *authors own table*

As illustrated in the table, each interview will be added in the appendix for academic transparency. Interview citations are structured to reference the appendix of the coding and the representatives ecosystem role. For example, (B2, Focal firm rep. 3, ref. 5-7) indicates the citation refers to Appendix B2, where statements 5-7 made by focal firm representative 3 can be found. This format ensures traceability and transparency of the qualitative data.

The sample did not include an end customer role directly involved in this ecosystem due to practicality reasons. While the customer role would add another perspective to the ecosystem, arguably, the result would not differ, as the research questions are more interested in the active ecosystem actors rather than the end customer. Conversely, a university representative was interviewed, who acts as a customer to the interviewed suppliers, occupying a focal firm role, while also serving as innovation hub and complementor, cf. section 4.3.2.

3.4. Data Analysis

To analyse the rich and in-depth empirical data, while minimising bias in the process, the paper employs the Gioia methodology (Gioia et al., 2012). This approach provides a structured yet flexible process to identify how ecosystem resilience is perceived, enacted, and shaped by institutions. This methodology corresponds with theory development through a multi-layered coding process.

First, an initial coding phase focuses solely on informant-driven concepts, followed by a refinement of these into broader first-order concepts. This corresponds with the empirical level in critical realism; an example in our data is representatives' description of the ecosystem. Next, second order themes are a further refinement of the first-order concepts, signifying the transition to a higher level of abstraction, where patterns in resilience strategies become evident. Furthermore, second-order themes are embedded in theoretical reflections, whereas first-order concepts reflect the participants' phrasings and concepts.

Discussions in the interviews revealed emerging insights at the empirical and actual level. Lastly, these second order themes will be further refined and grouped into aggregated dimensions, allowing us to identify the underlying mechanisms for the empirical and actual level shaping ecosystem resilience. The data structure and dimensions are explained in section 4. While the Gioia methodology is predominantly an inductive approach, its implementation with critical realism facilitates a retroductive approach that goes beyond perceptions. The analysis is therefore conducted with an iterative process, allowing flexibility and refinement of categories as new insights unfold.

Table 4: Example of the analysis process

Exemplary verbatim	First-order concept	Second-order theme	Aggregated dimension
"It's extremely risky business, so it's not really a question of friendship as it is a question of.. because a friendship to me is a luxurious thing. When everybody's safe, when everybody knows how to survive, then you can start to make friends. It's nice to have, it's not a must have." (Focal firm rep. 1)	Friendships vs. survival	Subjective perceptions towards ecosystem resilience	Perceptions and Practices of Resilience Across Ecosystem Actors
"Then when you are in defense there may be considerations, not only of pure strategic nature, so can I do that? Can I make money out of that? Of course, there are companies that are also making a decision of saying I do not work for defense projects. For example, out of principle." (Institutions specialist)	Business or morality	Subjective perceptions towards ecosystem resilience	
"Resilience in cash; having cash was number one and therefore managing costs, being very prudent, frugal, low inventory on everything, we order when customers are ordering – simply to manage the cash flow." (Focal firm rep. 2)	Revenue resilience	Strategic and operational resilience practices	

Source: authors' own table inspired by Magnani and Gioia (2022)

3.5. Qualitative Rigor and Validity

To ensure credibility and rigorous results, this section is dedicated to describing the paper's validity and reliability enhancement strategies.

Construct validity indicates the extent to which research is accurately measuring the theories and concepts it intends to explore (Gibbert et al., 2008). This is employed through the documentation of interview guides, coding structures, thematic analysis, and analytical assessments, enhancing transparency and replicability. This study employs data triangulation by collecting multiple perspectives from various sources, including CxO roles within the focal firm, other internal employees in the focal firm, suppliers, government specialists, ESA specialists, and launch brokers and providers. This approach ensured a multi-stakeholder perspective, capturing implications of an ecosystem by contrasting actors' perceptions and behaviour. Additionally, secondary data is employed to cross-check the data or deepen the findings, cf. section 3.3. Thus, the data triangulation further validates the findings by minimising bias and leading to more generalisability. Internal validity refers to the accurate identification of causal relationships (Yin, 2009). While this case is more theory-building and therefore exploratory rather than explanatory, internal validity is ensured through pattern matching across the interviews and relevant theoretical frameworks.

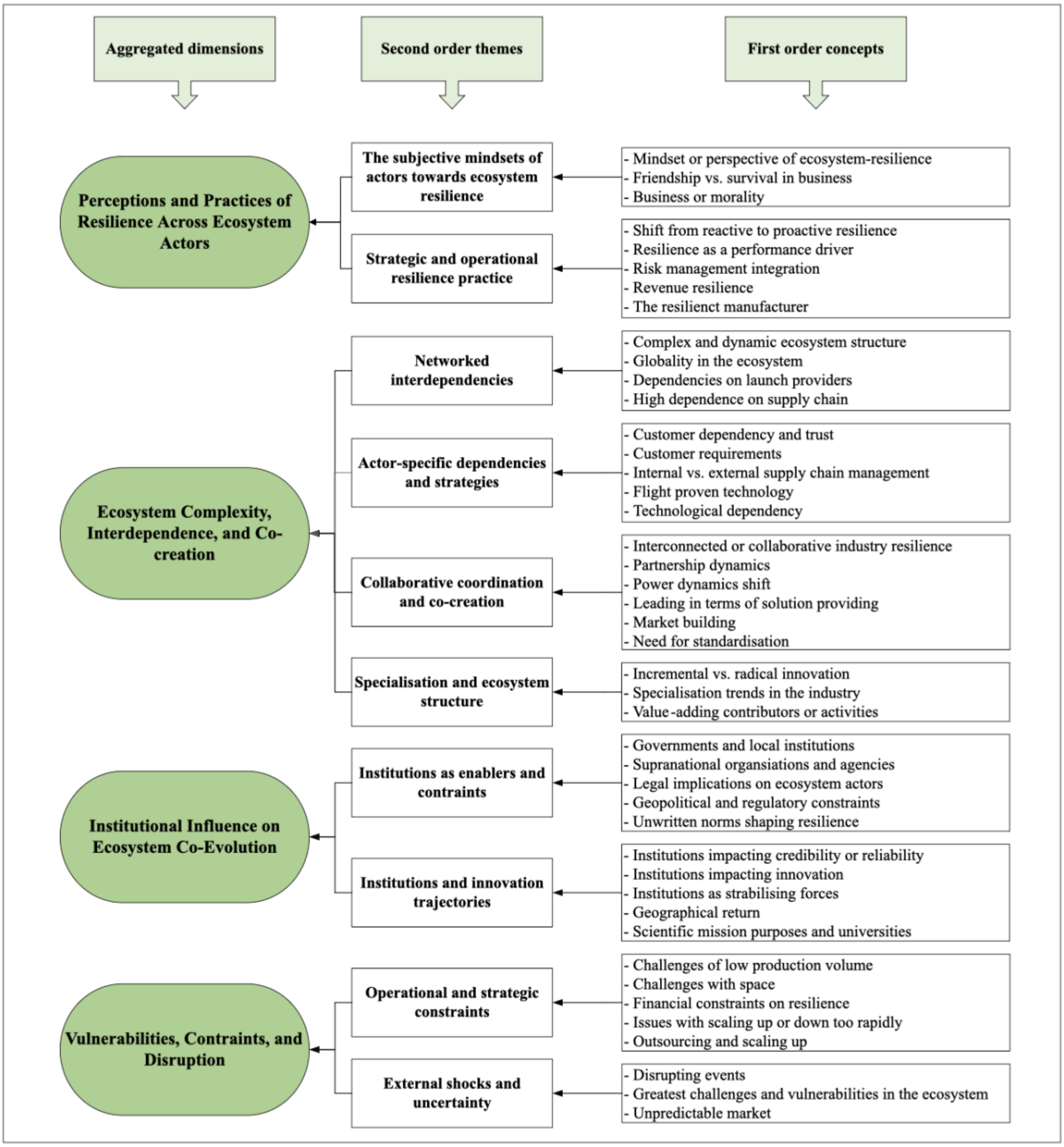
External validity suggests whether the results are generalisable (Eisenhardt, 1989). Since this paper employs a single embedded case study, generalisability is typically limited. This is especially the case for such a specific ecosystem as the small satellite ecosystem. However, the authors seek to contribute to the field by developing a new theoretical framework that explains ecosystem resilience and how other external factors, such as institutions, affect the relationship between ecosystem actors. Additionally, transparency in the research process increases the transferability of findings that can be easily applied. This relates to ensuring reliability, where the results can be replicated under the same conditions.

4. Findings

This chapter presents the empirical findings derived from the structured coding of the interview data, following the analytical approach outlined in section 3.4. Using the Gioia methodology, 44 broader first order concepts were identified across 12 interviews. These concepts, rooted in the participants' own expressions, were then grouped into second order concepts that engage with broader theoretical constructs from ecosystem and resilience theory.

As illustrated in Figure 2, the coded data is organised into three-level layers: first-order concepts, second-order themes, and aggregate dimensions. This coding framework provides a coherent foundation for the thematic analysis of how ecosystem resilience is enacted, perceived, and constrained across different actor types in the small satellite ecosystem, and how institutions impact the ecosystem's co-evolutionary process.

Figure 2: The aggregated dimensions



Source: authors' own figure inspired by Gioia et al. (2012)

The first aggregated dimension, *Perceptions and Practices of Resilience Across Ecosystem Actors,* captures how actors conceptualise and implement resilience themselves. This aggregated dimension encompasses two second-order themes and eight first-order concepts, highlighting subjective mindsets and operational practices in sustaining resilience. The second aggregated dimension, *Ecosystem Complexity, Interdependence, and Co-creation,* reflects the ecosystem's interconnectedness, demonstrating that resilience is irreducibly relational. With four second-order themes and 18 first-order concepts, this dimension is the most comprehensive of the four dimensions. The first two second-order themes emphasise on interdependencies, whereas the latter two second-order themes focus on collaboration, co-creation, and ecosystem structure.

The third aggregated dimension, *Institutions Influence on Ecosystem Co-Evolution,* highlights the roles of institutions as enablers and constraints, and how they impact innovation trajectories. This aggregated dimension includes two second-order themes, and 10 first-order concepts. Finally, a persistent fourth dimension emerged from the data, namely *Vulnerabilities, Constraint, and Disruptions.* This aggregated dimension comprises two second-order themes, and eight first-order concepts, synthesising insights into the operational and strategic constraints actors face, as well as exogenous shocks to which the ecosystem is exposed.

4.1. Perceptions and Practices of Resilience Across Ecosystem Actors

This aggregated dimension emphasises on ecosystem actors' perceptions of ecosystem resilience and their behaviour in terms of resilience practices, cf. figure 2. While this case study's unit of analysis is the ecosystem, it is important to delve into the subunits constructing the ecosystem. This aggregated dimension therefore has an actor-focus perspective and is specifically answering the first research question.

4.1.1. The subjective mindsets of actors towards ecosystem resilience

While ecosystem and resilience literature emphasise structural dynamics, institutional arrangements, and technological capabilities, the subjective mindsets of ecosystem actors remain underexplored. In the small satellite ecosystem rapid innovation, tight-knit relationships, and intense resource constraints or dependencies, resilience is often influenced by more than firm-level strategies. Individual beliefs, moral or ethical business decisions, and unwritten rules are navigated by actors. These subjective dimensions may form the nuance of ecosystem adaptive capacity or preparedness. Table 5 summarises the results from this second-order theme; detailed ethical considerations can be found in appendix R1.

Table 5: ‘Actor subjective mindsets toward ecosystem resilience’ summarising table

Actor	Perspective on Ecosystem Resilience	View on Collaboration	Subjective and ethical consideration
Launch Broker (Complementor)	Emphasises coopetition and shared success through interdependence. Resilience is both individual and collective	Advocates for trust-based collaboration with understanding of other’s behaviour	Moral commitment to geopolitical alliances
Focal Firm Rep. 1	Resilience begins with internal mindsets. Firms go through three phases: survival, existing, strategic resilience	Collaboration may follow as the ecosystem matures. Notes dependencies may be dangerous due to overreliance	Prioritises survival over idealised “friendships” or alliances.
Focal Firm Rep. 2	Resilience begins with internal cohesion.	Notes ecosystem interdependence – stresses firms must build resilience independently before collaborating	Skepticism of theory vs. practice. Firms don’t have the luxury to act as theory suggests
Focal Firm Rep 3.	Skepticism towards ecosystem-level responsibility of resilience	Trust plays a huge factor in collaborations	The ecosystem is constructed by different levels working simultaneously.
Government Specialist	Ecosystem resilience happens through competition. Ecosystem orchestration needs a leader.	Emphasises stakeholder alignment	Geopolitical dilemmas affect firms' decisions. Customer national interest tensions firms
Institutions Specialist	N/A	N/A	Defence projects raise dilemmas – morality vs. profits
Solution Provider	Resilience depends on preparedness	Emphasises stakeholder alignment as key to ecosystem preparedness	Risks of misalignment in terms of emerging threats may be disruptive.
Supplier A (Aluminium Supplier)	Macro shocks, i.e. geopolitical, affect resilience	Technical collaborations essential to delivering a great product	‘No actor can operate alone’
Supplier B (Component Supplier)	Resilience is tied to supply chain scalability	Technical collaborations are more beneficial than competition	N/A
Launch Provider (Downstream Supplier)	Ecosystem is overcrowding; survival will be priority	N/A	Implies existential risk
University Representative	The ecosystem is dynamic; ecosystem resilience is key. Resilience in supply chain, sustainability, and innovation	Emphasises coopetition and a shift toward more maturity	N/A
ESA Specialist	Innovation investments and strategic contracts supports ecosystem resilience	ESA’s involvement in the ecosystem fosters collaboration	Sustainability efforts may be a new legitimacy measurement for ecosystem actors

Source: *authors own table*

Ecosystem resilience is experienced and perceived differently by each actor based on values, interest, and exposure to risk. These subjective interpretations may impact how actors engage in alignment, collaborations, and react in different stages of the co-evolutionary process (Russel et al., 2018). As the interviewed complementor advocated a coopetition and collaborative approach, encouraging other actors in the ecosystem to support one another instead of heavily focusing on competition. Launch brokers were perceived as complementors, intermediaries, and as a vital bridge between satellite operators and launch providers. Emphasising the role of interdependence, it was suggested that collaboration is key to mutual success, and that a more interconnected mindset should be fostered across the ecosystem (A1, Launch Broker, ref. 1). The interviewed complementor noted that firms must act individually while still being aware of other actors' behaviour or the ecosystem changes.

> "Every company should be independently analysing the situation to be resilient on their own, but also none of us do anything in a vacuum. We absolutely should be looking around ourselves to say, 'How do we navigate this together?'" (A1, Launch Broker, ref. 3).

A focal firm representative acknowledges that resilience begins with the internal mindset of the firm, suggesting that actors within the ecosystem must be willing to shift their perspective (A1, Focal Firm Rep. 1, refs. 5-6). This is also highlighted by another focal firm representative, emphasising 'people and culture' as the first priority during turbulent times: "We need to be a coherent team, we need to trust each other, and we need to understand that we are in this together" (A1, Focal Firm Rep. 2, ref. 18). It was further noted that people represent a crucial asset for a firm's resilience, and that long-term sustainability is best achieved through collaboration (A1, Focal Firm Rep. 2, ref. 7). This suggests resilience begins with internal capabilities. As expressed, "[Firms] are going from surviving, to existing, to protecting themselves and being resilient" (A1, Focal Firm Rep. 1, ref. 5), this seems to be a notion across multiple actors' perceptions (A1, Focal Firm Rep. 1, ref. 7).

The interdependency towards institutions, cf. section 4.3.2, showcases the role of learning and strategic awareness of ecosystem dynamics. As market demand grows from both a commercial and governmental aspect, focal firms and component suppliers must adapt to the circumstances. A representative from a European university highlighted that adding value and being dynamic are key to this ecosystem (A1, University Rep., ref. 1). It was observed that the small satellite ecosystem has evolved from a closed, government-led domain into a dynamic and decentralised environment, where competition and cooperation coexist. This development suggests that the ecosystem is maturing, characterised by increasing interdependence and adaptability (A1, University Rep., ref. 2). A few other representatives highlight the evolution of the small satellite ecosystem as emerging out of the start-up phase and competition is growing (A1, Focal Firm Rep. 2, ref. 3; Launch Broker, ref. 4; Launch Provider, ref. 1).

> "There's no doubt the evolution of this is that once the technology starts to become mature, there are more players. And you need to move in the value chain and in terms of how to approach the market and the customers." (A1, Focal Firm Rep. 2, ref. 3)

The supply chain is perceived to be one of the most important parts for the ecosystem to be resilient. This notion is carried by multiple actors – focal firms, suppliers, and universities. Supplier representatives perceive the ecosystem more or less as a supply chain or value chain. It is perceived as the traditional upstream and downstream (A1, Supplier B, ref. 1), where other external factors impact them, such as regulation, competitors, or geopolitics. For one supplier, the resilience is highly connected with the supply chain and its scalability capacity (A1, Supplier B, ref. 2), cf. section 4.4.1. The other supplier interviewed stated that "no one can do it alone. Also, the field attracts very technical people who value collaboration over competition." (A1, Supplier A, ref. 5).

When asked whether resilience is an ecosystem-level responsibility or a firm-level responsibility, participants had different views on this. Within the focal firm it was viewed that resilience starts with the company, where collective efforts are of course a future step, however, it is not perceived as a necessity at this point.

> "I honestly don't see how that would work between companies. Of course, if you grow inorganically – for example, by acquiring another company – then you might build shared resilience that way. Other companies have done this. But I don't see that as the right move for [us] right now.." (A1, Focal Firm Rep. 3, ref. 6).

Others had a more optimistic vantage point; however, they had concerns in terms of future challenges when the market is reaching its saturation point (A1, Focal Firm Rep. 2, ref. 8; Breil & Ciocarlan, 2025). An interviewee with a sales perspective viewed ecosystem resilience to be an outcome of competition within the market by pushing each other, resulting in actors becoming more collectively stable (A1, Government Specialist, ref. 5). An ESA expert has a similar perspective as the ones prior.

> "It starts with the company. And of course, you can't rely solely on ESA. Their contracts can come in waves – sometimes there's a cluster, other times there's a long gap." (A1, ESA Specialist, ref. 4).

Firms must then start with ensuring their own survival before anything else. Relying on a space agency or another innovation hub is not fruitful. The ecosystem in general wants to develop projects with ESA, as the space agency drives improvement and innovation (A1, ESA Specialist, ref. 1). By innovating and testing new technologies the roles of space agencies are seen as an ecosystem continuity enabler (A1, Focal Firm Rep. 2, ref. 10) – arguably a proactive resilience strategy. Firms engage in these projects to learn from them, gain experience, and for the endorsement that follows, cf. section 4.3.2. ESA supports ecosystem resilience to some extent:

> "ESA wants to see a broad and healthy space industry. […] They can create competition – and competition is good. [...] ESA doesn't want to destroy companies. On the contrary, they want more space companies – especially from new member states like Poland and Romania. And when those countries step up, it pushes everyone else to perform better." (A1, ESA Specialist, ref. 6)

With that said, space agencies impact the general ecosystem resilience, however, this is achieved typically as an indirect objective, pushing firms for improvement through ensuring qualified competition or a long-term proactive strategy. One example is the Space Debris Charter (ESA 2023; ESA Space Debris Office 2024), which is proposing to implement a sustainable way of managing space and cleaning up space by de-orbiting satellites to prevent them from remaining in orbit for decades or even millennia (A1, Focal Firm Rep. 1, refs. 10-11; ESA Specialist, ref. 10). This agreement is posed to mitigate satellite collision and to mitigate the Kessler syndrome (O'Callaghan, ntd), where essentially a chained reaction of satellite collisions can wipe out all services or applications dependent on satellite technology. In addition to this ecosystem-level responsibility, the solution provider argues that stakeholders or partners need to be prepared in terms of emerging challenges such as cybersecurity or geopolitical landscape (A1, Solution Provider, ref. 3-4). Aligning stakeholders or partners was argued by the focal firm to be an important part of ensuring ecosystem-resilience (A1, Government Specialist, refs. 9-11).

A particularly insightful perspective was offered by a focal firm representative, who described the ecosystem as operating across multiple simultaneous levels. Components were seen as forming the foundational layer, followed by payload and mission design at an intermediate level, and end-to-end solutions at the highest level. This view reflects an understanding of the satellite sector as a multilateral and multi-layered ecosystem, shaped by differentiated yet interconnected capabilities.

> "These different levels also reflect different levels of revenue and profitability – different EBIT or EBITDA outcomes. At the bottom, the ecosystem is broad, but saturated with players. As you move up – like a pyramid – it narrows. The top tier, where full solutions are offered, has far fewer providers. [...] That's where you can really create value for the customer and distinguish yourself from the competition." (A1, Focal Firm Rep. 3, ref. 2)

This divergence in requirements and resources based on the levels is an interesting take on ecosystems. Not only does this perception highlight the complexity of this ecosystem, but it also emphasises the importance of strategic position within the ecosystem. Consideration of where value co-creation, coopetition dynamics, and funding opportunities differ across these levels, and they need to be carefully considered.

In the current geopolitical state, everything is shifting; mindsets, alliances, and economic stability. In the case of a focal firm within the ecosystem, a focal firm representative expresses concerns regarding our perception of the geopolitical alliances.

> "The way we think about alliances, the way we think about friendship. How far we are really friends up to the ultimate moments. Seems that there are two different concepts now in this world." (A1, Focal Firm Rep. 1, ref 9)

These alliances or 'friendships' might end up with firms blindly following their partners or alliances, even if it might not be the best choice. Another focal firm representative has expressed that Asian countries would prior rely on the US in terms of sharing data from orbit, however due to geopolitics these countries wish for more nationalised solutions. The representative believes that trust is a huge factor, as the countries need to ensure their own autonomy (A1, Focal Firm Rep. 3, ref. 12). The downstream supplier noted an oversupply compared to market demand, increasing the risk of multiple actors dying out: "So it's really a game of who's going to survive…" (A1, Launch Provider ref. 2). Subsequently, the need for building trust, reputation, and gaining legitimacy seems to be prominent in these situations.

In high-stakes innovation environments trust-based ties or informal ties may accelerate problem-solving and encourage knowledge sharing according to Jacobides et al. (2018) and Floetgen et al. (2021). However, it might not always be a priority:

> "…because a friendship to me is a luxurious thing. When everybody's safe, when everybody knows how to survive then you can start to make friends. [...] Friendship is good, but friendship shouldn't keep you distracted from the main elements which is living. So I would say you have to fight for your own survival before being friends and not be fooled by going too much into friendship I would say and keeping this with your utmost interest." (A1, Focal Firm Rep. 1, ref. 15)

The general perception is that carefulness needs to be practiced with partnerships (A1, Focal Firm Rep. 1, ref. 16). Since the industry is still quite young, supranational agencies are fostering knowledge sharing; 'everyone wants to learn', however due to the innovation-centric nature of the sector, firms must ensure their own survival (A1, ESA Specialist, ref. 2). Furthermore, financial stability was highlighted as a critical factor for stakeholders to view a project as viable and likely to endure over the long term (A1, Focal Firm Rep. 2, ref. 6).

4.1.2. Strategic and operational resilience practice

Strategic and operational resilience within the small satellite ecosystem must be understood less as an extraordinary response to crisis and more as the routine condition of doing business in an environment where failure is both irrevocable and highly contagious. Actors seldom frame resilience as an abstract, long-term safeguard; instead, they experience it as an everyday discipline necessitated by unforgiving physics, volatile demand and webs of interdependence.

Table 6: Summarising table of second-order theme 'Strategic and operational resilience practice'

Actor	Strategic and operational resilience practice	Financial resilience	Innovation under financial constraint	Supply chain resilience
Launch Broker (Complementor)	Pursued by complementors by scouting launch providers and monitoring geopolitical developments	N/A	N/A	Strategic resilience depends on optionality in suppliers. Diversification is highlighted to mitigate risk. Proactive management is critical; continuosly tracking new suppliers.
Focal Firm Rep. 1 & 2	Due to 'no-second-chance' environment, flawless performance is mandatory. The high-risk nature of space operations creates strong reciprocal relationship between firms. Resilient firms survive by combining access to capital with deep understanding of customer buying cycles.	Resilience efforts reflects whether a company can afford it – most firms lack the finanical depth to take these measures. Small firms seek new models to share risk with prime contractors without bearing the full cost burden.	Innovation is constrained by financial realities, as cash flow dictates innovation cycles. The industry rotates leadership in terms of technologies, where each development dominates the industry until the next generation emerges	Focal firms are vulnerable to supplier shifts due to low-volume manufacturing. Resilience is built through supplier diversification and readiness to switch quickly, however may not be realistic in this ecosystem. Resilience is built through strong relationships and financial vetting of suppliers.
Institutions /Government Specialist	A competitive industry strengthens the sector	Diversifying across market segments adds additional shock-absorption capacity	ESA supports innovation under financial constraint by subsidising early-stage experimentation rather than pursuing commercial returns	N/A
Solution Provider	Highlighted that a leader or orchestrator must manage the value co-creation process and align stakeholders, thereby ensuring its ecosystem is stable	N/A	Solution providers pursure innovation selectively, focusing on vertical integration where long-term value capture	N/A
Suppliers B	Competitive advantage has shifted from simply manufacturing satellites to orchestrating end-to-end, use-case specific solutions. Resilience depends on a layered approach combining technical excellence	Resilience is closely linked to financial flexibility.	Suppliers adopt a cautious approach to innovation, closely monitoring emerging manufacturing technologies while delaying adoption until operational and economic viability is clear	N/A
Launch Provider (Downstream Supplier)	Resilience is shared across firms, ecosystems, and states.	Volatile funding cycles drive cautious, incremental investment.	Launch providers anticipate market gaps, prioritising configurations that maximise commercial viability over peak technical performance	Emphasises vertical integration for control over cost and lead time.
University Representative	Universities foster resilience through the strategic formation of international consortia	Universities build financial resilience by adapting to disruptions and seeking alternative sources	N/A	Early contingency planning turn major shocks into manageable adjusments.

Source: *authors' own table*

Nowhere is the physical imperative clearer than in the simple fact that satellites cannot be repaired once they leave the launch pad. A single mis-specified component or an unforeseen solar storm can shorten a mission from five years to one, destroying the customer's business case or wiping out a focal firm's reputation in the same moment (A2, Focal Firm Rep. 1, ref. 4).

> "You don't have a second chance to to repair it or to change it, or to modify or to update, or you know… when it's done, it's done." (A2, Focal Firm Rep. 1, ref. 4)

In this 'no-second-chance' setting, focal firms and payload providers alike treat flawless performance not as a competitive advantage but as the baseline requirement for survival. The high stakes bind firms together in tight reciprocal relationships. Consequently, resilience may appear less about insulating any one company from shock than about sustaining a network capable of absorbing that shock collectively. Such interdependence reshapes commercial practice. Participants recount instances in which customers advanced milestone payments to prop up a focal firm's liquidity, reasoning that the cost of a partner's temporary weakness was trivial compared with the losses they would incur if a mission failed outright (A2, Focal Firm Rep. 1, ref. 16).

> "The demand is still not high enough compared to the supply. The supply has been built up on promises on the much bigger market that never happened." (A2, Focal Firm Rep. 2, refs. 28-29)

These relational buffers operate against chronic market volatility. Production capacity expanded in anticipation of exponential growth, but in later, lived reality orders arrive in irregular, episodic waves. Firms that weather the lulls are those that combine ready access to capital with an intimate understanding of customer buying cycles, allowing them to pivot resources toward the handful of large programmes that materialise each year (A2, Focal Firm Rep. 2, refs. 28-29). Resilience, therefore, seems inseparable from finance: managers speak of maintaining 'optionality' in cash and talent so that they can scale up when the market crests without undertaking irreversible commitments that would cripple them in the long run.

> "There are a lot of companies who can build a satellite today. [...]You can go to almost any country and they'll have a nanosatellite provider [...] So buying or building a satellite is not something very special today. Ten years ago, there were only a handful of companies that were good at this. Today, there are many more." (A2, Solutions Provider, refs. 6-7)

Moreover, technological commoditisation adds a further twist. What was once a unique capability – the manufacturing of a nanosatellite – has become almost commonplace, with hundreds of firms now able to assemble basic platforms. Competitive advantage, and thus strategic resilience, then migrates to the orchestration of end-to-end solutions in use case specific domains, where value lies not in the satellite itself but in the actionable insights it delivers (A2, Solution Provider, refs. 6-7). Furthermore, resilience is also shaped by institutional efforts to ensure supplier diversity. ESA, for example, promotes a competitive industry not only to strengthen the sector, but to secure better options for itself. More capable firms mean more choice, higher performance, and reduced dependency (A2, Government Specialist, ref. 12). Resilience is also pursued proactively by complementors. launch brokers, for instance, scout emerging launch providers and monitor geopolitical developments to shield clients from disruption. By cultivating early relationships and sensing market shifts, they turn uncertainty into preparedness (A2, Launch Broker, ref. 3). Universities foster resilience through the strategic formation of international consortia, enabling cost-sharing and access to alternative funding streams. Such cross-border collaborations serve to mitigate the impact of national-level disruptions and support the continuity of research activities (A2, University Rep., ref. 6).

Consequently, the resulting picture is one of layered, mutually reinforcing practices. At the technical core sits uncompromising design rigour; around it, contractual and relational risk-sharing arrangements stabilise cash flow and schedule; above that layer, strategic finance and market sensing keep firms poised to capture episodic demand; and overarching all of these is a continuous push up the value chain, away from commoditised hardware toward integrated services.

Financial resilience: cash, credibility and the limits of ambition

In the small satellite business, every substantive resilience measure ultimately resolves into a question of cash. Interview participants are blunt: resilience costs money, and most firms sit several rungs below the point at which they can finance the more sophisticated buffers they certainly know they need. They contrast their own narrow margins with a position in which immense purchasing volumes and a solid balance sheet allow the focal firm to carry its entire supply chain through systemic shocks (A2, Focal Firm Rep. 1, ref. 17, 20-21).

> “The second thing is very down to Earth and it’s a bit unfortunate, but it’s financial capacity. It’s asking a lot of money to be resilient.” (A2, Focal Firm Rep. 1, refs. 20-21)

Lacking such depth, mid-tier actors remain more reactive than proactive, relying instead on design modularity, standardisation and relationship capital to absorb disturbances they cannot afford to insure directly (A2, Focal Firm Rep. 1, refs. 20-21). Over the past decade, financial considerations have become markedly more salient: whereas early New Space customers tolerated venture-style risk, today’s customers translate satellite under-performance into explicit revenue losses and elevate supplier solvency to a primary selection criterion (A2, Focal Firm Rep. 2, refs. 5-8). Some therefore perceive resilience as having migrated from the engineering department to the income statement where a healthy equity buffer and predictable cash flow now mark out credible partners. Yet predictability is elusive for small satellite manufacturers whose order intake swings wildly from quarter to quarter. Consequently, firms may respond by pairing high-margin but sporadic component sales with lower-margin, multi-year satellite programmes that guarantee revenue and workforce utilisation. This ambidextrous mix demands strict cost discipline lest cash once again drain into the proverbial 'valley' that previous growths only just refilled (A2, Focal Firm Rep. 2, refs. 9, 17-19).

Moreover, it is this same limited capital that also shapes procurement strategy. Textbook strategy prescriptions such as dual-sourcing are often unaffordable; managers instead cultivate acute market timing and tacit knowledge of supplier motivation, accepting short-term exposure because funding redundant capacity would be existentially costly (A2, Focal Firm Rep. 2, refs. 42-44). Similar pragmatism governs relationships with large prime contractors: these integrators command hefty margins because they absorb programme risk, but that cost premium ultimately bleeds the tiers below dry. Smaller firms therefore experiment with partnership arrangements that share liability without recreating the costs of a traditional prime contractor (A2, Focal Firm Rep. 2, ref. 45). The financial approach behind these activities is intentionally portfolio-based. Executives refer to a mix of 'big eggs and small eggs': large, high-value contracts that build capability and reputation, alongside smaller, regular projects that support cash flow when major deals are delayed or infrequent (A2, Government Specialist, refs. 4-7). Universities build financial resilience by adapting to disruptions to funding and seeking alternative sources. However, such alternatives are not always available, exposing the vulnerability of research activities to shifting political and institutional priorities (A2, University Rep., ref. 7).

Innovation under financial constraint: rotating champions and selective bets

Rapid innovation is often described as the reality of the small satellite industry, yet interviewees emphasise that breakthrough cycles are governed as much by cash as by creativity. Each new subsystem demands heavy upfront investment that must be recouped over multiple years of production.

> "The pace of innovation is quite fast. The level of performance you have is quite high, but in

> the meantime the development is quite cash intensive and in financial means. Which means that once you have developed a product, you need this product to become a cash cow for a certain period of time. And by doing so, you are usually going to slow on the development of the next generation of your product. " (A2, Focal Firm Rep. 1, refs. 6-7)

Firms therefore maximise returns from a successful product generation until it becomes a cash cow, using the profits to fund the next wave of research and development. This creates a cycle of shifting technological leadership, where no single firm remains dominant for long; the current leader may soon be overtaken by a competitor with more recent investment and a stronger financial position (A2, Focal Firm Rep. 1, refs. 6-8). Solution providers pursue innovation selectively, focusing on verticals where long-term value capture appears viable. Rather than advancing technology for its own sake, they invest in domains with clear application potential, aligning development efforts with anticipated market demand and strategic positioning (A2, Focal Firm Rep. 2, ref. 6). Likewise, launch providers align their product design with anticipated market gaps, prioritising configurations that maximise commercial viability over peak technical performance. Strategic focus is placed on payload classes where competition is limited and sustainable demand is expected, supporting both differentiation and long-term survivability (A2, Launch Provider, ref. 3). Similarly, suppliers adopt a cautious approach to innovation, closely monitoring emerging manufacturing technologies while delaying adoption until operational and economic viability is clear. This enables them to remain informed and prepared for transition without overcommitting resources prematurely (A2, Supplier A, ref. 3). Furthermore, financial pressure also shapes risk appetite. When chemical thrusters were abruptly eclipsed by electric alternatives, one focal firm chose to abandon its recently acquired chemical technology: external scanning and partnering promised greater agility than trying to retain an uncertain technology in-house (A2, Focal Firm Rep. 1, ref. 9). Such pruning is a conscious resilience posture: instead of hedging every possible bet, firms concentrate on domains where they possess deep competences and rely on ecosystem ties to stay alert to adjacent breakthroughs. ESA supports innovation under financial constraint by subsidising early-stage experimentation rather than pursuing commercial returns. Low cost CubeSat missions enable accelerated development and in-orbit testing with limited financial exposure. While technical validation is still required, a higher tolerance for failure is accepted to strengthen upstream industrial capacity. This approach complements the selective, resource dependent innovation strategies observed among commercial firms. (A2, ESA Specialist, refs. 2, 8).

Supply-chain resilience: from brittle dependency to architectural redundancy

The satellite industry is structurally dependent on its supply base. Low purchasing volumes reduce the bargaining power of focal firms, making them vulnerable to sudden supplier withdrawal – for example, when a board manufacturer discontinued its support after securing a larger customer (A2, Focal Firm Rep. 1, ref. 3). From an operational perspective, procurement teams maintain an increasingly broad network of alternative suppliers, identified during previous disruptions, to ensure that critical components can be reordered within a week rather than over several months (A2, Focal Firm Rep. 1, ref. 22).

> "This is probably where we have the biggest risk because our volume is too low. It's difficult for us to have several suppliers." (A2, Focal Firm Rep. 2, ref. 1)

Furthermore, the 'small volume trap' is particularly acute for specialised mechanical parts: a lone specialist accepts the order only because of a personal relationship, and the focal firm is acutely vulnerable if that supplier suffers a disruption or finds a more lucrative offer elsewhere, either within or outside the small satellite ecosystem (A2, Focal Firm Rep. 2, ref. 1). Clearly, textbook principles of dual-sourcing remain largely aspirational. In the absence of sufficient volumes to sustain multiple suppliers, resilience is instead developed through active relationship management and regular financial assessments of key suppliers (A2, Focal Firm Rep. 2, refs. 3-4). Furthermore, the notion of rapid scale-up has exposed gaps in procurement forecasting (A2, Supplier B, ref. 3). Within the focal firm, policy has evolved from ad hoc substitutions to a more systematic approach based on architectural redundancy. Managers recognise that no satellite company currently possesses truly scalable in-house electronics production; as such, resilience must be achieved through partnerships that enable load-balancing as demand increases (A2, Supplier B, ref. 1). Firms are reconfiguring their ERP systems to ensure that every critical line item is linked to at least two pre-qualified suppliers. This provides procurement teams with an 'emergency response' function, allowing orders to be redirected without compromising traceability (A2, Supplier B, ref. 2). This same introspection extends to 'make-or-buy' boundaries. Production lines that have lain dormant are earmarked for outsourcing to specialists, while the focal firm retains a skeleton capacity to build a complete satellite end-to-end as an ultimate fallback (A2, Supplier B, refs. 4, 7, 10).

Additionally, even the most carefully managed supply chains remain vulnerable to external bottlenecks—such as access to launch capacity. Most major launch slots for 2025 have already been allocated, revealing a continued exposure to single-point-of-failure risks. While managers recognise this threat, they also frame it as an entrepreneurial opportunity. Emerging micro-launch providers that can offer earlier access are expected to command premium prices and, by diversifying launch options, may ultimately strengthen the resilience of the broader ecosystem (A2, Focal Firm Rep. 3, ref. 14). From this perspective, the issue of launch serves both as a stress test and a catalyst. It exposes structural weaknesses while encouraging innovative entrants who, by expanding capacity, help reduce systemic vulnerability over time. Strategic resilience is rooted in optionality: launch brokers establish parallel agreements with multiple launch providers across different regions, while intermediaries diversify their order books to ensure that neither a single client nor a specific rocket threatens their cash flow (A2, Launch Broker, refs. 1-2). That optionality is sustained proactively. Continuous mapping of nascent launch vehicles and geopolitical trends allows manifests to be re-configured long before disruption, and scenario planning is treated as a joint exercise with customers and launch providers rather than an internal contingency drill (A2, Launch Broker, refs. 3-4). On the supply side, emerging micro-launcher firms frame resilience as control over the value chain: vertical integration is expected to shorten lead-times and contain cost (A2, Launch Provider, ref. 1). Responsibility for resilience is nonetheless described as layered – firm, ecosystem and sovereign – because European member states 'cannot afford to lose' domestic micro-launch capability and therefore encourage cooperation even among rivals (A2, Launch Provider, ref. 4). Similarly, financing remains the most volatile variable: fund-raising cycles oscillate between scarcity and a fleeting 'golden age', rendering long-term capacity planning hazardous and compelling incremental investment decisions that can be reversed if the capital tide turns (A2, Launch Provider, refs. 5-6). The practical value of early mitigation is illustrated by the ESA's Euclid mission, which switched from Soyuz to Falcon 9 after Russia's invasion of Ukraine (Foust, 2023); contingency planning initiated years earlier allowed the change of launcher without redesigning the payload, turning a potentially mission-threatening shock into a manageable schedule adjustment (A2, University Rep., ref. 5).

4.2. Ecosystem Complexity, Interdependence, and Co-creation

This aggregated dimension highlights that this ecosystem is quite complex, dynamic, and generally interconnected. By presenting second-order themes regarding interdependencies, collaboration and co-creation, and lastly specialisation trends within the ecosystem, this section paints a picture of how dynamic ecosystems are.

4.2.1. Interdependencies

Technological requirements oblige the focal firm integrator to weave together and orchestrate an intricate architecture in which upstream component suppliers, lateral payload specialists and downstream service providers are mutually contingent. The focal firm’s role is to integrate diverse capabilities into a satellite that succeeds at the point of orbital deployment, as one interviewee noted, it 'needs to do the synthesis of everything possible in this industry' to meet customer expectations (B1, Focal Firm Rep. 1, ref. 2). Such complementarity confers extraordinary sensitivity to single-point failures; a malfunction in any subsystem irretrievably condemns the whole satellite, heightening both technical and contractual vigilance across the ecosystem (B1, Focal Firm Rep. 1, ref. 3, 8). Given low production volumes and reliance on global component markets, integrators possess limited bargaining power. They often lack the scale to be considered strategic customers and can be readily displaced if a more profitable customer emerges, cf. section 4.1.2 (B1, Focal Firm Rep. 1, ref. 7). The resulting co-creation and supply availability risks spill over to downstream actors who depend on timely launch and in-orbit commissioning, producing multilateral rather than bilateral dependencies; the constellation of actors must succeed together or fail together. Where bottlenecks are concentrated, such as high-value mechanical components sourced from a single specialist, organisational fragility is heightened. The focal firm recognises a strong dependency on individual suppliers for critical mechanical parts, which amplifies vulnerability within the supply chain (B1, Focal Firm Rep. 2, ref. 4).

The small satellite ecosystem is characterised by a structural tiering. Sovereign customers, such as ministries of defence, typically favour awarding turnkey contracts to so-called prime contractors – firms capable of assuming full programme risk, offering performance guarantees, and financing projects under a single balance sheet. Consequently, for a smaller manufacturer this creates a gate-keeping hierarchy: winning the end-user’s business is possible only by slotting in beneath a politically connected prime, lead contractor whose financial depth reassures the customer that any issues will be absolved without jeopardising mission continuity (B1, Focal Firm Rep. 2, ref. 8). Gaining access to such contracts often requires smaller firms to relinquish direct customer relationships and a significant portion of the project's economic value. Acceptance of reduced profit margins thus becomes the cost of entry for these actors (B1, Focal Firm Rep. 2, ref. 15). However, opting out of such arrangements is rarely a viable strategy. Prime contractors enable access to otherwise unreachable markets by offering capabilities and assurances that smaller manufacturers are typically unable to provide independently. The market architecture therefore reinforces interdependence: the focal firm is simultaneously dependent on the prime for market access and exposed to the risk of reduced margins or displacement if project priorities change (B1, Focal Firm Rep. 1, ref. 8).

Furthermore, regional heterogeneity – as seen in the Asia-Pacific region – amplifies ecosystem interdependence by reshaping both the nature and direction of inter-firm dependencies. In many emerging or mid-tier spacefaring nations, government customers regard satellite procurement as a means of fostering domestic capability development. As a result, formal contracts often include technology transfer provisions that, in effect, require the European prime contractor to integrate local universities, state-owned enterprises, and small industrial suppliers into the programme (B1, Government Specialist, ref. 1). By contrast, the mature space agencies and commercial operators possess established ground infrastructure, seasoned procurement teams and proven mission-operations practice. Their strategic objective is not capability acquisition but timely augmentation of existing constellations or service portfolios. They therefore purchase complete, specification-compliant satellite buses – perhaps bundled with launch brokerage and limited early orbit support – and they pay milestone installments promptly once technical acceptance tests are met (B1, Government Specialist, ref. 12). For the European prime, tighter bilateral ties with a capable customer enable clearer governance and reduced risk; yet both remain mutually dependent for delivery and long term success.

The launch broker describes a split ecosystem: data providers aim to collect insights from orbit, while infrastructure providers focus on getting payloads into space. Launch brokers help bridge this gap by matching customer needs with what launch vehicles can offer, and by managing the practical challenges of getting both sides to work together (B1, Launch Broker, refs. 1-3). The brokerage function has become essential in a market defined by launch constraints. The loss of access to Soyuz, disruptions to the PSLV schedule, and delays in the Vega programme have all reduced the number of practical launch options. Meanwhile, the leading rideshare programme offers only limited orbital diversity. As a result, satellites compete for a small number of viable launch slots, and managing this imbalance between supply and demand has become a continuous process of negotiation among manufacturers, brokers, and launch providers (B1, Launch Broker, refs. 4, 6-8, 10). Actors at either end of the value chain remain focused on their own areas of expertise. Launch providers concentrate on improving propulsion performance and rarely engage in customer analysis, while satellite manufacturers prioritise data products and often leave trajectory planning to others. As a result, brokers see themselves as aggregators of market intelligence and coordinators of payload allocation. In doing so, they absorb coordination costs that would otherwise be distributed across a complex network of bilateral contracts (B1, Launch Broker, refs. 5, 12-13).

4.2.2. Actor-specific dependencies and strategies

Table 7: Actor-specific dependencies summarising table

Actor	Customer dependencies	Technology dependencies	Internal vs. external supply chain strategy
Launch Broker (Complementor)	Most dependent on customers in the ecosystem	The ecosystem is driven by flight proven technology	Vertical integration is noted to be essential for survival
Focal Firm Rep. 3	Customers are vital; there is a shift towards strategic partnerships. The growing demand warrants for standardisation.	Flight heritage is critical and component reliability is vital for this sector. ESA is trying to formalise this by standardising it through TRL enforcing qualification procedures	Vertical integration is employed for control and resilience; however, inefficiencies may appear due to reluctance to challenge internally. Strategic sourcing is discussed.
Government Specialist	High dependency on customers. Stressed that becoming a trusted partner is the goal. Firm's internal resilience affects its relationship with customers	Flight heritage is used as a legitimacy enhancer or reassurance for the customers	Long-established firms are prone to employ vertical integration
Institutions Specialist	Customers include the public sector	Flight heritage is essential and TRL standardisation	N/A
Solution Provider	Solution-oriented value propositions warrants stronger ties and robust alignment of ecosystem actors. Interdependencies are essential	N/A	Scaling strategies enhance the need of outsourcing solutions and supply chain partnerships. But internal readiness and resilience is equally important.
Suppliers (Component and Aluminium)	Strong, long-term customers (focal firm) are preferred; trust and alignment is key; customer relationships evolved from transactional to strategic.	Specialisation together with the focal firm highlights value co-creation. Rapidly adopting technology build stronger ties Flight heritage is crucial	Outsourcing is highlighted for scalability purposes. Suppliers often struggle with dual sourcing due to low-volume procurement.
Launch Provider (Downstream Supplier)	Interdependency; no satellites equals no launches	Mature flight proven technology is prominent; customers are risk averse	Multiple firms choose to opt for vertical integration
University Representative	Indirect dependency	Universities support technology evolution through R&D efforts	N/A
ESA Specialist	Geopolitics impact customer requirements, enhancing national resilience and autonomy	Flight heritage validation and standardisation are fostered by ESA. Space agencies are innovation drivers	N/A

Source: *authors own table*

Table 7 summarises the results from this second-order theme, which addresses customer and technological dependencies, as well as internal/external considerations related to the firm's supply chain. Further details on customer dependencies and technological dependencies can be found in appendix R2.

Customer dependencies

It is evident that the ecosystem is characterised by strong interdependencies, with most ecosystem actors identifying the most significant of these occurring between their own respective customers and suppliers (B2, Supplier A, refs. 3-4; Launch Broker, ref. 3). Since there is an oversupply, the focal firm is incredibly dependent on its customers (B2, Focal Firm Rep. 2, refs. 18-19; Launch broker ref. 3). The oversupply generally gives customers a higher bargaining power (B2, Supplier A, ref. 7). Even if customers to aluminium suppliers, i.e. component suppliers, hold more bargaining power, they still decline work if it does not align with the firm's capabilities (B2, Supplier A, ref. 10). Moreover, the component supplier noted that recent geopolitical events have driven growing market demand, making end-to-end solutions increasingly attractive – beyond just delivering satellite infrastructures or mission specific payloads (B2, Supplier B, ref. 17). Both of the supplier representatives view the long-term customers or key accounts as an ongoing partnership (B2, Supplier A, refs. 5-6; Supplier B, refs. 6-7).

Trust is highlighted by multiple actors, which indicates an important driver for ecosystem co-evolution (B2, Focal Firm Rep. 2, refs. 6, 21-22, 27; Supplier B, refs. 6-7; Focal Firm Rep. 1, refs. 15, 17). Trust becomes a resilience enabler, as strong relational ties may allow firms to survive challenges (B2, Focal Firm Rep. 2, refs. 23, 26-27). Some ecosystem actors stressed that becoming a 'trusted partner' was the utmost important goal (B2, Focal Firm Rep. 2, ref. 21; Government Specialist, ref. 19; Launch Broker, refs. 4-5). Subsequently, diversifying the customer base to serve both mature and immature satellite markets improves the firm's resilience through diversification (B2, Government Specialist, ref. 19).

The growing demand impacts the need for standardisation furthermore (B2, Focal Firm Rep. 1, ref. 15), cf. section 4.2.3. The downstream supplier emphasises present interdependencies between customers and launch providers – without satellites they have nothing to launch and vice versa (B2, Launch Provider, ref. 4). Since there is a perceived risk with newer launch vehicles, customers are hesitant on embarking their satellites on immature launchers, subsequently creating an entry barrier for new launch entrants (B2, Launch Broker, ref. 6; Launch Provider, ref. 3).

Geopolitical developments have already influenced customer requirements, strengthening the emphasis on national resilience and autonomy. This is reflected in the growing demand for nationally owned satellites and sovereign control over data (B2, ESA Specialist, ref. 11), requirements to test or manufacture satellites domestically for sovereignty or defence purposes (B2, Focal Firm Rep. 1, ref. 16), and a shift among defence organisations towards acquiring their own space assets (B2, Solution Provider, ref. 5). However, as geopolitical dynamics drive the push for national space autonomy, this has led to the emergence of customers with limited technical knowledge of the underlying technologies (B2, Solution Provider, ref. 3, 5).

Technological dependencies

As modern society is moving at a fast pace in terms of technological advancements, sectors where technology is everything, firms are highly dependent on technology. Traditionally, interdependencies are typically a form of relationship between actors, however the notion of technology dependency emerged through the data. This may be due to the complexity and high-tech nature of this sector. Moreover, it aligns with how the space sector is transitioning to application-driven technology, becoming a tool to deliver valuable solutions (B2, University Rep., ref. 1).

The ecosystem is constantly improving and innovating, the focal firm explains how the ecosystem has been optimising satellite technology and ensuring reliable functionality (B2, Focal Firm Rep. 2, ref. 15). The emphasis on reliability and precision can be perceived as resilience being a performance driver, cf. section 4.1.2. Space agencies have the role of pushing these agendas and explore emerging technologies or do radical innovations, cf. section 4.3.2 (B2, Focal Firm Rep. 2, ref. 16; ESA Specialist, refs. 2-4, 14-16; University Rep., ref. 6).

According to one participant, while the rapid adoption of new technologies carries certain risks, it can also strengthen relationships with customers by presenting ideas or solutions they may not have previously considered (B2, Supplier A, ref. 11). Nevertheless, the industry remains driven by flight proven technologies – those that have demonstrated reliability through successful operation in orbit. (B2, Launch Broker, ref. 1). Subsequently, even if adopting new technologies may come with benefits for aluminium suppliers, it is not necessarily the case for all ecosystem actors, as they are driven by flight heritage. In other words, customers need reassurance that the ecosystem actor has experience and knowledge regarding the specific mission and therefore the risk is lower (B2, Government Specialist, refs. 14-16). As one of the interviewees noted 'Once you've proven yourself, trust builds' (B2, Supplier B, ref. 9). ESA is trying to formalise flight heritage by standardising it through Technology Readiness Level (TRL) or enforcing qualification procedures (B2, Focal Firm Rep. 3, ref. 7; ESA, 2025).

Internal vs. external supply chain management

As mentioned in sections 4.1.1 & 4.1.2, supply chain resilience has been a large topic in the interviews. To mitigate the potential risk of overreliance on suppliers, several focal firms employ vertical integration (B2, Focal Firm Rep. 1, ref. 4; Focal Firm Rep. 2, ref. 1; Launch Broker, ref. 7; Launch Provider, ref. 1). Especially long-established firms are prone to employ vertical integration, as the ecosystem was not as large nor collaborative in the past (B2, Government Specialist, refs. 14-16; Launch Broker, ref. 8). This may to some extent be perceived positively by the customers, as the focal firm or solution provider would have more control over the process (B2, Solution Provider, ref. 10). Still, as a focal firm representative highlights, applying internal pressure and fostering collaboration is different from applying the pressure externally. Unfortunately, this may result in a reluctance to challenge the internal ecosystem (B2, Focal Firm Rep. 1, ref. 5), which may result in inefficiencies and redundancies in the broader ecosystem.

Firms are attempting to implement strategic sourcing or improve its current supply chain; however, this shift will take time (B2, Focal Firm Rep. 3, ref. 4). Outsourcing was discussed by several interviewees, particularly in the context of growing market demand and the associated need for scaling strategies (B2, Focal Firm Rep. 2, ref. 1; Supplier B, ref. 20; Solution Provider, ref. 6).

From a supplier perspective, component suppliers have suppliers as well. The interviewed component supplier stressed out that its supply chain was fairly flat, as dual sourcing was rare; this is often the case with SMEs (B2, Supplier B, ref. 1; Focal Firm Rep. 2, ref. 24; Solution Provider, ref. 8). Nonetheless, when selecting a supplier or committing to a partnership, ecosystem actors drive the consensus of emphasis on supplier capability and scalability.

> "First of all, they [suppliers) need to have all the quality systems in place. […] And then that they can scale their capacity as well, because other than that, it doesn't really help us. So that's the two points we are checking. Quality systems and scalability" (B2, Supplier B, ref. 16)

This reflects the shift from only transactional or hierarchical structure to strategic-driven and value co-creation emphasis. Organisational resilience is increasingly understood to have implications for the broader ecosystem, highlighting the responsibility of firms to assess the financial stability, organisational capacity, and contingency planning of their suppliers (B2, Focal Firm Rep. 2, ref. 8). The relational nature of ecosystems is observed in interviewing a component supplier: "the best performing, and who delivers the most value to us, is a long-lasting relationship" (B2, Supplier B, ref. 19). The strong ties and collaborative nature of the described relationship aligns with ecosystem interdependencies, yet paradoxically resilience theory and resource dependency theory (RDT) emphasises on the risk of overreliance on an external partner. As noted by the component supplier: "if that supplier is not there anymore, then we do not have a resilient supply chain" (B2, Supplier B, ref. 19).

4.2.3. Collaborative coordination and co-creation

Table 8: Summarising table of second-order theme 'Collaborative coordination and co-creation'

Actor	Market-building strategies	Interconnected and collaborative behaviour	Partnerships and power dynamics	Customisation vs. standardisation
Launch Broker (Complementor)	N/A	Launch brokers play an intermediary role, ensuring collaboration and mutual understanding.	Collaboration and partnership dynamics have faced new constraints due to market evolution; launch diversity has decreased due to geopolitical shifts.	N/A
Focal Firm Rep. 1, 2, & 3	The ecosystem is shifting towards a solution-oriented driven by value co-creation through market building strategies.	Collaborations with other focal firms might be necessary to deliver larger orders. The ecosystem is shifting towards more strategic collaborations where the risk is shared. Institutions ensure business continuity, but firms cannot solely rely on this.	When interdependence is present, actors opt for informal partnerships; reputation is key in these partnerships. Sovereinty tendencies are rising due to geopolitics	Specialising firms may have difficulties in scaling up or may choose not to scale up for profit optimisation. Focal firms have historically done customisation; the need for standardisation is growing as the demand increases. Specialisation is mostly at the component level.
Government Specialist	In some regions, the focal firm has to educate the customers. Emphasises the importance of stakeholder alignment and orchestrating the ecosystem in those regions	Ecosystem actors are shifting towards a collaborative mindset, as it is perceived to ensure their survial. The ecosystem is interconnected: firms, institutions, governments	If there is no notion of interdependence, actors opt for contractual or formal relationships. Sovereignty tendencies are rising; to gain legitimacy in this region actors have to engage in local collaborations	N/A
Institutions Specialist	N/A	Regulations, institutions, and governments are either constraining or ensuring ecosystem continuity. Long-term relationships foster co-creation and co-evolution	Ecosystem actors are burden with the choice of whether they should collaborate with defence entities or not out of principle	A small iteration or customisation might still find place, even if the components or solutions are standardised.
Solution Provider	Highlighted that a leader or orchestrator must manage the value co-creation process and align stakeholders, thereby ensuring its ecosystem is stable	The market demand and geopolitics are affecting ecosystem resilience; it may constrain ecosystems or reduce them to national-level ecosystem; thus reducing collaboration	When interdependence is present, actors opt for informal partnerships. There is a need for outsourcing and collaborating externally to co-create value and improve the value proposition	N/A
Suppliers A & B (Aluminium & Component Supplier)	The ecosystem is shifting towards a solution-oriented driven by value co-creation through market building strategies.	The collaborative relationship with suppliers is prominent; they amplify co-evolution and knowledge sharing. 'No one can do it alone' The need for outsourcing to manage larger orders is noted.	Partnerships are shifting towards strategy and formalised. Outsourcing is seen as value co-creation and ensuring larger orders	N/A
Launch Provider (Downstream supplier)	N/A	Ecosystem actors may be loosely coupled as they have the same customers. It is interconnected as firms, institutions and governments all affect each other. Culture, collaboration, and interdependence were emphasised.	Partnerships are shifting towards strategy and formalised, ensuring security for the firm	N/A
University Representative	N/A	Triangle of collaboration: government, industry, and universities. Institutions and universities foster consortia aand support ecosystem continuity through funding, knowledge sharing, and R&D efforts	Sorvereignty tendencies arise due to shifts in geopolitical alliances	N/A
ESA Specialist	N/A	Information sharing and learning is prominent in this ecosystem. Actors collaborating on one objective is ESA's Space Debris Charter. Space agencies foster consortia aand support ecosystem continuity through funding, knowledge sharing, and R&D efforts	Sorvereignty tendencies such as defence arming strategies arise due to shifts in geopolitical alliances. Reputation is highly emphasised on	COTS components are standardised components with a lower quality, typically used in R&D missions by ESA, as it is cheaper and faster

Source: *authors own table*

Leading and aligning stakeholders in market building strategies

An emerging point in the interviews has been the shift from technological and transactional driven structure to a solution-oriented and value co-creation for the customer through what they call market building strategies (B3, Focal Firm Rep. 2, refs. 4-5, 22-24; Supplier B, refs. 15-16; Focal Firm Rep. 3, ref. 2, 9). As introduced in section 4.1.2., there is a tendency for veteran firms to opt for this type of ecosystem-based structure, however, the need to lead and align diverse ecosystem actors may complicate this shift.

The solution provider highlighted that the leader or orchestrator must manage the 'menu of offerings' for the customer, thereby ensuring its ecosystem is stable and has the means to scale up or down when needed (B3, Solution Provider, refs. 1, 23, 28). Subsequently, building a modular yet cohesive solution ecosystem usually would happen through direct relationships, synergising each other's capability and interest. However, this collaborative coordination and co-creation may face conflicting interests in terms of ego and long-term objectives of the ecosystem actors (B3, Government Specialist, ref. 32-36).

Interconnected and collaborative ecosystem behaviour

Ecosystem actors are very interdependent; this ecosystem consists of public sectors, government, space agencies, universities, and commercial firms. .

> "I always like to think that the triangle between government, industry, and universities is important, and that the triangle is solid. It gives balance to that competition, but it also opens opportunities for collaboration." (B3, University Rep., refs. 1-2).

Institutions and governments tend to have a big impact on the entire ecosystem, where their regulations might be either constraining or ensuring ecosystem continuity, cf. 4.3.1. (B3, Institutions Specialist, refs. 4-5). The relationship between regulators, commercial entities, and universities adds value to the final offering.

The entire ecosystem is still maturing, technology is still emerging, and the skills are constantly evolving. Ecosystem actors must consistently adapt and learn, which may be constrained by the nature of information sharing. While space agencies do share information with ecosystem actors (B3, ESA Specialist, ref. 8), and firms are generally willing to exchange information when formal non-disclosure agreements are in place, defence-related or other confidential projects often require strict information control (B3, ESA Specialist, refs 6-7). Although such practices may be necessary to protect competitive advantage and ensure organisational survival, ecosystem theory underscores the importance of co-evolution, which relies on openness and collaboration among actors.

The unpredictability of the space sector creates a bottleneck in terms of supply chain planning, highlighting the importance of collaborative relationships with suppliers (B3, Focal Firm Rep. 1, refs. 18, 23-25). The component supplier further explained that when issues arise, they would collaborate with the focal firm/entity to find a joint solution (B3, Supplier B, refs. 2-3). This emphasises on the collaborative relationships necessary in this ecosystem. The supplier further emphasises that to scale up as an SME might be through shared effort with external entities, where multiple component suppliers collaborate to deliver the same large order (B3, Supplier B refs. 9-14, 21, 23; Focal Firm Rep. 2 refs. 1-2). This notion is also supported by a focal firm representative, who suggested that the ecosystem may need to form a consortium in order to effectively adapt to rising demand (B3, Focal Firm Rep. 3, refs. 10-11).

Complementors are perceived to interact with focal firms as well, where ground stations or other activities are valuable add-ons to the final value proposition. Typically, the customer would choose the complementarity, however, with turn-key solutions, the focal firms are establishing the interconnectedness with these offerings (B3, Focal Firm Rep. 3, refs. 3-9). Launch brokers or rideshare programs are one of the most essential complementarities, as ecosystem actors are very dependent on launches. Launch brokers are playing an intermediary role for launch providers and focal firms/customers, however, relationships with launch brokers are present even if the customer has the direct contact (B3, Focal Firm Rep. 2, refs. 13-14; Government Specialist, refs. 14-16). Collaborations between launch brokers, launch providers, and customers may often face misaligned objectives and limited mutual understanding, where launch brokers are ensuring an enabling collaboration (B3, Launch Broker, refs. 1-2). Universities may also act as complementors, particularly in re-integrating start-ups to provide access to knowledge and experts, thereby stabilising the ecosystem and lowering entry-level barriers (B3, University Rep., refs. 3-4).

A downstream supplier inferred that ecosystem actors may be loosely coupled, as focal firms, universities, complementors, and downstream suppliers have the same customer (B3, Launch

Provider, refs. 4, 6-8), aligning with the definition of Iansiti & Levien (2004). Additionally, an aluminium supplier expressed that all ecosystem actors are important, and suitable partners are hard to find (B3, Supplier A, refs. 3-4), as 'no one can do it alone' (B3, Supplier A, refs. 11-12). Unless firms are producing the same components, complementarity or focal value proposition, ecosystem actors tend to collaborate (B3, Supplier A, ref. 13). However, many ecosystem actors are shifting towards a more collaborative mindset, as it is perceived to ensure their survival (B3, Supplier A, refs. 7-8; Government Specialist, refs. 26-28; Focal Firm Rep. 2, refs. 4-7, 29-31).

A recurring theme across interviews with the focal firm, institutional specialists, and suppliers was the role of long-term relationships in fostering co-creation and mutual growth. These relationships often evolve beyond transactional exchanges into strategic collaborations, in which partners are willing to adapt jointly and share risks (B3, Focal Firm Rep. 1, refs. 21-22; Focal Firm Rep. 2, refs. 8, 32-33; Institutions Specialist, refs. 2-3). Subsequently, successful collaborations emerge when suppliers or customers are willing to 'go the extra mile' for each other (B3, Institutions Specialist, refs. 2-3). Suppliers have shared this notion, that collaborations amplify the co-evolution as actors share knowledge and adapt together to space regulations (B3, Supplier A, refs. 1, 5-6). Similarly, long-term relationships may lead to scaling up alongside its partnerships to adapt to ecosystem actors' strategic direction (B3, Supplier B, refs. 8, 19-20).

One of the examples of ecosystem actors all collaborating or behaving similarly is ESA's Space Debris Charter (ESA, 2023), proposing to have a sustainability approach towards space and satellites in orbit (B3, Focal Firm Rep. 1, ref. 29; ESA Specialist, ref. 20; Focal Firm Rep. 2, refs. 16-17). This ambitious objective is created to ensure ecosystem sustainability and continuity, aligning with ecosystem resilience (B3, Focal Firm Rep. 2, refs. 16, 18). European ecosystem actors are all aligned in terms of this charter, as it may affect their legitimacy if they do not employ such an approach. ESA also impacts the co-evolution process through encouraging ecosystem actors to improve, when participating on its projects, cf. section 4.3.2 (B3, ESA Specialist, refs. 3-5; Supplier B, refs. 17-18; University Rep., ref. 11). Space agencies also foster the regional ecosystem sustainability, as it supports less mature member states to boost innovation and competition (B3, ESA Specialist, refs. 11, 17). However, ecosystem actors cannot solely rely on institutions or space agencies to ensure business continuity (B3, ESA Specialist, ref. 9; Focal Firm Rep. 3, refs. 18-19).

Partnership dynamics and power dynamics

Ecosystem actors often experience only brief periods of technological dominance, as the pace of innovation is fast and continuously evolving (cf. Section 4.1.2; B3, Focal Firm Rep. 1, refs. 8–9, 12–14). As a result, power dynamics within the ecosystem are in constant change, contributing to its highly dynamic nature. Ecosystem actors typically opt for informal agreements, when interdependencies are present, however, if there is no notion of interdependence, ecosystem actors opt for contractual or formal relationships (B3, Focal Firm Rep. 1, ref. 14; Government Specialist, refs. 18-19; Solution Provider, refs. 10-12). Other ecosystem actors, such as the downstream supplier and component supplier, argue that most likely partnerships will be most-likely strategy-driven and formalised in the future, as it ensures security for both parties (B3, Launch Provider, ref. 3; Supplier B, refs. 4-5). Consequently, being a shift from technology driven to strategy driven (B3, Supplier B, refs. 4-5).

> "… if you want to focus really on what you are good at, then you also need to find partners for the things you are not good at." (B3, Supplier B, refs. 6-7).

This notion was echoed by the solution provider, who acknowledged that the firm is not an expert in all areas and therefore relies on external partnerships to co-create value and enhance its overall value proposition (B3, Solution Provider, refs. 13-16). A focal firm representative argues that these partnerships are not only technology-driven or strategy-driven, but also politically driven. In response to the evolving global landscape, there has been a rise in sovereignty-driven initiatives, a renewed prioritisation of defence capabilities, and a reconfiguration of geopolitical alliances (B3, Focal Firm Rep. 3, refs. 10-11; Focal Firm Rep. 1, ref. 19; ESA Specialist, refs. 14-15; Government Specialist, refs. 2-5, 23-24; University Rep., ref. 7). The complementor argues that collaborations have faced new constraints due to market evolution; launch diversity has decreased due to geopolitical shifts (B3, Launch Broker, ref. 4).

Reputation is key when entering new partnerships, as it builds trust, it shows commitment and may be a sign of stability (B3, Focal Firm Rep. 2, refs. 6-7). As the ESA specialist expressed, making errors as an ecosystem actor may be ruining the actor's reputation (B3, ESA Specialist, refs. 9-10), however, acknowledging the issue and publicly outlining a clear plan for improvement represent reactive resilience strategies that may help mitigate severe reputational damage (B3, ESA Specialist, refs. 21-22). Additionally, to gain legitimacy or increase the firm's reputation, ecosystem actors enter collaborative agreements with local partners (B3, Government Specialist, refs. 6-8), which are able to 'open the doors' to that region (B3, Government Specialist, refs. 18-19). Another strategy is to enter agreements with prime contractors, who are the larger corporations that may add a better sense of responsibility (B3, Focal Firm Rep. 2, refs. 9-10; 34-35, 37-38).

Customisation and standardisation impacting co-creation processes

Specialising firms may have difficulties in scaling up or may choose not to scale up to optimise their profits, however the latter affects the entire ecosystem, as it may create a bottleneck by restricting its capacity (B3, Focal Firm Rep. 1, refs. 10-11). However, specialisation is mostly present at the component level (B3, Focal Firm Rep. 3, ref. 13). Focal firms may dive into specialisation through niche markets or building markets (B3, Focal Firm Rep. 3, ref. 14). Subsequently, this specialisation trend is assessed to affect mostly component suppliers negatively, whereas focal firms are expected to thrive in this (B3, Focal Firm Rep. 3, ref. 15).

Focal firms have historically done customisation, where the satellites were unique to the specific missions (B3, Focal Firm Rep. 1, ref. 15). Currently, some focal firms have decided to shift towards standardisation and therefore integrate themselves as solution providers, expanding their role within the ecosystem (B3, Focal Firm Rep. 1, refs. 15-17). It is perceived that most ecosystem actors are navigating similar challenges due to the continuously evolving market. Standardisation is considered critical for stimulating customer demand, as satellites have historically been associated with high levels of risk. By promoting standardisation, it is believed that collaboration will increase, driven by improved success rates and greater confidence in system reliability (B3, Focal Firm Rep. 1, refs. 26-28). However, a small amount of iteration or customisation might still find a place, even if the components or solutions are standardised (B3, Institutions Specialist, ref. 1). The ESA specialist gave the example of COTS (commercial-off-the-shelf) components, which are standardised components with a lower quality, as they are not as tested for radiation. These are typically used in research or scientific missions by ESA, as it is cheaper and faster (B3, ESA Specialist, refs. 1-2).

4.2.4. Specialisation and ecosystem structure

In the formative years of the small satellite ecosystem, a handful of pioneers were compelled to build every subsystem in-house simply to get some of the first CubeSats into orbit. One participant recalls that the focal firm's unusually broad product catalogue as being pure heritage from a period when an external supply base did not yet exist, and would realistically never be replicated by a rational market entrant today (B4, Focal Firm Rep. 2, ref. 7). That same early generalism gradually gave way to a far more segmented landscape. The most valuable subsystems are now delivered by firms that may be defined as specialists (B4, Focal Firm Rep. 1, ref. 2). Typical examples include propulsion, star trackers, reaction wheels and other high-performance elements supplied by single-product champions whose entire survival depends on excelling at one technology (B4, Focal Firm Rep. 1, ref. 3).

Several structural forces within the ecosystem drive increasing specialisation. Firstly, the rapid pace of performance improvement makes it prohibitively expensive to maintain state-of-the-art capabilities across a wide portfolio. As a result, satellite integrators tend to relinquish responsibility for areas in which they can no longer sustain technological leadership (B4, Focal Firm Rep. 1, refs. 4-5). Secondly, disruptive shifts – such as the transition from cold-gas to electric propulsion – may take place within a single product cycle. Such changes expose generalist firms to the risk of stranded investments, while favouring agile, niche suppliers capable of adapting more rapidly to technological change (B4, Focal Firm Rep. 1, refs. 10-11). Thirdly, the capital-intensive nature of hardware development compels component manufacturers to maximise returns from a given product generation before securing funding for its successor. As a result, market leadership often shifts from one specialist to another, rather than remaining with generalist firms (B4, Focal Firm Rep. 1, ref. 8). Yet specialisation is not without systemic risk. Should a critical component be monopolised by a single niche firm, limited production capacity may limit the entire value chain, forcing integrators to prioritise resilience measures such as dual sourcing (B4, Focal Firm Rep. 1, ref. 13-14). Suppliers themselves acknowledge the careful balance required in their operations: the more specialised their offering, the more important it becomes to engage in projects with enough technical complexity to make full use of their capabilities and ensure continued relevance (B4, Supplier B, ref. 2). Launch brokers serve as intermediaries between satellite operators and launch providers. They monitor spare capacity across multiple launch vehicles, advise customers on the trade-offs associated with different orbital options, and keep launch providers informed of actual market demand. This coordination helps reduce both negotiation time and transaction costs for all parties involved (B4, Launch Broker, refs. 1-3). Rideshare, dedicated and mid-inclination options are mixed to suit each constellation; this flexible scheduling helps young operators reach orbit on budget and gives launch firms steadier utilisation (B4, Launch Broker, ref. 4). In consequence, the ecosystem moves towards a configuration where only actors that add discernible value, through exceptional performance, integration skill or customer intimacy, retain profitable positions.

Institutional actors further reinforce this trajectory. ESA, for example, actively promotes a broad and robust industrial base by employing competitive procurement processes and providing technology demonstration funding. These measures aim to maintain multiple capable firms within each niche and to avoid strategic dependence on any single supplier (B4, ESA Specialist, ref. 2). A new micro launcher company positions by aiming at equatorial and medium-inclination orbits that large rideshare programmes largely ignore; this choice leaves the busy sun-synchronous market to incumbents yet opens fresh options for satellite manufacturers whose missions need those geometries (B4, Launch Provider, refs. 2-3). The company in question also bundles insurance, logistics and space-situational-awareness services with each launch; forward planning like this shortens lead-times for customers and secures the firm a central role in an under-served segment of the market (B4, Launch Provider, ref. 1). Furthermore, national governments reinforce this effect by attaching offset or localisation requirements to major programmes. These provisions compel prime contractors to collaborate with regional specialists, thereby expanding the specialised tier of the ecosystem (B4, Government Specialist, ref. 5). Universities fill a practical niche; their labs test early-stage technologies such as miniaturised propulsion and onboard autonomy that industry cannot yet afford to mature, and they offer training that eases the skills shortage in satellite manufacturing (B4, University Rep., refs. 1-2). Academic projects often evolve into firms as universities guide ventures through incubation, engage with policy-makers, and align research with national net-zero goals; converting experimental work into lasting economic value (B4, University Rep., refs. 3-5).

Downstream, the commoditisation of the satellite bus has intensified rivalry among manufacturers, pushing them to differentiate through domain- or use case-specific applications rather than through generic satellite capability (B4, Focal Firms Rep. 3, ref. 5-6). Consequently, solution-oriented focal firms may now move towards assembling an 'à-la-carte menu' that spans payload procurement, ground infrastructure, launch and data exploitation, reflecting the evolving expectation that customers purchase mission outcomes rather than satellites (B4, Solution Provider, refs. 2-3; cf. section 4.2.3). Evidently, the small-satellite ecosystem is therefore progressing from broad-spectrum manufacturing towards a layered structure in which satellite integrators orchestrate networks of highly focused component and service providers. In other words, value is migrating to whatever form of specialisation, technical, integrative or application-specific, most effectively solves the customer's problem at each point in time, and the ecosystem is now beginning to reorganise itself around that very same logic.

4.3. Institutional Influence on Ecosystem Co-Evolution

This aggregated dimension emphasises on how institutions, such as governments, space agencies, and universities, impact the co-evolutionary process within the ecosystem. The dimension reveals second-order themes like *institutions as enablers and constraints,* and *institutions and innovation trajectories,* highlighting their role as stabilisers and technology developers.

4.3.1. Institutions as enablers and constraints

Table 9: Summarising table of Institutions as enablers and constraints

Actor	Institutions as enablers	Institutions as constraints
Focal firm (Rep. 1, 2, 3)	Participating in ESA projects adds accreditation and credibility for new entrants. Institutions are enabling the ecosystem through innovation funding.	Institutions may instil norms or practices that affect the entire ecosystem (e.g. Space Debris Charter); if this is not followed, firms may struggle to attract investment. Governments are failing to support the ecosystem through actual procurement; when they do engage in procurement, they impose time constraints. Government financing is inherently political
Government Specialist	Local offset obligations ensure that the investment spent in satellites from cross-border enterprises is returning to the local economy	Government financing introduces complexity, as it is highly political.
Launch Broker (Complementor)	Allocation of resources through funding programs for various type of firms	Governments are failing to support the ecosystem through actual procurement
Suppliers (Upstream and Downstream)	Compliance to ESA or NASA documentation standards elevates internal quality systems and broadens customer base	Regulations may be constraining for launch providers, as space agencies do not accept the launchers until they succeed.
ESA Specialist	Association with ESA is widely interpreted as evidence to a firm's ability to meet demanding technical and procedural requirements.	Funding constraints due to geographical return; firms must wait for new funding decisions before they may participate in additional ESA projects. Political considerations may override technical merit
Institutions Specialist	Institutions foster early development, stabilising funding, and domestic capabilities. Institutions enable through long-term contracts which may shield firms from commercial market volatility	May limit SMEs participation due to geographical returns. Geographical return may consolidate power among larger firms, reinforcing their dominants. Restriction of strategic flexibility and governance blurriness bring uncertainty and risk of overlapping bureaucratic requirements
University Representative	Institutions are fostering standardisation – example of ECSS standards	The standardisation programs have limited enforceability, as they are only applicable to firms that voluntarily choose to adopt them

Source: authors' own table

Formal public institutions operate as both enablers and constraints in the small satellite ecosystem. Their influence can be broadly categorised around three areas: accreditation, allocation and agenda-setting. In each category the instruments that release funding, confer credibility or set technological direction simultaneously impose conditions that circumscribe how those benefits may be exploited, so every advantage often inadvertently arrives coupled to an obligation that firms must accommodate.

Accreditation often begins with flight heritage acquired through collaboration with a recognised space agency. Participation in ESA projects allows manufacturers to signal compliance with rigorous standards, gaining credibility in export markets. While not exactly a formal endorsement, association with ESA is widely interpreted as evidence of a firm's ability to meet demanding technical and procedural requirements (C1, ESA Specialist, ref. 11). Moreover, ESA's early-stage funding offers newcomers credibility and hands-on experience, preparing them for the higher risks of commercial missions (C1, ESA Specialist, ref. 21). ESA's funding does more than support process development; it enables learning cycles that private investors would seldom be willing to pay for. Managers note that participating in such projects allows a less mature firm to operate like a real company while displaying ESA's logo on marketing materials, effectively turning procedural compliance into brand equity (C1, Focal Firm Rep. 1, refs. 21-22). The same interviewees acknowledge, however, that once a firm proves capable, ESA raises its testing requirements significantly; consequently extending timelines and potentially drawing limited engineering resources away from active commercial bids (C1, Focal Firm Rep. 1, ref. 6). Accreditation thus confers a credibility premium that opens export markets even as it pulls resources into an institutional cadence not fully aligned with commercial time-to-market.

Allocation operates through the geographical-return rule and cognate political instruments that distribute public money across member states (C1, Focal Firm Rep. 2, ref. 1; Launch Broker, ref. 5). ESA contracts flow back to the nations that subscribed the underlying programme; domestic industry is nurtured and sovereign capability objectives are advanced (C1, ESA Specialist, ref. 2). Consequently, this enables firms operating on thin margins, often without access to venture capital, to secure multi-year, design-to-specification contracts that help cover operational costs and justify long-term investment. Moreover, the funding structure has also prompted manufacturers to establish subsidiaries across multiple EU member states, allowing them to access a broader range of national budgets rather than being limited by the funding capacity of their home country's delegation (C1, Institutions Specialist, ref. 1). However, once a member state's allocated ESA budget is used up, companies based only in said country face a structural disadvantage: they must wait for new funding decisions before they can take on additional ESA work. This often forces them to either leave engineering teams underused or shift their focus toward commercial projects instead (C1, ESA Specialist, ref. 3). The constraining impact of ESA's geographical return policy is most evident when awarding prime contracts for multinational missions. In one case, a company with stronger technical qualifications and relevant mission experience was assigned a subcontractor role, as the prime position was reserved for industry from the member state contributing the largest share of funding; showing how political considerations can override technical merit (C1, ESA Specialist, ref. 15). The mechanism clearly enables the host nation's supply base, yet it simultaneously constrains firms from smaller states, who must either accept a reduced work-share or abandon the mission altogether. These allocation mechanisms influence where companies establish operations and how they shape their market strategies. While they can support early growth, they may also limit firms' ability to optimise their footprint or resource allocation based on efficiency or competitiveness (C1, Institutions Specialist, ref. 9). This constraint becomes more apparent in large-scale public procurements negotiated directly with consortia deemed financially strong enough to co-invest in infrastructure, such as the 'Iris²' secure-connectivity initiative, where only major incumbents with access to significant private capital were invited to participate, effectively relegating smaller integrators to lower-tier supplier roles (C1, Institutions Specialist, ref. 9; Focal Firm Rep. 3, ref. 5). Public allocation thus opens doors but also hard-codes hierarchy: it promotes domestic participation while consolidating bargaining power in the hands of firms that already command scale. In contrast, governments are criticised for solely funding the ecosystem without procuring its products, pushing firms to innovate and improve, yet failing to support them through actual procurement (C1, Focal Firm Rep. 2, refs. 3-5; Launch Broker refs. 6-7). Conversely, when governments do engage in procurement, they often impose strict time constraints on firms (C1, Focal Firm Rep. 2, ref. 12). Additionally, government financing introduces further complexity, as it is inherently political due to its reliance on 'tax-payer' funded resources (C1, Focal Firm Rep. 2, ref. 2; Government Specialist, ref. 1; University Rep., ref. 14). Within some regions, legitimacy efforts impact the willingness for actors to collaborate. Local offset obligations serve the same purpose as geographical return – ensuring that the investment spent in satellites from cross-border enterprises is returning to the local economy (C2, Government Specialist, refs. 11-14). This can happen through contributing with training, infrastructure, facilities, or CSR efforts.

Agenda-setting expresses institutional influence over the direction, pace and normative framing of innovation. Through programmes such as GSTP, ESA provides funding for high-risk technologies that private investors often consider too uncertain, thereby guiding the sector's development toward capabilities seen as strategically important for Europe (C1, ESA Specialist, ref. 1). Demonstrator missions extend this influence beyond technology development to testing operational concepts in real-world conditions. For example, a small satellite sent to an asteroid under ESA helped validate the potential of small satellites for deep-space exploration (C1, ESA Specialist, ref. 8). The same mechanism can become a constraint when space agency priorities or regulatory ambitions move faster than what the commercial sector is ready to deliver (C1, Launch Provider, ref. 5; University Rep., refs. 9-10). Recent changes to debris-mitigation and spectrum policies show how agenda-setting by institutions can shift design priorities across the industry (ESA, 2025); another example is the ECSS standards, however they are only valid for actors choosing to uphold them, making them a non-binding reference (C1, University Rep., ref. 6; Focal Firm Rep. 3, refs. 22-23). Participants report that propulsion systems were once considered unnecessary weight for small satellites, yet within just two years, disposing of satellites safely at the end of their missions has become both a regulatory expectation and a reputational issue (O'Reilly et al., 2021). As a result, new satellites are increasingly designed with propulsion and software features that allow for controlled de-orbiting (C1, Focal Firm Rep. 1, refs. 2-3). Consequently, initiatives like ESA's Zero Debris Charter, while still voluntary, have started to influence design decisions in practice (C1, Focal Firm Rep. 2, refs. 6-9, 15-18). Firms aiming to align with emerging standards or secure institutional support often treat the charter's goals as if they were requirements. Satellites that cannot remove themselves from orbit are now widely perceived as contributing to space debris, which can undermine both public image and future funding opportunities (C1, Focal Firm Rep. 1, refs. 2-3). This trend pushes companies to allocate mass and budget to propulsion or dragsail systems (ESA, 2021), increasing costs in the short term but also generating demand for de-orbit technologies that would otherwise struggle to attract investment (C1, Focal Firm Rep. 1, refs. 9-11). Another example of soft agenda-setting is the widespread adoption of the CubeSat form factor. Originally developed for educational use, it has now become the default standard for small missions supported by ESA and other agencies. Focal firms note that deviating from this format means losing access to a mature ecosystem of off-the-shelf parts and services, forcing firms to build systems from scratch (C1, Focal Firm Rep. 1, refs. 12-13). Institutional support for the CubeSat model has enabled fast and cost-effective development, but it also discourages experimentation with alternative satellite designs.

Evidently, across these three mechanisms, enablement and constraint operate in parallel. Accreditation provides legitimacy but adds cost; allocation delivers funding while limiting strategic autonomy; and agenda-setting reduces risk in frontier exploration while imposing rules that shape timing and direction. Firms that succeed in the small satellite ecosystem do not necessarily avoid institutional influence; they learn to navigate it. They use the credibility of agency-backed missions to secure commercial contracts, balance nationally returned work with global supply strategies, and convert programme requirements into distinctive capabilities more quickly than their competitors. In this sense, public institutions are not merely external forces or gatekeepers; they are active co-producers of industrial development. Their incentives, funding models and governance structures must be interpreted as carefully as any other market signal. How such institutional influence shapes not only firm behaviour, but also long-term innovation trajectories across the ecosystem, is the focus of the following chapter, cf. section 4.3.2.

4.3.2. Institutions and innovation trajectories

According to Breil & Ciocarlan (2025), institutions, space agencies, and governments significantly influence the ecosystem by establishing governance structures that shape strategic and operational practices, i.e. through technical standards, regulations, informal norms, cf. section 4.3.1. This section will present the views on institutions in relation to innovation trajectories. This second order theme entails how institutions are playing a stabilising or governing force in the ecosystem, impacting credibility and reliability among ecosystem actors, and how institutions and universities directly affect innovation within the ecosystem.

> "I think that triangle – industry, university, and government/policy – shapes the direction of satellite technology and also the regulation, which is becoming really important." (C2, University Rep., refs. 12-13). (Leydesdorff & Zawdie, 2010)

Table 10: Summarising table of Institutions and innovation trajectories

Actor	Institutions as stabilising forces	Institutions impacting innovation trajectories	The role of universities and innovation trajectories
Launch Broker (Complementor)	Institutions are stabilising forces through long-term, strategic investments. Criticises institutions for being too risk-averse	The ecosystem is very dependent on public funding done by institutions. Criticises institutions noting their commitment should happen earlier in the process	N/A
Focal firm (Rep. 1, 2, 3)	Space agencies develop own political systems or strategy around space. ESA was prominent for survival during Covid-19. R&D investments may ensure ecosystem continuity. Criticises institutions for only investing without procuring the focal offer.	The ecosystem is very dependent on public funding done by institutions. Space agencies are enablers of technological development; their role is to stimulate innovation, ensuring ecosystem sustainability	Universities impact the national context, but may limit cross-border talent mobility, constraining other countries in sustaining their domestic ecosystem. "a healthy ecosystem needs the right expertise"
Government Specialist	N/A	Local offset obligations serve the same purpose as geographical return – ensuring that the investment spent in satellites from cross-border enterprises is returning to the local economy	Commercial or private ecosystem actors can initiate academic collaboration to tap into the knowledge and technological skills
Institutions Specialist	Space industry is very sensitive to geopolitics, regulations, and defence agenda. Institutions enhance reliability and credibility through collaboration participations	Institutions prioritise innovation trajectories that affect firms' internal strategies; this may be reciprocal. Geographical return may affect firms expanding to other countries to receive the investment for innovation	N/A
Launch Provider (Downstream Supplier)	ESA programs may stabilise the actors.	Public funding and institutional programs (e.g. EIC Accelerator program) are vital for start-up survival	Multiple firms choose to opt for vertical integration
University Representative	Institutions may act as catalysts for co-evolution in the ecosystem. Criticises lack of global regulations, which hinders international cooperation	Commitment to long-term stability and ecosystem continuity, blossoms collaborative institutional efforts and de-risking R&D projects	Universities influence innovation trajectories, regulation, and talent. Act as innovation hubs – heavily focused on R&D and attract funding fast. Act as a bridge between academia and commercial market
ESA Specialist	Space agencies are perceived to enable ecosystem resilience through R&D and funding efforts. Institutions enhance reliability and credibility through collaboration participations	Institutions like space agencies are shaping R&D and project focus through co-funding innovation and determining strategic priorities	ESA projects are used to elevate universities and raise national competence.

Source: authors' own table

Institutions as stabilising forces

Typically, national space agencies are led by the national government, meaning the formal institutional powers are very present. These space agencies usually develop their own political system or strategy around space (C2, Focal Firm Rep. 1, ref. 1). Since governmental forces are in play, the space industry is very sensitive to geopolitics, regulations, and defence agendas. Recent geopolitical events have created a higher demand from the defence side, resulting in higher budgets and a push for innovative and reliable solutions (C2, Institutions Specialist, ref. 5; European Commission, 2025).

> "You can argue that the [home country] government has a responsibility to create a certain resilience, by giving more to […] the new space industry. [...] They put innovation money out – and I've said that directly to the ministers – you keep putting innovation on innovations [...] I want you to start buying our products because what's the point of innovating forever?" (C2, Focal Firm Rep. 2, ref. 3)

Institutions and governments are perceived to have a certain responsibility to enable ecosystem resilience by multiple ecosystem actors (C2, Focal Firm Rep. 2, ref. 3; ESA Specialist, refs. 27-28). However, the notion of institutions being a stabilising or governing force within the small satellite ecosystem is met with skepticism by a few participants; the focal firm argues that institutions or supranational agencies are acting through funding, thus securing continuous development in the ecosystem (C2, Focal Firm Rep. 2, refs. 6-8). While this does not stabilise the ecosystem in the short-term, it certainly affects the ecosystem in the long run – ergo ensuring ecosystem resilience through innovation, knowledge sharing, and development (C2, Focal Firm Rep. 2, refs. 6, 9-10; ESA Specialist, ref. 40). This view is challenged by another representative within the focal firm, who highlights the role of supranational agencies as a key part of the ecosystem, emphasising their integral contribution to its structure and functioning: "Without ESA, for example, the European space industry wouldn't really survive" (C2, Focal Firm Rep. 3, ref. 4). Without institutional support, many SMEs would not be able to deliver the value proposition (C2, Focal Firm Rep. 3, ref. 4), as the industry is generally constrained by low volume, cf. 4.4.1. In the example of COVID-19, SMEs and start-ups within the ecosystem were heavily affected – during this disruptive event ESA played a vital role in ensuring the survival of the ecosystem (C2, Focal Firm Rep. 3, refs. 5-6; ESA, 2020). It was further noted that institutions play a crucial role in funding, as this not only helps stabilise the existing ecosystem but also attracts new entrants to the sector (C2, Focal Firm Rep. 3, ref. 10).

As mentioned above, supranational agencies might act as a stabilising force in reducing inefficiencies and might even influence a reduction of redundancies. A university representative even argued that these institutions may act as catalysts for co-evolution in the ecosystem (C2, University Rep., refs. 16-17). The interviewed launch provider gave the example of EIC Accelerator Program managed by the European Commission, where firms compete for the associated grants (C2, Launch Provider, ref. 1; European Innovation Council, 2025). This is an example of how the institutions may work as stabilising forces in the ecosystem (C2, Launch Provider, ref. 2). Another example is space regulations, specifically the standardisation of satellite development, where ESA introduced the European Cooperation for Space Standardisation (ECSS) framework as a response to misalignment between engineering and operational standards (ESA, ntd). These efforts have supported the development of synergies in the small satellite sector by promoting a shared set of practices and technical standards, thereby facilitating collaboration. However, the absence of global regulatory frameworks continues to hinder international cooperation. This challenge could be addressed through stronger institutional coordination at the global level, which may reduce complexity, foster innovation, and build trust among ecosystem actors (C2, University Rep., ref. 15). Additionally, the interviewed complementor agreed with the focal firm – institutions are stabilising the ecosystem mostly through long-term, strategic investments. This is especially vital for start-ups where venture capital may be limited (C2, Launch Broker, ref. 1). In principle, these institutions, i.e. space agencies, governments, or defence, can reduce regulatory 'roadblocks', provide grants, or act as customers. However, the complementor criticised institutions of remaining too risk-averse, not fulfilling their role and providing occasionally "drip-fed" funding that fails to bring developments to end (C2, Launch Broker, ref. 1).

> "Yes, they will say that they are a stabilising force, and I will challenge that by saying they have not committed in a way that truly makes them a stabilising force." (C2, Launch Broker, ref. 4)

This complementor highlights the case of European launch vehicles, noting that they have not received the support and stabilisation required for sustainable development. In the context of smaller launch vehicles and the new space environment, governments have often failed to act as committed anchor customers – those who provide the level of funding necessary to see projects through to completion. Instead, 'drip-fed' or 'token' funding has hindered ecosystem co-evolution by limiting the number of viable launch providers (C2, Launch Broker, ref. 2), leading to the exit of several SMEs. It is inferred that institutions must take an active role in de-risking and catalysing key sub-sectors, as well as fostering innovation within the ecosystem – thereby contributing to its overall resilience

As mentioned, institutional roles impact innovation trajectories and the stability of the ecosystem, however, when the roles are unclear or overlapping, it may undermine it. An example is the roles of the European Defence Agency (EDA) and national Ministries of Defence (MoDs) within the EU. The 'blurriness' of jurisdiction and authority between these roles have impacted the stabilisation in defining the programmatic lines effectively (C2, Institutions Specialist, ref. 15). As the representative explains, recent efforts have been employed by the EDA to adopt an approach of pooling resources and not overstepping its role regarding MoDs (C2, Institutions Specialist, ref. 15). This approach has impacted the cooperation positively; nonetheless, institutional misalignment may stagnate ecosystem collaboration, and therefore it may reduce the overall ecosystem resilience.

Not only can institutions act as stabilising or governing forces, but they also enhance reliability and credibility for other ecosystem actors through collaborations (C2, ESA Specialist, refs. 13-14; Institutions Specialist, ref. 14). Learning from these collaborative projects and applying the knowledge, information, or technology inside the firm adds to the experience and perceived reliability by other ecosystem actors (C2, ESA Specialist, refs. 13-14). Participating in these institutional projects results in visibility, enhancement of credibility, and an endorsement of legitimacy (C2, ESA Specialist, refs. 15, 25-26, and 34).

> "If ESA believes in you, it's an endorsement. It marks you as an approved space manufacturer. That's why the ESA brand is so important." (C2, ESA Specialist, ref. 16).

This notion is also emphasised by the institutions specialist within the focal firm, who argues that participation in institution-led projects results in legitimacy through institutional endorsement. Such involvement creates visibility for the firm, and signals reliability and credibility to potential customers (C2, Institutions Specialist, ref. 14; Focal Firm Rep. 2, ref. 11). As mentioned in section 4.2.2, flight heritage functions as a requirement or an unwritten norm within this ecosystem. Therefore, opportunities to test out new technology associated with scientific missions, increases the firm's strategic advantage.

Impacting innovation trajectories through funding

Investment or funding represents a key dependency faced by all ecosystem actors. Financing is typically sourced through either private or public channels. As noted by the complementor, the ecosystem remains heavily reliant on public funding, particularly through ESA, EDF, or national government programmes (C2, Launch Broker, ref. 1; Focal Firm Rep. 2, ref. 1). Institutions like space agencies are shaping R&D and project focus through co-funding innovation and determining strategic priorities (C2, ESA Specialist, refs. 37-38). On occasions, space agencies and national governments prioritise prospects, which affects the firm's internal processes and innovation trajectories (C2, Institutions Specialist, refs. 1-2). However, this can be reciprocal, where ecosystem actors actively influence institutional innovation trajectories creating an interdependency between the actors (C2, Institutions Specialist, refs. 3-4).

As mentioned in the above, institutions are seen as stabilising forces by several ecosystem actors through funding prototyping and capability preservation (C2, Focal Firm Rep. 3, ref. 8). Subsequently, this commitment to long-term stability and ecosystem continuity fosters collaborative institutional efforts and supports the de-risking of research and development projects (C2, University Rep., ref. 14). However, there is a need for institutions to fully commit earlier in the process and at scale – especially within the space sector, which is a high-risk industry (C2, Launch Broker, refs. 1-3; ESA Specialist, ref. 39). However, defence institutions can uncover investment fast due to high-pressured circumstances (C2, Institutions Specialist, ref. 5).

Most projects or missions remain heavily dependent on institutional funding, as venture capital or market returns are currently insufficient to ensure self-sustainability (C2, Focal Firm Rep. 3, refs. 2-3). This is further discussed by the downstream supplier, adding that public funding and programs such as the EIC Accelerator are vital for start-up survival (C2, Launch Provider, ref. 1).

ESA's geographical return rule, where countries receive industrial contracts in return to their financial contributions (C2, ESA Specialist, refs. 3-5, 10, 18-21, 23, 31-32; Institutions

Specialist, ref. 6-11), indulge member states to exploit this mechanism in influencing national space industry (C2, ESA Specialist, ref. 3-4, 10); this is especially beneficial for less mature national players in the European ecosystem (C2, ESA Specialist, ref. 4). However, it is heavily influenced by politics due to the amount of investment the member state contributes with (C2, ESA Specialist, ref. 18-20). Moreover, ESA often reserves contract quotas for SMEs to ensure an overall ecosystem co-evolution, where nobody is left behind (C2, Institutions Specialist, ref. 12-13).

As drivers of innovation, institutions are also enablers of technological development, overcoming technological limitations through scientific missions. This supports curiosity-driven exploration of space and builds long-term ecosystem continuity (C2, Focal Firm Rep. 2, ref. 6, 9-10; ESA Specialist, ref. 13-14). Therefore, ESA is not positioned as a 'backstop' in the way governments intervene when national industries fail; rather, its role is to stimulate innovation, ensuring ecosystem sustainability (C2, Focal Firm Rep. 2, ref. 9-10).

The role of universities in innovation trajectories

While universities often occupy the role of customers or complementors, they may also be viewed as anchor institutions within the ecosystem. Their influence extends to shaping innovation trajectories, contributing to regulatory development, and supplying talent to the sector (C2, University Rep., ref. 12-13). The university representative argues that universities act as innovation hubs (Steiber & Alänge, 2015), as they are heavily focused on research and are faster at gaining funding (Leydesdorff & Zawdie, 2010). By having access to funding, and fruitful knowledge and skills regarding technology, universities can de-risk technology within the ecosystem through testing, researching, and documenting it before commercial markets (C2, University Rep., ref. 10-11). In other words, the complementarity lies in universities being the bridge between academia or scientific research and the commercial market (C2, University Rep., ref. 10-11).

> "The universities were able to launch their own research missions, and that also opened up the sector to the private industry, with many players appearing in the space sector every day. That changed the relationships of collaboration and competition that you were talking about at the beginning. Now you have the private sector and the public sector competing with each other, which is good, but they also have this symbiotic relationship" (C2, University Rep., ref. 2-3).

Consequently, commercial or private ecosystem actors can initiate academic collaboration to tap into the knowledge and technological skills (C2, University Rep., ref. 2-3; Government Specialist, ref. 1-2). This ties into the notion of universities being innovation hubs. Governments in general use ESA projects to elevate their universities and raise national competence: "it's high-tech work. You need a certain level of expertise to contribute to it. […] You also raise the knowledge level inside the country" (C2, ESA Specialist, ref. 35). Universities may therefore act as talent pipelines, ecosystem anchors, and innovation hubs. As they educate the next generation of satellite engineers, space lawyers, and scientists through various degree programs, including collaborative arrangements such as co-funded PhDs, they supply talent for the space sector (Fonseca de la Bella, 2025). Additionally, they cover skills and knowledge gaps through their complementary short courses and professional training (C2, University Rep., ref. 7-9, 12-13). University has a lot of impact in the national context, however, there is a limited cross-border talent mobility, which constrains other countries in sustaining their domestic ecosystem – "a healthy ecosystem needs the right expertise" (C2, Focal Firm Rep. 3, ref. 11).

4.4. Vulnerabilities, Constraints, and Disruptions

This aggregated dimension reveals firm-level vulnerabilities across the ecosystem and external disruptions impacting the ecosystem. This dimension consists of two second-order themes such as *operational and strategic constraints,* and *external shocks and uncertainty,* highlighting the vulnerabilities and complexity within the ecosystem.

4.4.1. Operational and strategic constraints

Within this second-order theme the presence of systemic operational and strategic constraints is shaped by the unique environmental, political, and industrial aspects of the space sector. The restricting nature of space adds another layer of complexity, forcing ecosystem actors to anticipate and adapt to unique constraints – once the satellite is sent to space, it cannot be changed, updated or repaired, meaning the technology must be quite robust (D1, Focal Firm Rep. 1, ref. 2, 3). For instance, actors have designed power systems that are capable of operating with limited energy availability (D1, Focal Firm Rep. 1, ref. 11-12).). Unfortunately, not all space constraints can be predicted or mitigated – satellites in orbit may be affected by space environmental hazards, where radiation, solar storms or even satellite collision risks are affecting the satellites (D1, Focal Firm Rep. 1, ref. 3). Since space is still underexplored, regulations are being updated regularly, which may bring constraints for ecosystem actors (D1, Supplier B, ref. 9). Ecosystem actors must therefore be quick at adapting to different circumstances, which combined with the technology complexity and space constraints, the space sector is generally costly (D2, Launch Provider, ref. 2).

Due to the added layer of complexity, the sensitivity to geopolitics, dependencies on governments, and low demand, the focal firm and a supplier stresses that the ecosystem is manufacturing in low volumes, which is a constraint on multiple levels (D1, Focal Firm Rep. 1, ref. 1, 13). As the ecosystem is shifting away from proof-of-concept approach, focal firms have been building multiple one-of-a-kind satellites, resulting in a low component volume (D1, Focal Firm Rep. 1, ref. 13). The satellites require several different components, which all must be compatible, however they are all generated in low volumes; thus, it is perceived as one of the most complex operational issues (D1, Supplier B, ref. 6; Focal Firm Rep. 2, ref. 3). The focal firm explains that this ‘high mix-low volume’ relationship may result in being unprioritised by electronics suppliers or other suppliers supplying mechanical, electronic components or material with dual usage (D1, Focal Firm Rep. 1 ref. 8-9; Focal Firm Rep. 2, ref. 7).

A way to stabilise the supply chain is through dual-sourcing or outsourcing, which was addressed by the focal firm, solution provider, complementor, and supplier (D1, Focal Firm Rep. 2, ref. 4; Launch Broker, ref. 5; Solution Provider, ref. 1, 2-3; Supplier B, ref. 4, 17; Focal Firm Rep. 3, ref. 7). The focal firm however stressed that the approach to outsourcing or dual sourcing depends on the firm’s size, as large MNEs are capable of attracting suppliers and hold a larger bargaining power towards suppliers, smaller firms do not possess the ability to manage their supply chains in the same way (D1, Focal Firm Rep. 2, ref. 1, 4, 13). SMEs cannot always afford traditional resilience measures, such as dual sourcing or supplier redundancy, which demonstrates a need for contextualising resilience strategies that distinguish the strategies by firm’s scale and stage of growth.

For SMEs outsourcing may be employed if there is a need for scaling up the business. As aforementioned, demand from governments is increasing and the ecosystem is beginning to mature, meaning SMEs must develop strategies to ensure survival for when the market might reach a market saturation point (Breil & Ciocarlan, 2025). Through outsourcing focal firms, solution providers, or suppliers might be able to scale up their offerings (D1, Solution Provider ref. 1-3; Supplier B ref. 13-14; Focal Firm Rep. 2, ref. 3-4). One of the focal firm representatives perceived outsourcing partners as complementors:

> "We rely on complementary companies to add value to our product. If you have a smart solution in mind and you're missing two key elements […]: should we develop those elements internally, or would it be smarter to partner with a company that already has the capability?" (D1, Focal Firm Rep. 2, ref. 3).

In this case complementors are not viewed as a loosely coupled actor to the focal firm, but as a formalised partnership. Firms are realising that internalising all activities limits scalability, which is why collaboration with complementors, or strategic outsourcing may mitigate these. However, three focal firm representatives highlight the negative consequences of scaling up too rapidly based on optimistic market projections (D1, Focal Firm Rep. 2, ref. 5-6; Government Specialist, ref. 4; Focal Firm Rep. 3, ref. 6). One of the suppliers consistently stresses that internal scalability is not always achievable, highlighting the need for modularity and external partners (D1, Supplier B, ref. 1-3, 5, 7, 11-12, 15-16).

4.4.2. External shocks and uncertainty

External shocks and uncertainty affect all within the small satellite ecosystem, exposing firms to sudden disruptions in supply, demand, technological trajectories and geopolitical conditions; any of which can destabilise even well-prepared strategies (D2, Focal Firm Rep. 1, ref. 1). Such disruptions reflect the risks associated with tight inter-firm coupling in ecosystems where value creation is distributed but control is unevenly allocated, cf. section 4.4.1. Physical phenomena further expose the fragility of the small satellite ecosystem. One customer's satellite lost four years of its planned service life after being struck by a solar storm; an uncontrollable external shock that might only have been mitigated through more robust propulsion capability (D2, Focal Firm Rep. 1, ref. 2). In more severe cases, entire rideshare batches have been rendered unusable, showing how space weather can instantly eliminate both physical assets and projected revenue streams (D2, University Rep., ref. 18-19). In parallel, evolving technological trajectories introduce another layer of uncertainty. As previously mentioned, one firm's investment in chemical propulsion quickly became obsolete when electric alternatives advanced more rapidly than anticipated, leading management to abandon the line and instead "keep an eye very open on the ecosystem" rather than pursue a narrowly proprietary strategy (D2, Focal Firm Rep. 1, ref. 4). Certainly, this shift reflects the ecosystem's dynamic structure, where leadership rotates quickly and firms must remain alert to developments across interconnected domains in order to maintain strategic flexibility, cf. section 4.1.2.

Market volatility amplifies the impact of external shocks by disrupting demand predictability. Despite years of optimistic forecasts, demand has lagged behind rapid supply growth, forcing firms to "sacrifice margins simply to win business" and exposing them to revenue cycles (D2, Focal Firm Rep. 2, ref. 11; ref. 13; Foust, 2024). Managers aim for "resilience in revenue" through a mix of long-term contracts and flexible sales, but overcapacity depresses prices and makes forecasting unreliable (D2, Focal Firm Rep. 2, ref. 5; ref. 6). Price competition has intensified, with firms offering extra satellites at no additional cost—undermining price signals and investment planning (D2, Government Specialist, ref. 1). Finance and policy shifts add further uncertainty: defence budgets can unlock capital "in an extremely fast way," while civil ministries move slowly (D2, Institutions Specialist, ref. 1; ESA Specialist ref. 3). Asymmetric responsiveness affects which ecosystem actors receive timely support. Meanwhile, venture capital has moved from abundance to scarcity, creating a funding "valley" for newer entrants (D2, Launch Broker, ref. 5). These shifts demonstrate how institutional incentives and redistributive mechanisms shape firm-level risk, cf. section 4.3.2.

On a global scale, geopolitical events often trigger abrupt strategic realignments across the small satellite ecosystem. The sudden loss of Soyuz rideshare capacity following Russia's invasion of Ukraine forced firms to shift very rapidly to alternative launch providers, a transition made even more difficult by ongoing pandemic-related shutdowns (D2, Launch Broker, ref. 1-2; Palmer, 2024). Consequently, geopolitical shocks can sever critical interdependencies and impose costly reconfiguration across ecosystem actors. At the same time, new US-imposed tariffs have introduced unforeseen duties on satellites assembled abroad, compelling operators to "price these tariffs into the cost of doing a launch" and adjust vehicle choices amid shifting policy environments (D2, Launch Broker, ref. 3-4, Rainbow, 2025). Similarly, component sourcing has become equally fraught: growing demand for "China-free active parts" in response to cybersecurity concerns, along with supply risks tied to national stockpiling of key materials like solar cells and aluminium, has forced firms to redesign payloads or secure secondary suppliers on short notice (D2, Focal Firm Rep. 3, ref. 6-7; D2, Focal Firm Rep. 3, ref. 14-15). These types of disruptions are the strategic burden of maintaining operational flexibility in politically sensitive domains, where external regulation and trade barriers can quickly reconfigure value flows and jeopardise established complementarities within the ecosystem.

Additionally, dependence on a limited number of launch providers constitutes a systemic vulnerability within the small satellite ecosystem. In what has been described as a 'quasi-monopolistic' landscape, the exit or disruption of a single provider would 'considerably hamper' access to orbit across the ecosystem (D2, Launch Broker, ref. 5-6). This reflects a broader issue of platform dependency, where critical infrastructure is concentrated in the hands of few actors. Similar concerns apply to privately controlled systems such as Starlink, whose operation remains subject to unilateral decisions by their owners (Gatti et al. 2025). These dependencies have prompted renewed interest in sovereign alternatives, as firms and governments seek to reduce exposure to externally controlled assets (D2, Solution Provider, ref. 1-2). The COVID-19 pandemic further exposed the ecosystem's vulnerability to external shocks, particularly in supply chains and liquidity. Material prices surged, and availability was scarce, forcing some suppliers to pre-stock critical components on behalf of their customers (D2, Supplier A, ref. 1; D2, Focal Firm Rep. 3, ref. 9-12; NASA OIG, 2023). At the same time, recent disruptions have revealed persistent capability bottlenecks, particularly in relation to human capital. Declining academic pipelines and restricted cross-border talent mobility have made it difficult for smaller countries to rebuild the expertise required to recover effectively from major shocks (D2, University Rep., ref. 13). These gaps reveal the ecosystem's reliance not only on physical components but also on distributed technical competencies, without which recovery and adaptation remain constrained. However, not all consequences of external shocks have a purely negative impact. Heightened defence demand and a broader push to "avoid dependency on the US" have further accelerated procurement of European satellites and stimulated electronics manufacturing in newer member states, providing a stabilising effect that partially offsets wider commercial uncertainty (D2, Focal Firm Rep. 1, ref. 12; D2, Focal Firm Rep. 3, ref. 8). Firms that manage to diversify across project sizes, customer segments, and geographies – combining "big eggs and small eggs", cf. 4.1.2. – are better positioned to buffer against sudden cancellations and to capitalise on emergent opportunities (D2, Government Specialist, ref. 2), cf. section 4.1.2.

5. Discussion

In the following sections, core findings from chapter 4 will be discussed, highlighting interesting insights, cf. section 5.1. Subsequently, an integrated framework unfolding ecosystem resilience will be presented, cf. section 5.2, emphasising on the underlying mechanisms between aggregated dimensions identified through Gioia's methodology, cf. chapter 3. This is followed by a conceptual discussion theorising the views and behaviours of ecosystem actors, namely the stage perspective model, cf. section 5.3. Section 5.4 emphasises on institutions and their impact on a balanced ecosystem. Lastly, chapter 5 concludes with reflections on the concept of ecosystem resilience, and the theoretical contributions made by this thesis.

5.1. Core Findings

The findings reveal that resilience in the small satellite ecosystem is experienced first as a matter of mindset and everyday practice. Interviewees consistently situated resilience inside the firm, describing it as a shared attitude that privileges trust, coherence and an ability to shift perspective long before any formal mechanism comes into play, cf. section 4.1.1. Yet the same respondents stressed that conviction alone is insufficient: resilience must be routinised through design rigour, cash discipline and the orchestration of supplier and customer relationships, cf. section 4.1.2. This includes a form of financial *optionality*, also referred to as financial resilience, in talent and cash enabling firms to scale up. What emerges, therefore, is a layered capability in which uncompromising technical quality, contractual risk-sharing and prudent financial management reinforce one another to keep missions on track despite volatile demand and the unforgiving physics of space, cf. sections 4.1.2, 4.2.1.

Actor-specific dependencies deepen that picture. Focal firms and component specialists alike concede that oversupply gives customers bargaining power, that most SMEs cannot fund textbook dual-sourcing, and that survival often rests on a handful of long-standing partners whose own solvency must be continually assessed, cf. section 4.2.2. Institutional actors add a second, reciprocal layer of influence. Collaboration with ESA enhances reputational capital and facilitates mission learning through funded demonstration projects – flight heritage itself still stems primarily from proven in-orbit performance, regardless of customer, cf. section 4.3.2. ESA involvement may help generate such heritage indirectly, yet the credibility it confers is based on the fact that components have successfully flown, not merely on agency affiliation. National procurement rules redistribute work in line with political contributions, opening access for some firms and constraining others, cf. section 4.3.1. Universities and space agencies further shape innovation trajectories by funding high-risk demonstrators and seeding specialist talent, so institutional agendas become both a catalyst and a boundary condition for private strategy, cf. sections 4.3.2, 4.2.4.

Resilience is irreducibly relational. Satellites integrators must synthesise a globally dispersed supply base, yet low volumes leave them weakly positioned with suppliers, compelling firms to complement contractual safeguards with deep relational ties and, where feasible, selective vertical integration, cf. sections 4.2.1, 4.1.2. Meanwhile, the commoditisation of satellite hardware has prompted a shift in how firms present their offerings. Instead of emphasising technical features alone, manufacturers are increasingly framing their satellites as tailored solutions to specific customer needs – such as maritime monitoring or signal intelligence. This pivot toward use-case specificity enhances the perceived value of the offering and creates opportunities for firms that excel in managing partners and configuring modular solutions. It does not so much reflect a migration of value upstream or downstream as a strategic repositioning that aligns technical capabilities with mission outcomes. At the same time, evolving demands, i.e. cybersecurity, are redefining the resilience threshold; while once regarded as a peripheral concern, it is rapidly becoming integral to compliance and legitimacy, cf. sections 4.1.1, 4.3.2.

While resilience was generally associated with a firm-level responsibility, interviewees were challenged and asked to reflect if it may be a shared effort. The results showed that more ecosystem actors view resilience as not a solely internal organisational trait, but a shared effort across firms, institutions, and governments, cf. section 4.1.1. Culture, collaboration, and interdependence were emphasised as essential to internally overcoming disruptions. Institutions and universities act as stabilising forces by fostering consortia and supporting continuity through funding and shared projects, cf. 4.3.2. The market demand and geopolitics are affecting the ecosystem resilience, as it may constrain ecosystems or reduce them to national-level ecosystems, focusing on sovereignty-driven strategies. Shared resilience efforts therefore require broader ecosystem alignment and leadership; a role often missing, as the question is ‘who is the orchestrator’, cf. section 4.2.3.

Finally, the findings expose persistent vulnerabilities. Low production volumes, capital constraints and single-source bottlenecks restrict the scope for classic redundancy, while external shocks – from launch-market congestion to geopolitical changes – can propagate quickly through the tightly coupled ecosystem, cf. sections 4.4.1, 4.4.2. Participants respond by combining architectural redundancy where affordable with ad-hoc improvisation where it is not, confirming that resilience is a dynamic, continuously negotiated state rather than a fixed inventory of buffers, cf. section 4.1.2.

Altogether, these observations demonstrate that ecosystem resilience is neither an emergent macro-property nor a collection of isolated firm-level strategies. Instead, it is a multiscalar phenomenon produced at the intersection of subjective mindsets, operational routines, institutional incentives and structural interdependencies, cf. sections 4.1, 4.2, 4.3. While actors may operate independently within the limits of their own capabilities and resources, their decisions often have broader implications for the ecosystem as a whole. Long-standing relationships grounded in trust enhance co-evolution and co-creation, illustrating how historical ties continue to influence present-day adaptive capacity. These findings further highlight that resilience – though frequently analysed at the firm level – cannot be fully understood in isolation from the wider ecosystem External factors – institutional actors, geopolitical currents, the presence of primes, and the sector's dependence on flight proven technology – constantly mediate what firms can and cannot do, cf. sections 4.3.1, 4.3.2, 4.4.2. Subjective interpretations of the ecosystem guide the strategies that managers deem feasible, meaning that ecosystem resilience may go unnoticed by individuals even as it operates in practice. The small satellite context illustrates a multi-layered system working simultaneously: component supply, satellite integration and service delivery operate in unison, cf. section 4.2.4. Institutions work as stabilising forces, yet they also influence opportunity and risk through policy shifts and national priorities. In the lived reality of small volumes and technological dependency, these forces together explain how, and under what conditions, the ecosystem builds its capacity to absorb shocks, adapt and continue creating value, cf. sections 4.4.1, 4.4.2.

5.2. An Integrated Framework Unfolding Ecosystem Resilience

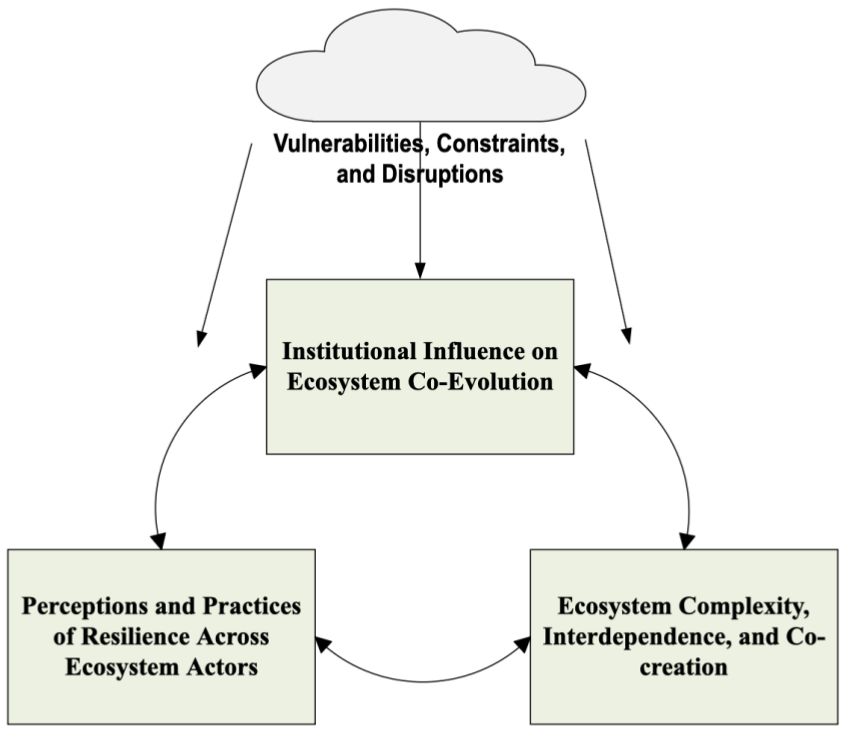
Using the Gioia methodology of organising and analysing the data, it revealed four aggregated dimensions, cf. section 3.4 and chapter 4. These dimensions are not isolated, but dynamically interconnected, as they overlap and form a recursive system that underscores resilience within ecosystems.

In the first dimension, resilience within the ecosystem is experienced first as a matter of mindset, cf. section 4.1.1. These perceptions shape fundamentally their resilience strategies, cf. 4.1.2. Consequently, shared perceptions affect how these actors engage in co-creation or respond collectively to disruptions. This dimension thus serves as the empirical domain, exploring their behaviour and mindsets. These perceptions and practices manifest within a highly interdependent and dynamic ecosystem. The second dimension reveals the factual domain, as it explains the context of the ecosystem and its complex nature, cf. 4.2. This ecosystem structure influences the ecosystem actors' perceptions and resilience strategies, as they must adapt and navigate the complex ecosystem. Ecosystem actors' engagement in co-creation and collaboration is often reflected on the present interdependencies, collaboration dynamics, and future trends, which may influence how the actors perceive risk and opportunities. Consequently, the second aggregated dimension enacts the first dimension. Since the small satellite ecosystem is highly regulated or affected by the institutions, this equals another layer into understanding ecosystem resilience, cf. 4.3.1. Institutional actors enhance ecosystem capabilities or influence innovation trajectories through funding, project availability, skills improvement, knowledge sharing, and fostering collaboration, cf. 4.3.2. The findings reveal that institutions within the ecosystem, especially space agencies in this context, are acting as an underlying mechanism typically impacting the ecosystem and therefore the firms' resilience strategies. The findings revealed that ecosystem actors may influence institutions as well, where actors propose missions or projects to the institutions. Instances have shown how commercial firms have impacted institutions' adoption of technological developments, such as the Cubesats formfactor, cf. section 4.3.1.

Lastly, all these dimensions are indirectly or directly affected by ecosystem vulnerabilities, constraints, or disruption, cf. 4.4. These external disrupting events often challenge or enforce the responsibility of institutional entities, which adds pressure on the complex nature of the ecosystem and catalyse shifts in practices and perception. Disrupting events may therefore act as a 'clean-up' actor, where the weaker ecosystem actors are risking their survival. The interrelated structure of this paper is therefore exploring the underlying mechanisms emerged from the data collection. While the first three dimensions highly influence each other, the last dimension has an exogenous nature, meaning it is independent of the ecosystem.

In terms of alignment with the research questions, the first two dimensions – Perceptions and Practices of Resilience Across Ecosystem Actors, and Ecosystem Complexity, Interdependence, and Co-creation – primarily address the first research question. While the first dimension captures subjective interpretations of ecosystem actors and their immediate resilience practices, the second dimension explains the context in which ecosystem actors navigate and adapt to. The second research question, regarding institutions, is primarily answered by dimension three (Institutional Influence on Ecosystem Co-Evolution). Since institutions enforce regulations, governance structures, ecosystem continuity strategies, and norms, ecosystem resilience is highly affected by these. It is then assessed that dimension 4 (Vulnerabilities, Constraints, and Disruptions) is a layer that extends on the first three dimensions, introducing internal and external pressures happening in three levels: 1) macro-, 2) meso-, and 3) micro-level, cf. section 5.3.

Figure 3: An integrated framework reflecting the four dimensions of ecosystem resilience



Source: *authors' own figure*

In summary, the actor-level perceptions and mindsets shape resilience strategies within the complex and dynamic ecosystem, which are enabled or constrained by institutions, all of which are recalibrated or restructured by disruptive events.

5.3. Stage Perspective Towards Ecosystem Actor Resilience

This section discusses key findings considering the first research question: How different actors perceive and experience ecosystem resilience, and how does it affect their actions? The data highlights both differing and converging perceptions and behaviours around ecosystem resilience, while also revealing patterns in the firm's stage of development, its size, and capacity to engage in ecosystem resilience. Consequently, to theorise this relationship, the authors propose a stage perspective towards ecosystem actor resilience, where actor stage affects their capability to engage in the ecosystem. The pyramid, Stage Perspective Model (SPM), emphasises on relevant steps in order to achieve the ability to engage in ecosystem resilience.

Actor perceptions of ecosystem resilience

As mentioned before, various ecosystem actors argued that resilience usually manifests at a firm-level, however, when asked if resilience should be a shared effort, most participants expressed that this would be ideal. In contrast, a few participants stressed firm-level autonomy and responsibility, noting ecosystem resilience is not yet achieved, cf. section 4.1.1. Participants note ecosystem resilience is a goal, however, it must be combined with firm-level resilience, since firms have to ensure their own survival first. Firm-level resilience was found to be focal in the literature, cf. 2.2, which corresponds with the empirical findings of this paper. In contrast, interviewees expressed that while collective resilience efforts were ideal, they might not be feasible for the firm's size or corporate strategy. However, while collective efforts of resilience is the goal, ecosystem actors admit that this is rarely the case. The data reveals that resilience begins with mindsets and values, resembling Teece (2007) micro-foundational views of ecosystems, where actor resilience practices and values influence the broader ecosystem. Since there is no unified consensus of whether resilience is a shared effort, this tension resembles the alignment problem in the ecosystem (Adner, 2017).

The focal firm generally illustrated the ecosystem as fragile and interdependent dominated by self-preservation, where cash flow, reputation, and scalability issues are prominent. The focal firm and supplier representatives generally emphasised on stabilising its supply chain, having the capacity to predict or follow the market, being financially stable, and self-determination or the firm's mindset – these were all firm-level objectives. The interviewed suppliers added diversification to remain stable. The complementor and one focal firm representative expressed resilience capabilities such as vetting the suppliers to ensure their stability and ensuring customer value.

Moreover, defensive strategies are meant as mainly surviving and improving the firm's capabilities, whereas offensive strategies are reflected on market building, and market share optimisation (Appendix G). Larger actors may perceive the resilience more offensively, as they attempt to capture value through ecosystem orchestration or reshape the ecosystem based on what gaps are available. Furthermore, this aligns with the solution providers or focal firms appealing for market building strategies, orchestrating other ecosystem actors by employing co-creation or co-evolutionary concepts. Actor perception therefore transcends the 'resilience-to-protect' into 'resilience-as-a-performance-driver' (Stonig et al., 2022). This highlights a needed lens for discussing ecosystem resilience – the actors' stage in terms of ecosystem resilience.

Actors had different interpretations of ecosystem resilience, where 1) suppliers in particular thought of it as supply chain resilience, 2) start-ups focused purely on own survival, 3) solution provider perceived it as what could be argued as network resilience and market resilience, 4) focal firm representatives perceived it as stakeholder alignment, firm-level and partnership resilience, and lastly the university perceived it as something highly necessary.

Theoretical framework

There seemed to be a correlation to the firms' maturity level, and the stages towards ecosystem resilience. A focal firm representative emphasised that firms go from purely a 'survival' phase to 'existing-in-the-market' phase, to 'protecting-oneself' phase, cf. section 4.1.1. Inspired by this, the authors present the ecosystem actor resilience stage model.

Figure 4: The Stage Perspective Model (SPM)

Source: *authors' own figure*

This conceptual model aims to visualise how an actor's ecosystem maturity level shapes its capacity to contribute to ecosystem resilience. Notably, the actor's maturity level is highly influenced by resource capacity, strategic orientation, ecosystem role, and institutional context. This model draws inspiration from concepts related to alignment and interdependence from Adner (2017) and Jacobides et al. (2018). As actors move through maturity stages, they shift attention from firm-level to ecosystem-level. A focal firm representative emphasised that firms go from purely a 'survival' phase to 'existing-in-the-market' phase, to 'protecting-oneself' phase. Thus, the Stage Perspective Model (SPM) offers a new theoretical lens that theorises underlying generative mechanisms to why actors engage in co-resilience practices while others mainly emphasise survival.

Stage 1: Self-preservation and survival

When actors first enter the ecosystem, their main focus is survival. Our empirical data emphasised on financial stability as a major pillar for firm-level resilience; one participant referred to it as 'resilience in revenue' and 'resilience in balance sheets', cf. section 4.1.2. This stage is the initial stage where actors must avoid risk and establish themselves on the market.

Stage 2: Compliance and legitimacy

In this stage the firm gains legitimacy by complying with regulations, building a keen customer reputation, and being reactive with external institutional pressures (Rana & Sørensen, 2021). Since reputation functions as a form of currency in this context, the ecosystem actor must strengthen its credibility. In the small satellite ecosystem, it is achieved through flight heritage, cf. sections 4.1.2 and 4.2.2..

Stage 3: Resilience strategies

As the firm matures in the ecosystem, it proceeds to anticipate the ecosystem dynamic, where proactive resilience and business continuity is prominent; strategies such as vertical integration, R&D programs, and standardising processes are especially present. Actors with financial flexibility pursue organisational resilience through diversification, formal governance. Firms engaging in partnerships are done contractually due to protection efforts at this stage, cf. sections 4.1.1, 4.1.2, 4.2.3.

Stage 4: Co-specialisation and partnerships

Firms engage in partnership resilience and joint initiatives, with their immediate ecosystem, ensuring stability for their own entity but also the process towards the customer. Within this stage ecosystem actors build mutual dependency with their partners, where they ensure their critical partners are stable. At this stage the actor may develop joint contingency plans, demonstrating relational awareness. Partnerships flourish co-specialisation, where the partners have shared strategies, such as buying a machine to produce specific components for the focal firm, cf. sections 4.2.1 & 4.2.2, or focal firms creating training courses for internal staff and customers (Breil & Ciocârlan, 2025).

Stage 5: Co-resilience and co-evolution

Lastly, at the peak of the SPM, the ecosystem actor reaches a co-resilience level, where no actor fully controls it, but all are affected by the ecosystem and vice versa. This is a stage where the actor is fully embedded in the ecosystem, reaching a level of eco-embeddedness and co-

evolution. According to Zang et al (2022), actors who achieve eco-embeddedness lead to resource accessibility, knowledge transfer, collaboration, and shared risk form strategies.
While the SPM appears to function as a progressional structure, actors can move up or down due to internal changes, external pressures, or disruptions to name a few. The results identify several internal factors that impact ecosystem actors’ capacity to transition into the last stages in the model. Key internal intervening factors are: financial stability; talent, skills, and the capability to emerge from stage 1; supply chain; and the general size of the firm, cf. section 4.1. The SPM suggests a fluidity of how the resilience focus may shift over time; it is argued that disruptive events calibrate the firm's position in the SPM. For example, ecosystem actors at stage 4 regressed to stage 1 during COVID-19 due to unpredictable events.

Disruptions as recalibrators

This underlying mechanism highly affects the ecosystem. Arguably, the disruptions might be on different levels as well namely macro-, meso-, and micro- level, cf. 4.4 & 5.1. According to Breil et al. (2024), micro-level disruptions imply events within the firm, such as staff turnover or operational failures; meso-level disruptions imply ecosystem or industry level events, such as major technological shifts or regulatory changes; lastly, macro-level disruptions are national or supranational challenges, such as geopolitics, COVID-19, or sudden tariffs. These distinguished levels are arguably impacting ecosystem actors' behaviour and position within the stage model.

While micro-level disruptions primarily impact the individual firm and its immediate ecosystem, they often prompt a recalibration of 3rd stage ‘Resilience strategies’. The data reveals micro-level disruptions may take place due fragile supply chains, volatile markets, and price pressures, cf. section 4.4.2. These may be mitigated through the 3rd stage of the model. Firms acknowledging their vulnerabilities and understanding market dynamics can overcome these disruptions. However, if the firm has not ensured its own survival first, it may be of great difficulty to overcome these, cf. section 4.1.1. Meso-level disruptions affect the ecosystem, particularly due to fast-pacing innovation and environmental risks, interdependencies, policy and financing instability. Lastly, macro-level disruptions impact the ecosystem in both positive and negative manner. Macro-level disruptions may be devastating for ecosystem actors, such as COVID-19, where SMEs and startups were heavily affected only being able to survive due to institutional interference, cf. sections 4.3.2. and 4.4.2. As noted in section 4.4.2, not all external shocks are negative. The geopolitical shifts boost the growing demand for national autonomy and control, resulting in defence procurement in European countries. This phenomenon allows ecosystem actors to move into the 4th stage ‘Co-specialisation’ and explore those opportunities.

External shocks and uncertainty manifest in multiple forms: rapid technological shifts, volatile demand patterns, fragile supply chains, geopolitical ruptures, environmental hazards, and unpredictable public finance cycles. Each one of these can destabilise business models built around long development cycles and tight margins. Resilience in such an environment does not stem from eliminating shocks, which remain intrinsic to space activity, but from cultivating adaptive capacity. This includes maintaining redundant supplier relationships, diversifying revenue streams, monitoring regulatory and geopolitical signals, and preserving the organisational agility to redeploy capital and talent when disruptions arise. The degree to which firms institutionalise these adaptive responses determines whether they merely absorb shocks or convert them into strategic advantage within an ecosystem characterised by accelerating change, cf. section 4.3.2.

Disruptions are thus forcing ecosystem actors to reassess their ecosystem awareness and engagement. As mentioned in section 4.4.2, meso-level and macro-level disruptions go beyond any single firm’s control. This forces the firm to anticipate and understand the shifts across the ecosystem in order to adapt and overcome such changes. Disruptions such as COVID-19, US decoupling in the space sector etc., actors are prompted to collaborate with ESA or other (supra)national institutions to share risk in R&D activities. Arguably, disruptions may act as catalysts for learning, including thriving in these shocks by reconfiguring strategies and partnerships to explore emerging opportunities. Firms who are not able to do so, might not evolve within the ecosystem (Moore, 1993). Disruptions may therefore act as a recalibrating role, encouraging firms to review their position. This corresponds with Russell et al (2018), who argue that ecosystems self-organise during turbulent times, where actor behaviour is diverse and dynamic. However, Iansiti & Levien (2004) argue that ecosystems consist of loosely interconnected actors, who share the risk and fate encouraging them to recalibrate relationships and roles – arguably this is only accelerated during disruptive events.

Theoretical reflections

As a reflection of the underlying mechanisms in the ecosystem actor's perceptions and behaviour, these might be influenced by institutional logics. Institutional logics refer to the constructed belief system of the actor which affects the behaviour and action of the actor (Thornton et al., 2012). While this theoretical integration was not considered at the beginning of the paper due to our retroductive approach this emerged as an explanation of the underlying mechanisms that shape ecosystem actors' perceptions and behaviour.

As actors evolve within the ecosystem, they are shifting their perceptions and abiding different institutional logistics. Using Thornton et al. (2012) and revised interinstitutional system ideal types, the different SPM stages may be linked to different institutional logics.

Stage 1 'Survival': market logic might be dominant, where actors are driven by profit-optimising. Their business strategy is mainly transactional, where the attention is mostly directed at funding and market situation.

Stage 2 'Compliance and legitimacy': market/state logic may influence the actor, as they are engaging in legitimacy through complying with regulation and procedures, whereas the actors still focus on market logic such as pleasing stakeholders, successfully operating (Yang, 2024).

Stage 3 'Resilience strategy': corporation logic may be argued to be an influencing cognitive belief, where the firm's market position is a source of legitimacy, and its strategy is typically on increasing size, diversification, and protection of the firm (Thornton et al., 2012).

Stage 4 'Co-specialisation and partnerships': arguably follows community logic, where there is a unity of reciprocal trust. Reputation is important and it is run by relational networks (Thornton et al., 2012). Endorsement by space agencies and synergy achieved through quality partnerships impact the firm's institutional legitimacy level (Rana & Sørensen, 2021).

Stage 5 'Co-resilience and co-evolution': while this stage would follow community logic. Moreover, an interesting proposition would be ecosystem logic, where sources of authority would be interdependencies. Its nature would be collaborative and interconnected, where the basis of strategy arguably is the ecosystem continuity and value co-creation.

While this categorisation serves as an initial reflection, it is recommended that the underlying logic of the ecosystem be further examined in order to better understand its guiding belief system. In the authors' earlier work, it was argued that the ecosystem constitutes an institutional context in its own right (Breil & Ciocârlan, 2025). Although this was not fully explored in the present study, it is suggested that ecosystem logics may function as an underlying mechanism guiding the behaviour of more mature ecosystem actors. Burford et al (2021) and Dong et al. (2022) argue that institutional context shapes the firm's resilience level. Perhaps by shaping individual actors' resilience strategies, they collectively impact the ecosystem resilience level (Russel et al., 2018).

5.4. The Role of Institutions in Shaping a Balanced Ecosystem

Within the small satellite ecosystem each actor pursues both its own survival and agenda yet, in doing so, continuously re-shapes the collective conditions under which all others must operate. Moore's (1993) seminal analogy of co-evolving species remains compelling precisely because it highlights this tension between autonomy and mutual dependence; Iansiti and Levien (2004) later sharpen the point by emphasising that actors' shared fate obliges them to recalibrate roles whenever shifts in resources, technology or legitimacy unsettle the status quo, cf. section 2.2. When capacity saturates or capital tightens, three archetypal responses surface. Some firms may assimilate weaker actors, pruning redundancy and consolidating capabilities; others simply exit; a third set sidesteps the crowd altogether, diversifying into under-served niches or pioneering complementary service layers through adjacent actor roles, cf. section 4.2.4. These uncoordinated behaviours are a continuous, collective restoration of the balance of the ecosystem; not a static balance but a moving centre of gravity that reflects prevailing resource constraints, legitimacy norms and technological frontiers, cf. sections 4.3.1, 4.4.1. The centre is rarely still for long; every successful adaptation sets new baselines against which rivals must once again measure fitness, cf. section 4.1.2.

On the other hand, institutional hubs complicate this notion of a self-balancing ecosystem. Supranational agencies, such as the ESA, are in this ecosystem context hubs and thus wield agenda-setting power: by supplying research funds, defining standards or endorsing fledgling firms, they can tilt the balance of the ecosystem more deliberately without facing the same market discipline, cf. section 4.3.1. This context is complicated further by the fact that while ESA cares about the ecosystem's overall health, its mandate is far more scientific rather than commercial; projects are therefore commissioned to advance exploration or security goals even when market demand is thin, cf. section 4.3.2. Such deliberate interventions may in some instances nurture long-term capabilities within the ecosystem, but they can also create temporary micro-populations of technology firms that flourish while subsidy flows but contract once that artificial stream of support is withdrawn. Unlike commercial hub firms, ESA's influence rests on its capacity to allocate non-market resources and confer legitimacy, cf. chapter 4.3.1. Similarly, while early rounds of public, government innovation grants may prove catalytic, some executives now report diminishing marginal benefits and insist that predictable government demand would serve them better than fresh instalments of speculative R&D finance, cf. section 4.3.2. They describe a tipping-point at which subsidy no longer attracts new capability but merely prolongs dependency; secure procurement contracts, by contrast, allow firms to scale production and draw private capital. The consensus seems to be that as long as ministries remain sponsors of experiments rather than paying customers, suppliers are cushioned from the rigours of price, schedule and performance that genuine markets impose.

Likewise, ecosystem balance is never morally neutral. For instance, through decisions about debris mitigation, firms that internalise end-of-life disposal or encrypt sensitive observation data absorb private costs for public benefit; those that defer such measures impose negative externalities on the collective, cf. section 4.4.2. In the long run, institutional enforcement may align incentives; in the short run, equilibrium is sustained by a blend of reputational pressure, customer preference and normative commitment, cf. section 4.3.2. Here again hub actors matter: when ESA embeds active-de-orbit capability as a threshold requirement, moral becomes material, cf. section 4.3.1.

Seemingly, these dynamics suggest that a balanced ecosystem is best portrayed as a continuously re-established condition arising from competitive selection, invasive disruption, hub-led redirection and geopolitical turbulence, cf. sections 4.4.2, 4.3.1. While the similarities between business and biological ecosystems seem compelling, the analogy holds only if one recognises that ecosystem actors possess foresight and agency, unlike their biological counterparts. Firms therefore do not merely adapt to the balancing of the ecosystem; through lobbying, alliance-building and strategic investment they actively shape the landscape in which future balances will settle, cf. section 4.2.3. Ecosystem balance, understood as a perpetually re-established condition, supplies the horizontal axis along which the aforementioned stage perspective is advanced through, cf. section 5.2. At the lowest stages, firms experience ecosystem balance as something external and fragile: survival hinges on keeping cash outflows in step with incoming revenue, securing a single dependable launch slot, or persuading one anchor customer to renew a contract, cf. section 4.1.2. Because any shock may be existential, their resilience is necessarily reactive; a late component delivery or an unexpected regulatory fee can push them below the viability line, cf. section 4.4.1. Consequently, they perceive the broader ecosystem as background turbulence and concentrate on short-term self-preservation rather than on shaping collective conditions.

Progress to the middle stages begins once those measures succeed often enough to lengthen time horizons. At this stage ecosystem balance is no longer a distant backdrop but something very real that can be influenced; firms experiment with portfolio diversification and exploratory partnerships, cf. section 4.1.2, 4.2.4. Disruptive events certainly still unsettle them; yet instead of merely absorbing impact they recalibrate and look for complementary voids that these disturbances reveal, cf. section 4.2.3. The timeline noted earlier applies: shock; institutional response; firm-level strategy shift; diffusion of a revised mindset across peer groups, cf. section 4.3.2, 4.1.1. Every iteration supplies learning that thickens organisational routines and gradually converts resilience from a stock of contingency assets into a capability for purposeful adaptation, cf. section 5.2. Some firms even branch into adjacent roles within the ecosystem thereby expanding their option value and influence, cf. section 4.2.4.

Near the final stages, ecosystem balance becomes an object of design. Prospective hub firms possess the foresight, resource depth and relational capital to tilt selection mechanisms; they lobby for interface standards that favour their own architecture; they seed supply-chain finance to stabilise key subcontractors, cf. section 4.3.1; they frame sustainability norms so that compliance coincides with their own roadmap, cf. section 4.3.2. By distributing incentives, hubs may alter the fitness landscape on which all others gauge survival, effectively raising or lowering whole ladder rungs beneath them. Although such effects have not yet materialised in the small satellite ecosystem examined – where institutional hubs continue to dominate – the pattern is theorised to reflect a generalisable dynamic in maturing ecosystems, where private actors increasingly assume orchestrator roles.

Seen in this light, ecosystem balance and the aforementioned stage perspective are mutually reinforcing rather than sequential. Each stage confers a distinct capacity to sense, respond to and ultimately engineer ecosystem balance conditions; each freshly negotiated equilibrium, in turn, reshapes the contours of the stages by altering which capabilities matter and which strategies attract reward, cf. section 5.2. Firms ascend because they learn to read the shifting patterns of succession, invasion and ecosystem fragmentation; the ecosystem stabilises, though temporarily, because ascending firms and hubs translate that reading into investments that dampen volatility for themselves and, by extension, for their immediate partners, cf. sections 4.2.4, 4.3.1. The process may almost appear circular: turbulence repositions actors; repositioned actors renegotiate ecosystem balance; the renegotiated state sets fresh entry points and obstacles for those still ascending the stages, cf. section 5.2. The discussion that follows must, therefore, account for ecosystem balance not as an endpoint but as an emergent, contested and mediated process; only then may one explain how resilience arises within the ecosystem, why it sometimes fails and what role institutions ought to play in steering co-evolution towards outcomes that balance innovation, commercial viability and collective sustainability, cf. sections 4.3.2, 4.4.2. Seen in that light, the SPM and ecosystem balance narratives do more than coexist; they operationalise core propositions of resilience theory in relation to ecosystems. By tying concrete examples such as launch scarcity, spectrum politics and debris norms to those theoretical constructs, one may establish that each stage represents a distinct resilience regime and that movement between regimes is triggered by the very disturbances whose consequences the system is trying to modulate, cf. sections 4.4.1, 4.4.2.

Furthermore, the migration of value within the ecosystem may very well emerge as a core mechanism through which ecosystem balance is reconfigured and resilience is enacted. As customer needs evolve, value gravitates toward whichever form of specialisation most effectively addresses these needs, which would prompt firms to reassess their position within the value chain, triggering role shifts, entry into adjacent domains, or strategic withdrawal from saturated segments, cf. section 4.2.4. Consequently, the resulting reorganisation is not merely reactive but also constitutive of ecosystem balance itself, as firms and institutions jointly realign capabilities, legitimacy and interdependencies to match new sources of value. In this sense, migration of value becomes a structural driver of coevolution: it not only reshapes the fitness criteria by which firms are evaluated, cf. section 4.3.1, but also creates the conditions under which resilience may emerge – not as insulation from disruption, but as the ability to detect and reposition around newly valuable functions, cf. section 5.2. Understanding ecosystem balance as a function of value migration thus may help explain why actors behave as they do under constraint: they are not just responding to external shocks but are proactively contesting the ecosystem logic of value creation in ways that reveal its resilience potential, cf. section 5.3.

5.5. Reflections on Ecosystem Resilience and Theoretical Contributions

The findings and subsequent discussions assembled in the preceding sections allows a clearer conceptual distinction between resilience as classically understood at the level of the single firm and resilience that manifests at the level of a business ecosystem. In the small satellite ecosystem, respondents described several organisational resilience strategies, yet the data also pointed repeatedly to dependencies that no individual firm may solve on their own: launch-market congestion, supranational procurement cycles and the resilience of long-standing partners whose own fate lies outside the focal firm's control.

Table 11: Distinction of Organisational Resilience and Ecosystem Resilience

Dimension	Organisational resilience	Ecosystem resilience
Unit of analysis	Single firm	Ecosystem; network of interdependent firms, complementors, institutions
Core mechanism	Firm-specific dynamic capabilities; proactive and reactive resilience strategies	Relational and structural mechanisms: diversity of actors, modularity, redundancy of links, institutional support
Control & agency	Largely under top-management control	Distributed, yet steerable: agency is dispersed across firms, but institutional hubs may shape incentives and influence collective behaviour; no single actor can unilaterally secure or appropriate resilience
Primary resource base	External & Internal Resilience Enablers	Variety, complementarity, trust and alignment across actors
Failure mode	Bankruptcy or loss of competitive position of the focal firm	Cascading collapse, fragmentation or lock-in of the entire ecosystem

Source: ***authors' own table***

The table above clarifies the conceptual and structural distinctions between organisational and ecosystem resilience. While organisational resilience refers to a single firm's capacity to anticipate, absorb, and recover from shocks, ecosystem resilience emerges from the dynamic configuration of interdependent actors. It is less about control and more about coordination, where resilience depends not solely on any one firm's preparation but on the alignment, redundancy, and adaptability across the network. Whereas a firm can pivot between proactive and reactive strategies in response to disruption, an ecosystem lacks a single steering point; its resilience is shaped by the cumulative and distributed actions of many actors, some of which may contradict or amplify each other. Failure, therefore, does not manifest as a single firm's bankruptcy but as cascading collapse, value-chain lock-in, or fragmentation of the entire ecosystem. While firms may not explicitly recognise themselves as part of an ecosystem, their actions still contribute to or constrain ecosystem resilience. This raises an ontological point: ecosystem resilience may emerge even in the absence of conscious coordination, as long as the underlying interdependencies shape behaviour in ways that sustain the focal value proposition.

The contributions of the thesis invite a revised definition that captures this collective quality without detaching resilience from the value-creating purpose that gives an ecosystem coherence in the first place.

> *'Ecosystem resilience is the collective capacity of an ecosystem of interdependent and complementary actors and institutions to absorb shocks, reorganise and continuously deliver the focal value proposition.'*

Two implications follow. First, resilience is not a peripheral add-on but a property of the very same architecture that enables value creation; unsurprisingly, the proposed definition shares similarities with the previously established definition of an ecosystem itself. Second, the idea of '*reorganisation*' expresses that a restoration of the pre-shock configuration is neither necessary nor always desirable. Consequently, reorganisation may entail the exit of fragile suppliers or the entry of new service layers of complementors; what matters is that the focal value proposition continues to remain attainable.

Several theoretical contributions emerge once this definition is juxtaposed with the findings from the case; the first concerns agency. Agency in ecosystem resilience is simultaneously purposeful and bounded; it relies on repeated acts of local adaptation whose aggregate outcome is neither centrally coordinated nor entirely accidental. The discussion of the SPM enforces this dynamic, showing how firms progress from self-preservation towards co-resilience as they acquire the resources, legitimacy and relational capital needed to influence ecosystem-level conditions.

The second contribution concerns the processual nature of resilience. Rather than unfolding through a linear or sequential logic, resilience materialises through iterative cycles of disturbance, improvisation and consolidation. Each iteration left behind altered routines and alliance structures, supporting the contention that resilience is path-dependent. The ecosystem is never in steady state; its stability at any moment is provisional, contingent on the alignment of expectations, resource flows and institutional signals.

Third, demonstrating how ecosystem hubs – institutions; most visibly national and supranational space agencies – act as orchestrators that may deliberately tilt the balance of an ecosystem toward resilience or fragility. Their grant regimes, procurement rules and technical standards allocate resources, codify quality thresholds and confer legitimacy, thereby structuring the perceived option space within which firms operate. By adjusting these levers in response to exogenous shocks and endogenous signals, hub agencies function as adaptive stabilisers: They stop harmful chain reactions that could unsettle the ecosystem and support promising trials so their lessons quickly spread across the ecosystem.

Moreover, the thesis contributes to theoretical integration by bridging ecosystem theory – traditionally concerned with value creation, coordination and interdependence – with resilience theory, which has remained largely focused on the firm. By demonstrating that resilience is not external to value creation but embedded in the same structures that enable it, this study supports calls for more integrative, multiscalar theorisation of adaptive capacity in complex systems.

Finally, the thesis introduces an ontological insight: ecosystem resilience can emerge even without explicit recognition from actors that they are part of an ecosystem. Interdependencies shape behaviours regardless of whether they are perceived or named, meaning that ecosystem resilience may be a latent, structuring property; materialising through action long before it is formalised in discourse or strategy.

6. Conclusion

This thesis set out to investigate how ecosystem resilience is perceived, enacted, and shaped within the small satellite industry. By adopting a critical realist lens and drawing on rich qualitative data from multiple ecosystem roles, the study moved beyond firm-level resilience to examine the collective dynamics that found the ecosystem's ability to absorb shocks, adapt, and continue delivering value. The findings demonstrate that ecosystem resilience is neither an abstract, emergent property nor a mere aggregation of firm-level practices. Rather, it is a multiscalar phenomenon shaped by the interaction of subjective mindsets, operational routines, institutional incentives and structural interdependencies. Actors interpret resilience through diverse lenses and these interpretations influence both their individual strategies and the broader ecosystem configuration.

In response to the first research question – *How do different actors perceive and experience ecosystem resilience, and how does it affect their actions?* – the thesis shows that perceptions of resilience are highly situated. Less mature firms experience resilience as a reactive struggle for survival, while more embedded actors begin to influence resilience conditions through diversification, modularity, or integration. These behavioural patterns are captured in the SPM, which outlines how firms move from perceiving ecosystem balance as fragile and external to actively shaping it through design, coordination, and resource allocation. The stage perspective demonstrates how perceived room for manoeuvre grows with capability and position, resulting in distinct ecosystem resilience regimes.

In response to the second research question – *How may institutions impact the co-evolution and resilience of the ecosystem?* – the thesis identifies institutional actors, especially national and supranational space agencies, as central orchestrators. These institutions affect resilience by granting legitimacy, distributing resources, and setting technical and normative standards. Their actions may stabilise the ecosystem or, conversely, induce dependency or fragmentation. As a result, the concept of ecosystem balance is introduced to explain how institutions, along with firms, continuously renegotiate the ecosystem's structure in response to shocks, technological change, and value migration. Rather than a steady state, balance is an emergent, contested process where institutions remain central in steering resilience in desired directions.

Theoretically, the thesis contributes to bridging the gap between ecosystem theory and resilience scholarship by framing resilience as a relational, co-evolving property rooted in networked structures and institutional scaffolding. Practically, it offers a diagnostic framework for assessing and strengthening resilience; not through isolated measures, but through aligned strategies that reflect the realities of interdependence.

Practical implications

The findings and discussion highlight how resilience exists both at a firm- and ecosystem-level. Practical implications are distinguished for four key stakeholder groups, namely institutions, governments, commercial firms, and innovation hubs. As discussed in sections 4.3 and 5.4, institutions such as ESA play a vital role in conferring legitimacy that is ambivalent for emerging firms. For ESA the implications are that competitive tendering and time-limited grants perhaps ought to be complemented by earlier, clear signalling of future budget trajectories; this would allow firms to wean themselves gradually and steer competence development towards sustainable demand. The endorsement mechanisms must be employed carefully to avoid creating 'tech-bubbles'; it is suggested a more transparent criteria-based mechanism beside geographical returns. As mentioned in section 5.4, institutions have a role in balancing the ecosystem, and while innovation capital is prominent, institutions must avoid creating artificial ecosystems. Future proposals should be evaluated for their potential to increase ecosystem resilience and ensure ecosystem continuity. Governments are encouraged to transition from innovation investor to customer. Since the ecosystem is suffering from oversupply, governments are able to contribute with procurement contracts. However, governments should avoid artificially creating ecosystems, instead drive market-like mechanisms. Commercial firms may use the stage model as a guide of actor transitions from survival to co-resilience. Firms must assess their stage in the model, and align their strategies accordingly; however, disruptions are important to note as recalibrators within the model, meaning actors may assess their stage to be at 4, however, the disruption they are facing might warrant stage 3 instead. The model should be viewed as fluid. Commercial firms must pursue stage 5, as they have a bigger influence through shaping the landscape of its business. Our findings suggest that relational capital should be prioritised by actors, as trust was a key factor in partnerships and co-evolution. Innovation hubs are encouraged to prioritise relational facilitations and foster this sort of behaviour for a more collaborating ecosystem.

Limitations

While this study provides a grounded explanation of how ecosystem resilience manifests in the small satellite sector, it is subject to several limitations. First, the use of a single embedded case study limits the generalisability of findings to other ecosystems with different structural dynamics, maturity levels, or institutional configurations. Second, the data relies heavily on qualitative interviews, which, while rich in insight, are inherently shaped by the perceptions and experiences of the selected participants. Certain roles, such as end customers, were not directly represented, potentially narrowing the range of perspectives. Third, resilience as an emergent property remains difficult to observe directly; this thesis infers it through actor narratives, which may only partially capture underlying systemic mechanisms. Finally, the evolving nature of the industry means that some findings may reflect a particular moment in time rather than long-term trends.

Future Research

While the present study identifies ecosystem resilience as a relational, multi-scalar phenomenon, its qualitative focus and single ecosystem scope leave several important questions open. The evidence that the small satellite ecosystem comprises overlapping 'sub-ecosystem' layers of component supply, satellite integration and service delivery indicates that resilience may very well be nested across several analytical layers, cf. section 4.1.1; whether this layering is typical of other technology ecosystems, or perhaps peculiar to markets characterised by low production volumes and stringent regulation, remains unproven. Consequently, comparative research across ecosystem layers could ascertain how far such stratification conditions adaptive capacity and whether certain layers disproportionately absorb or transmit shocks when compared to each other. Furthermore, the thesis proposes the notion of an emergent 'ecosystem logic' that may supplement established market, state, corporation and community logics as firms mature, cf. section 5.3. Conceptual elaboration and empirical validation of this idea would deepen institutional theory and clarify how cognition evolves when actors become embedded in densely interdependent settings, and might reveal how managerial decision making shifts as ecosystem logic gains salience, while discourse analyses could trace its diffusion through industry narratives. Another avenue concerns the temporal dynamics of institutional interventions. The findings suggest that supranational agencies can both stabilise and inadvertently conjure up fragility, depending on how funding mechanisms interact with firms' lifecycles. Longitudinal mixed-methods studies that track cohorts of firms before, during and after specific programmes could help shed light on the durability of capability gains and the risk of subsidy dependence. Moreover, the proposed stage model developed here is retroductively grounded in twelve interviews and therefore to some extent heuristic. Quantitative tests assessing financial performance, partnership densities and innovation outputs could for instance evaluate whether progression through the proposed stages systematically correlates with superior resilience outcomes, or whether alternative trajectories exist. Collectively, these lines of inquiry promise to further move the field beyond single case, static descriptions towards a more cumulative, generalisable understanding of how business ecosystems weather disruptions while continuing to create value.

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