Navigating the Deep Tech Landscape: Effective Incubation Practices

Master thesis submitted to Delft University of Technology in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE

in Management of Technology
Faculty of Technology, Policy and Management
by

Terence Celestina
Student Number: 1524658

To be defended on January 16, 2025

Graduation Committee

Chairperson:	Dr. Geerten van der Kaa	Values, Technology and Innovation
First supervisor:	Elif Çelik	The Delft Centre for Entrepreneurship

Contents

List of Tables

List of Figures

Abbreviations

AI	Artificial Intelligence
B2B	Business-to-Business
DT	Deep Tech
IP	Intellectual Property
IoT	Internet of Things
R&D	Research and Development
TRL	Technology Readiness Level
VoD	Valley of Death

Preface

For the last six months, I have been working on my thesis to complete the master program Management of Technology at TU Delft. I have researched how incubators can better support deep tech startups.

I chose this subject because I am very interested in the deep tech startup potential. I have good friends that are founders of deep tech companies and am very fond of their developments. I think this field has immense potential and would like to continue consulting and aiding deep tech startups throughout their journey.

I would like to thank my daily supervisors from the TU Delft, Elif Çelik for having the patience to guide me through the past months. Being critical and giving advice. I would like to especially thank her for being adaptable and making the time to meet me even in her free time.

Abstract

Deep tech (DT) startups possess transformative potential but face distinct challenges, including long R&D cycles, high capital demands, and a focus on non-consumer markets. This research reveals that conventional incubation models, often tailored to agile startups, fall short in meeting the specific needs of DT ventures. Through a multi-case study of Dutch DT startups, this study finds that incubators must adjust their strategies to align with the DT lifecycle, particularly emphasizing business access over generic support.

The research highlights the need for incubators to act as facilitators, connecting DT startups with external actors such as other deep tech companies and prospective business to business customers at early stages to mitigate costly, late-stage pivots. By securing relevant market access from the outset, DT startups can focus on targeted product development tailored for their complex, high-stakes markets. The proposed framework calls for lifecycle-based support that aligns incubator support factors with DT-specific needs, ultimately improving commercialization outcomes and supporting broader societal impact.

These findings provide actionable recommendations for incubators and stakeholders, paving the way for more effective DT incubation practices that bridge the gap from lab to market.

Executive Summary

Deep Tech (DT) encompasses transformative innovations based on advanced scientific and engineering breakthroughs, such as quantum computing, photonics, and advanced materials. Unlike conventional technology startups, DT ventures are characterized by prolonged R&D cycles, high capital demands, and complex commercialization pathways, which often lead to high failure rates despite their immense potential to address societal challenges such as climate change and healthcare.

Although DT startups promise disruptive solutions, their long development timelines and high risks discourage many entrepreneurs. These challenges contribute to a 'valley of death', where financial, technological, and market hurdles lead to failure for most DT ventures. The complexity and capital intensity of DT innovation often deter investors, while conventional incubation models do not address the unique needs of these startups.

Incubators can play a pivotal role in addressing these challenges by offering specialized support tailored to the unique lifecycle and requirements of DT startups. By providing access to technical expertise, business networks, and funding opportunities, incubators can help start-ups navigate critical stages of development. However, traditional 'one-size-fits-all' incubation practices fail to meet the nuanced demands of DT ventures.

This thesis investigates the central question: *How do the needs of DT startups differ from those of other types of startup in their engagement with incubators, and what implications does this have for tailoring the services provided by incubators?* A multicase study approach was used, focusing on DT startups in the Netherlands. Data were collected through semistructured interviews and cross-case analysis, with insights codified into tangible (e.g., infrastructure, funding) and intangible (e.g., knowledge transfer, network building) components.

The research highlights specific ways incubators can better support DT startups:

1. **Strategic Industry Partnerships:** Facilitate partnerships between DT startups and established companies in the same industry to provide technical expertise, market validation, and access to resources. Such collaborations can help startups navigate early R&D challenges, mitigate risks associated with the

'valley of death', and accelerate commercialization by leveraging the established networks and market presence of the partner company.

2. **Stage-Specific Financial and Investor Support:** Recognize that DT startups have varying financial needs throughout different stages of the life cycle, often requiring significant investments during R&D and scaling phases. Incubators should offer mentorship to help startups identify suitable investors for each stage, tailor funding strategies, and refine their pitch to align with the expectations of potential backers.

3. **Customized Mentorship Programs:** Develop sector-specific mentoring frameworks that address the unique challenges of DT startups. This includes guidance on navigating regulatory compliance, managing intellectual property, and strategically engaging with investors and industry stakeholders at different stages of development.

4. **Extended Incubation Periods:** Adapt incubation timelines to account for the prolonged R&D and commercialization phases typical of DT startups. Providing support beyond the traditional incubation time frame ensures that startups have the necessary resources and guidance to overcome long-term challenges.

By implementing these strategies, incubators can significantly improve the success rate of DT startups, fostering innovation and societal impact. This research provides a framework for enhancing the effectiveness of incubation practices, contributing to the broader deep-tech ecosystem.

1 Introduction

The DT industry has the potential to reshape technological landscapes and create new economies (dealroom.co, 2023; Fiaschi, 2024; Schuh et al., 2022). Innovations resulting from DT are defined as disruptive solutions arising from major technological or scientific advances that are unique and often hard to reproduce (Abbasi et al., 2022; De la Tour et al., 2017; MIT REAP, 2022). A DT venture typically operates in industries such as advanced materials, artificial intelligence, biotechnology, blockchain, robotics, photonics, and quantum computing (de Tommaso, 2024; De la Tour et al., 2017; dealroom.co, 2023; Parmentola et al., 2021). However, with the potential that DT has to offer the industry, startups originating from DT face difficulties and usually do not survive due to long development times and complexity. Studies indicate that only 10-20% of DT startups reach full commercialization (Parmentola et al., 2021), while more than 90% of early-stage DT ventures face significant technical, financial or market challenges, leading to a failure rate of 65-80% within the first five years (S. A. Gbadegeshin et al., 2022). Furthermore, the chance of failure in the early stages of DT start-ups can be as high as 70-90% (Colombelli et al., 2019).

Incubators play a crucial role in supporting start-up activities (Albort-Morant and Ribeiro-Soriano, 2016; Colombo and Delmastro, 2002; S. A. Mian et al., 2016). Incubators aim to facilitate entrepreneurial activity through an incubation program. A business incubation program is a tool for promoting innovation and economic development (Al Mubaraki and Busler, 2011) by providing value-adding activities to incubatees with the intention of increasing their survivability (Berbegal-Mirabent et al., 2023).

Incubators are widely regarded as beneficial for the performance of their tenant ventures by providing critical resources. However, empirical evidence on the impact of incubation support on venture performance is inconclusive. Although some studies highlight positive results (Lee and Osteryoung, 2004; Peters, Rice, and Sundararajan, 2004), others do not reveal a significant effect, attributed to the generalized services that incubators often provide, which may not align with the specific needs of every startup (Chan and Lau, 2005; Meyer, 2003; Soetanto and Jack, 2016b). DT startups, in particular, encounter distinct challenges and requirements that differentiate them from other types of start-up (A. G. L. Romme et al., 2023; TechCrunch, 2023), suggesting that conventional incubator models may not fully address these specialized needs. This research aims to map the unique needs of DT startups against the support mechanisms provided by incubators.

Description of key terms in this thesis

In the context of this research, DT is defined through the traits described by dealroom.co, 2023, which are developments that require longer/slower cycles of research and development (R&D) for an product of emerging technology to be translated into commercial solutions for consumers. Usually developed by highly academic entrepreneurs (PhDs or postgraduates) (Siota and Prats, 2021).

DT and conventional technology, such as hard technology and software technology, are often used interchangeably, but they represent distinct categories of technological innovation. DT innovation leverages scientific and engineering breakthroughs to solve complex problems and create new markets. In contrast, conventional tech companies build on existing technology (In, 2024; Parmentola et al., 2021). DT startups are characterized by high-value and hard-to-reproduce technological advances that push the technological frontier and disrupt existing solutions (In, 2024; Peña et al., 2023; Review, 2023). Since high-tech startups are built on technology that has already been adopted, there is potential for rapid initiation and commercialization within established markets (Mishanin, 2023). The diffusion process of conventional tech startups is faster as it is marked by more rapid adoption.

1.1 Knowledge Gap

There exists a large systematic summarization of the business incubation literature. The existing literature describes the effect of incubator activity in different regions such as developing countries (D. Williams et al., 2019, Hermawan et al., 2019, Masutha et al., 2019, Osimo et al., 2019, Silva et al., 2019). However, research on the incubation process is fragmented and mainly consists of the generic incubation process (Berbegal-Mirabent et al., 2023). There is a notable lack of research that specifically addresses DT as an industry and explores incubation methods tailored to its unique characteristics. The mentioned support is typically suitable for companies with traditional commercialization cycles, such as software and digital companies (Colombelli et al., 2019; S. A. Mian et al., 2016). However, the importance of specialized support for tech startups dealing with complex technologies is desired (T. Williams and Nguyen, 2021 and Taylor and Anderson, 2022).

Based on the literature, several key aspects highlight gaps in current research. A crucial step is mapping the specific needs of DT startups to the support incubators offer. This includes exploring the diversity of services and evaluating particular offerings -such as monitoring, mentoring, training, and access to equity resources - to determine whether they function as complements or substitutes (Berbegal-Mirabent et al., 2023). In addition, it is essential to understand how these relationships are experienced by startups and what conditions are necessary for a successful exit from the incubator. As Hausberg and Korreck, 2020 notes, the relationship between the typical incubation period and the extended development cycles of DT startups is a significant factor. Similarly, the correlation between the substantial funding required for prolonged development and the support incubators provide is critical and warrants further exploration (Kruachottikul et al., 2023). In addition, the incubator network and its role in fostering connections that aid the growth of DT start-ups are vital areas for investigation, as highlighted by Kruachottikul et al., 2023.

1.2 Problem statement

Based on the knowledge gap identified in 1.1, the primary problem can be formulated as follows: Despite the significant potential and impact of deep DT startups, the prevalent 'one size fits all' incubation models do not adequately address their specialized needs (Colombelli et al., 2019; S. A. Mian et al., 2016). These models, traditionally designed for digital and software-based startups, offer standardized services that do not align with the unique requirements of DT ventures.

1.3 Research Objective

The primary objective of this research is to identify and analyze the unique needs of DT startups and to develop a framework for incubators that optimizes their support strategies for these ventures. Specifically, the research seeks to:

- delineate the distinct characteristics and challenges of DT startups compared to conventional tech startups,
- assess the current incubation practices and identify their shortcomings in addressing the needs of DT startups,
- investigate the critical resources and capabilities that DT startups require from incubators
- Propose strategies and a comprehensive framework that incubators can adopt to enhance their effectiveness in supporting deep-tech startups.

By achieving these objectives, the research aims to provide actionable insights to incubators, policy makers, and stakeholders in the innovation ecosystem, contributing to the successful commercialization of DT innovations. The study will employ a multicase study approach, focusing on DT startups in the Netherlands, to develop a comprehensive understanding of the incubation processes and outcomes for these startups.

1.4 Research Questions

The central research question for this Master's thesis is

> *How do the needs of deep-tech startups differ from those of other types of startups in their engagement with incubators, and what implications does this have for tailoring the services provided by incubators?*

To address this research question, the following subquestions are posed:

1. How do the characteristics and requirements of DT startups differ from those of conventional tech startups?
2. How do incubators currently support startups?
3. What are the capabilities that DT startups require from incubators?
4. What strategies can incubators adopt to enhance the effectiveness of their support for DT startups, considering the unique challenges and opportunities these startups face?

1.5 Relevance of Research

The problem mentioned above is relevant for society since there is a strong sentiment in Europe for DT to address the biggest problems of the world, such as climate change, healthcare and sustainable energy ("The European Deep Tech Report 2023", 2023). However, most European patents remain inactive and never find their way into companies or products, except for the rise in machine learning patents. This is mainly due to the complexity and substantial funding required to bring these innovations to market ("The European Deep Tech Report 2023", 2023). Current incubator models exacerbate this issue by offering short incubation periods and focusing on startups that can achieve quick commercialization (S. A. Mian et al., 2016). The trivial selection mechanisms in these incubators tend to favor ventures that yield fast returns. This study addresses these challenges by exploring how specialized incubation strategies can better support DT start-ups, enabling them to overcome commercialization barriers and contribute to solving societal challenges.

As mentioned in 1.1, there is limited research that concludes with a theoretical framework for DT incubator strategies, highlighting a gap in the academic literature. This underscores the scientific relevance of the problem statement.

MOT Relevance

In the Master of Management of Technology program, students are trained to become technology managers or entrepreneurs in tech-driven environments, with a focus on turning innovations into viable business models. The course 'Technology, Strategy, and Entrepreneurship' offers a foundation in entrepreneurship and teaches how to develop and implement innovation strategies in both large and small firms (TU Delft, n.d.). This research aligns with these goals, examining how complex tech ideas move from research to commercialization, with a focus on incubators supporting deep-tech startups and practical applications of tech management theories.

1.6 Research Approach and Design

This study employs a qualitative multicase study design to explore how incubators support DT start-ups, given the exploratory nature of the research. The goal is to identify which support factors most benefit DT startups, particularly at the end of the incubation process. A cross-case analysis is performed to compare the results in multiple startups, focusing on the company level of the analysis. Data collection involves semi-structured interviews with founders, following a flexible approach to allow investigation of questions and capture of rich insights, minimizing researcher subjectivity and bias (Biggam, 2020).

The research examines DT startups in the Netherlands that have been in operation for more than three years and have undergone incubation, thus having experienced common hurdles of complexity, financial hardship and uncertainty (A. G. L. Romme et al., 2023). The focus is on academic start-ups, where limited business experience increases uncertainty (Cohen et al., 2019; McAdam and McAdam, 2008). The Netherlands is chosen for its high Universal Basic Income, which contributes to stable and high-quality incubators (Boston Consulting Group, 2024; Fattorini and Regoli, 2020). Examples include YES!Delft and UtrechtInc, globally recognized for their robust programs and successful results (InnovationQuarter, 2018; Utrecht University, 2018; UtrechtInc, 2024). The Dutch Incubation Association (DIA) further ensures incubator quality through consistent standards (Association, 2023; Failory, 2024).

The study employs an inductive approach to develop a nuanced theoretical framework, using insights from the existing literature as a foundation and enriching it through interview analysis.

The thesis is structured as follows: The next chapter reviews the relevant literature, followed by an explanation of the research methodology. Subsequent chapters analyze the case study findings and cross-case analysis, culminating in the development of a final theoretical framework. The conclusion discusses implications for incubator design and DT startup support and offers recommendations for future research.

2 Literature Review

2.1 Introduction

The purpose of the literature study is as follows.

1. Identify the knowledge gap.
2. Select a definition of DT relevant to this study.
3. Gain insight into the characteristics of DT, such as lifecycle stages and risks.
4. Gain insight into current incubator practices and frameworks.

To achieve these goals, a methodical selection of the literature was performed, focusing on defining the relevant characteristics of DT, examining the stages of the life cycle, the risks and the unique challenges these startups face. The review also addresses the most relevant incubation models available. The overarching objective of the literature review is to highlight key factors and frameworks that can bridge the gap between early-stage innovations in DT and successful commercialization.

2.2 Literature Selection Methodology

A literature review was conducted to understand the relationship between DT startups and the support mechanisms provided by incubators. The search databases used for this study was Web of Science. This subsection will describe the approach used to filter and select the articles for this study.

Search Terms

To facilitate the analysis of incubator services for DT startups, a systematic literature review is adopted, illustrated in Figure 1, adapting a multistage approach. In the first stage, the rationale, scope and objectives of the study are defined by reviewing previous systematic reviews in related fields (Hausberg and Korreck, 2020; Sohail et al., 2023). These reviews were crucial in highlighting research topics related to incubator services, with a particular emphasis on the gaps related to DT startups and the unique challenges they face. Themes such as incubation types, entrepreneurial ecosystems, and the role of incubation in startup growth were explored, ultimately the focus was narrowed to services tailored to DT incubation.

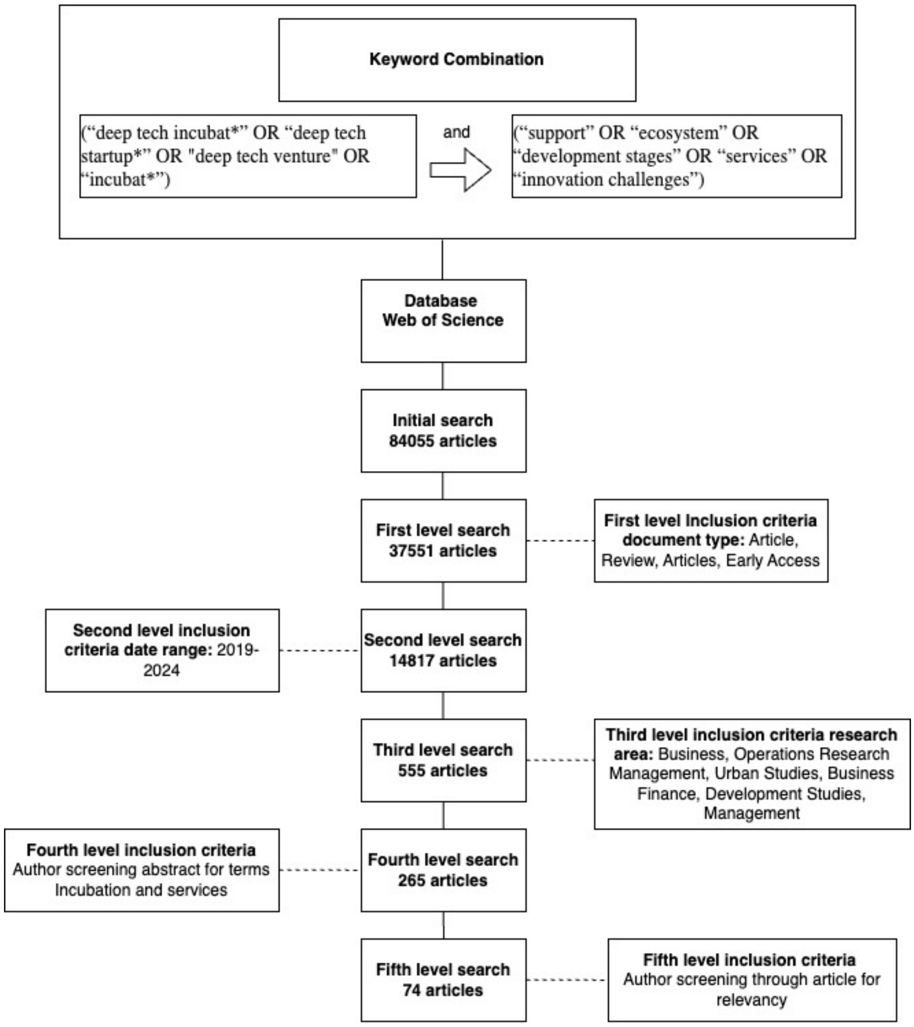

Figure 1. Five-stage process of data collection.

The literature on incubator services is often fragmented, lacking a clear synthesis, and limited when applying it to DT startups. To address these gaps, the Web of Science database was used, known for its breadth and inclusion of high-quality journals (Hausberg and Korreck, 2020).

In the second stage, a comprehensive keyword strategy was developed specific to DT incubators. This strategy was refined to ensure relevant results, avoiding overly broad terms such as 'accelerators' that tend to produce false positives in the context of DT incubation (Hausberg and Korreck, 2021).

In the third stage, constraints were applied including limiting results to business and management focused areas, document types such as articles and reviews, and English-language publications. This produced a robust data set of 555 articles directly relevant to understanding incubator services. In doing so, we excluded articles from disciplines less pertinent to our research, such as engineering and healthcare.

The fourth stage involved screening the abstract of the resulting articles to ensure that they specifically addressed incubation and services, as defined by S. Hackett and Dilts, 2004. This allows a systematic analysis of the contextual role of incubators in startup ecosystems, the services provided, the mechanisms driving these services, and the results, particularly the long-term development and commercialization success of DT startups. This process resulted in a dataset of 265 articles, covering a wide geographic and temporal range.

In the final stage, the articles were completely reviewed and selected based on relevance. The final selection of 74 articles provided a detailed empirical basis for analyzing how incubators currently support tech startups.

The articles *New Product Development Process and Case Studies for Deep-Tech Academic Research to Commercialization* by Kruachottikul et al., 2023 and *Exploring the University-Industry Cooperation in a Low Innovative Region* by Parmentola et al., 2021 were particularly influential and formed the basis for developing a comprehensive risk table for DT start-ups.

Key articles, including *Business Incubators and Accelerators: A Co-Citation Analysis-Based, Systematic Literature Review* by Hausberg and Korreck, 2020, provided comprehensive insights into the services offered by incubators and their impact on startup success. The most influential framework was derived from Bergek and Norrman's *Incubator Best Practice Framework* Bergek and Norrman, 2008, which was deemed the most relevant for analyzing the unique needs and strategic components management of DT startups.

Backward and forward snowballing

The reverse snowball approach was used to select the relevant incubator frameworks. This method serves as a valid alternative to database searches, as supported by Wohlin's guidelines (Wohlin, 2014). The results of this process are illustrated in figure 2.

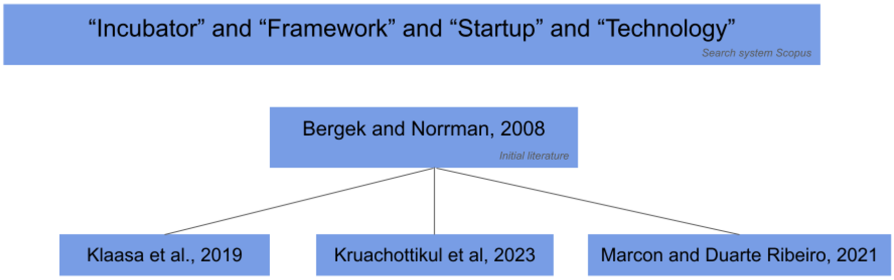

Figure 2. Example of snowballing effect in search process

In addition, the number of references was a primary selection criterion. However, when examining the context of DT startups and incubators, many relevant papers, especially the more recent ones, exhibited fewer citations than might be expected. The selection threshold based on the citation count was adjusted to include newer publications with emerging insights. Table 1 summarizes the criteria used to include articles during the literature review process.

Table 1. Table of Inclusion and Exclusion Criteria

Criteria	**General Search Inclusion**	**General Search Exclusion**	**Netherlands-Specific Inclusion**	**Netherlands-Specific Exclusion**
Citation Count > 100	Yes	No	No	Yes
Published in Last 3 Years	Yes	No	Yes	No
Provides New Data or Ideas	Yes	No	Yes	No
Findings Similar to Other Works	No	Yes	No	Yes
Context Specific to DT	Yes	No	Yes	No

2.3 DT Startups and Their Landscape

Throughout the current literature, it is notable that DT is often defined as novel scientific or engineering breakthroughs. For instance, Uber and SpaceX both are described with this definition, but differ in their technological depth. Uber revolutionized transportation with its ride-sharing model (Smith, 2020), while its core technology is built on existing software. In contrast, SpaceX exemplifies DT through groundbreaking advances in space exploration, such as reusable rockets, which represent significant engineering challenges (Muegge, 2019). This comparison highlights how similar terms are used to describe different technologies. To address the first subresearch question, *"How do the characteristics and requirements of deep-tech startups differ from those of conventional tech startups?"*, DT will be defined and characterized in this section.

2.3.1 Definition and Characteristics of DT

Romasanta et al., 2023 trace the origins of DT to a Chinese investment book from 1993. This book refers to industries such as electronics, biological engineering, and fine chemicals. Since this article, the term DT has been used frequently in the mainstream media. DT is a young concept and is poorly defined (Marques, 2023). In the following subsection, a definition is set for DT.

Romasanta et al., 2023 described that DT can not be defined by a term but should be dimensionalized. The article does this using bibliometric methods from Kovacs et al., 2019 and found that DT can be characterized by two underlying dimensions: impact and novelty. High impact leads to significant changes, altering how industries operate or creating entirely new markets. However, high novelty implies that the innovation is significantly different from existing technologies. Hence, DT does not refer to a specific industry, but rather to industries that are more likely to be impacted by DT technology. La Tour et al., 2022 limits DT to consisting of innovations based on hardware, materials, and chemicals. Rakic, 2020 further differentiated between breakthrough and disruptive innovations. Disruptive innovation disrupts the market and creates new market niches.

Two features are noticeable; there is no exact definition for DT and it is not restricted to a specific industry. This study will systematize the existing definitions by classifying DT based on intrinsic definitions, keeping it separate from the lose associations, presented in Table 2.

Intrinsic Definitions	Traits	Examples of Industry	References
DT & DT startup	Usually the result of intense R&D, often originating from highly academic individuals like PhD candidates or professors. Requires significant capital in R&D, industrialization, and commercialization. Takes a long time to reach market-ready maturity. High market risk, as the market demand for the product is not proven. Expected to have large economic, societal, and environmental impacts.	Advanced materials, Artificial intelligence, Biotechnology/life-sciences, Blockchain, Cleantech & energy, Drones and robotics, Medtech, Photonics and electronics, Space, Quantum Technologies.	A. G. L. Romme et al., 2023, Lin et al., 2021,dealroom.co, 2023; Fiaschi, 2024; Rathore and Agrawal, 2023

Table 2. Definition of DT for this research

DT, hard-tech, and high-tech are often used interchangeably with the same terms, but they represent distinct categories of technological innovation. High-tech refers to technologies that are software-driven and thus less complex than DT innovations that combine complex software with novel forms of complex hardware (Perelmuter, 2021). High-tech companies use the latest advanced technologies to enhance existing products and markets (In, 2024; Parmentola et al., 2021). DT start-ups usually originate in university laboratories, e.g., university spin-offs, meaning that the technology itself is new. The business strategy of DT is therefore not built for the consumer-facing market. Instead, mainly focus on business-to-business or government sectors (Group, 2021). Unlike projects where standard methods can be employed at any stage to rapidly develop a product, DT projects require more time.

2.3.2 DT Startup Growth Phases

The first part of the initial sub-question is addressed in the previous section, where the characteristics of DT are discussed. This is best illustrated by the framework presented by Romasanta et al., 2023 in Figure 3.

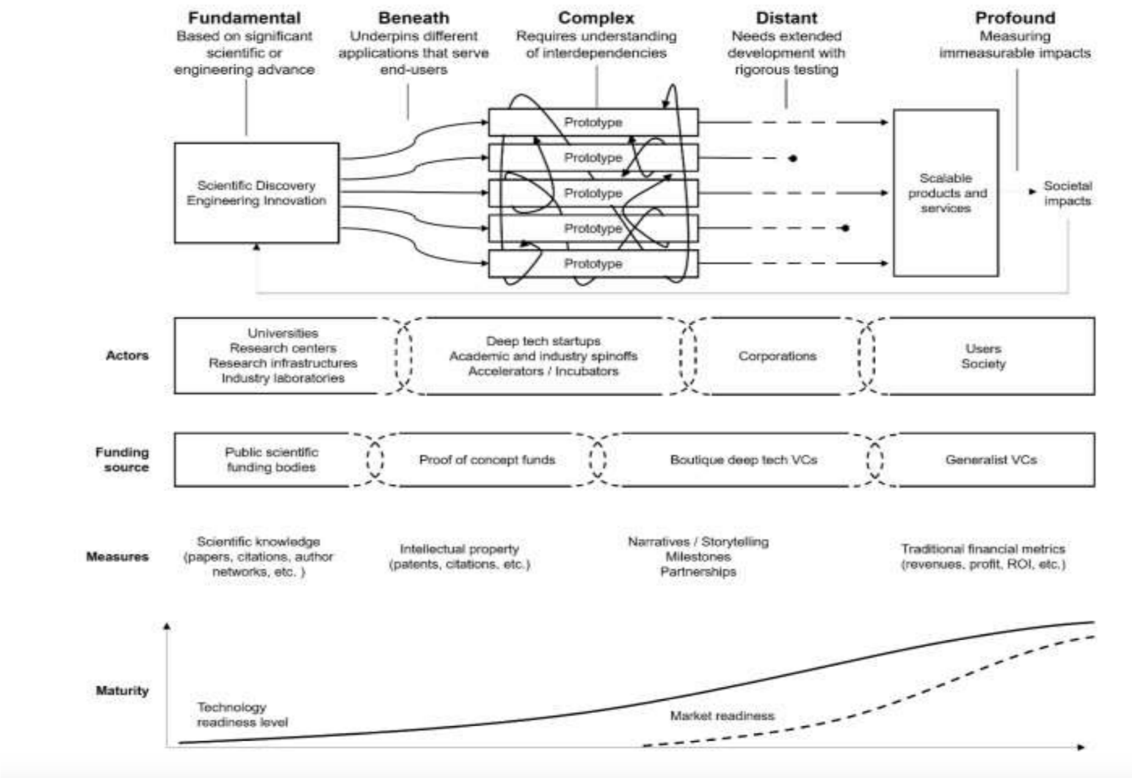

Figure 3. DT Framework (Romasanta et al., 2023)

DT startups go through a different growth model than conventional technology startups (Schuh et al., 2022; Yusubova et al., 2019). The growth model, also referred to as the lifecycle model, represents the different stages through which a startup progresses from initiation to commercialization. In the following section, the first sub-question will be further explored by examining the lifecycle model for DT startups. Conventional tech startups typically follow a lifecycle model consisting of four stages—early stage, R&D stage, growth stage and late stage—as illustrated and defined in figure 4.

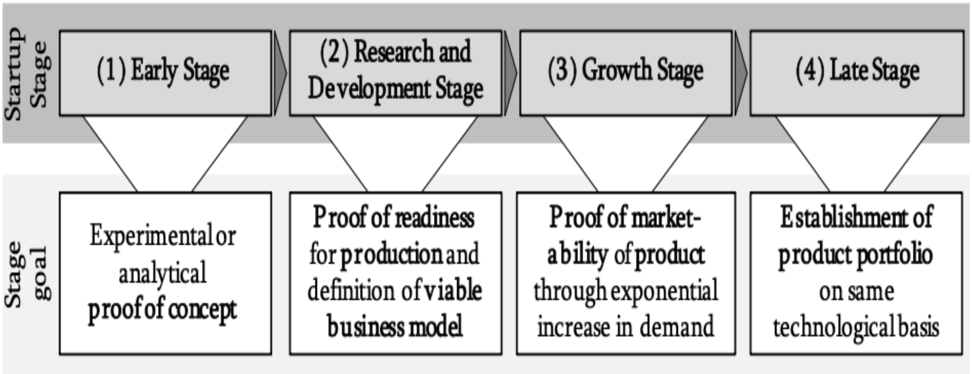

Figure 4. Tech startups life cycle stages (Schuh et al., 2022)

Articles Borini et al., 2024 and Schuh et al., 2022, state that, while the DT lifecycle also consists of the same four stages mentioned above, there are differences in the characteristics of the stages. As evident in Figure 6, compared to conventional startup, DT startup begins very slowly, with a longer development time before reaching market readiness.

Early Stage: The Early stage of DT startups serves to develop an initial rough concept and validate the potential of the technology. The general marketability and technical and economic feasibility of the idea must be evaluated in close cooperation with experts, and a sound analytical or experimental proof of concept must be provided to justify further pursuit of the idea (Hahn and Schnedler, 2019).

R&D Stage: The R&D Stage transitions the proof of concept to a first product. This stage also involves identifying a business model with possible clients to demonstrate the technical and economic feasibility of the technology (e.V., 2018). The R&D stage involves developing products and systems with high technological complexity. This complexity contributes to the longer time to market being at least 3 - 5 years (A. G. L. Romme et al., 2023). This stage is important because it is where DT ventures encounter the so-called "valley of death" (VoD), a period in which initial components are exhausted and substantial investment is needed to scale the technology to market readiness (Ellwood et al., 2022; A. G. L. Romme et al., 2023). The concept of VoD is illustrated in the graph provided in Figure 5, where the horizontal axis represents the time to market in terms of the Technology Readiness Level (TRL), and the vertical axis reflects the components needed for technology development. The TRL framework is a well-regarded and practical tool for evaluating the maturity of new technologies. With its nine distinct levels, TRL helps determine how ready a technology is at various stages of its lifecycle. This includes conducting a detailed system analysis, completing conceptual design studies, exploring design options, and making informed decisions about when to begin full-scale development (Mankins, 2009). By offering a structured approach, TRL enables stakeholders to make better decisions and efficiently allocate components as technologies progress from initial concepts to fully developed solutions. This framework helps to understand the major challenges that DT startups face, with VoD typically starting at TRL 4 and ending around TRL 7. These challenges will be explored further in Section 2.3.3.

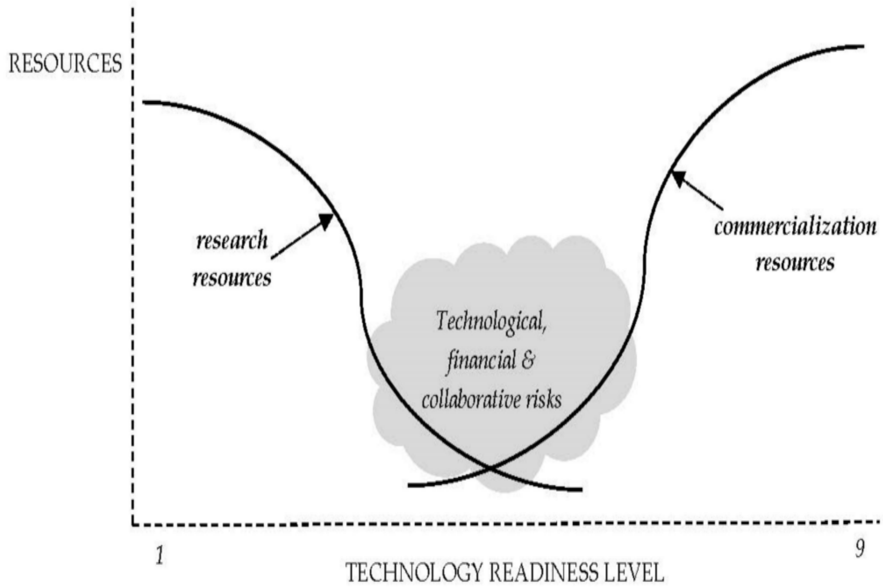

Figure 5. Valley of death (Jacobs, 2023)

Growth Stage: The startup enters the market with its product, aiming to create demand through various measures, thus confirming the actual marketability of the product (Frick and Meusburger, 2013). The overarching goal is to establish these additional products in the market, continue to achieve high growth rates, and ideally create a new market segment (Siegel and Krishnan, 2020).

Late Stage: In final instance, the meanwhile proven technology must be integrated into further products by the DT startup in order to start a diversification of the product portfolio. The overarching goal is to successfully establish these additional products on the market, continue to achieve high growth rates, and, in the best case, establish a new market or a new market segment (Passaro et al., 2016; Tech, 2018) While a DT startup goes through similar stages, the difference is best illustrated in Figure 6.

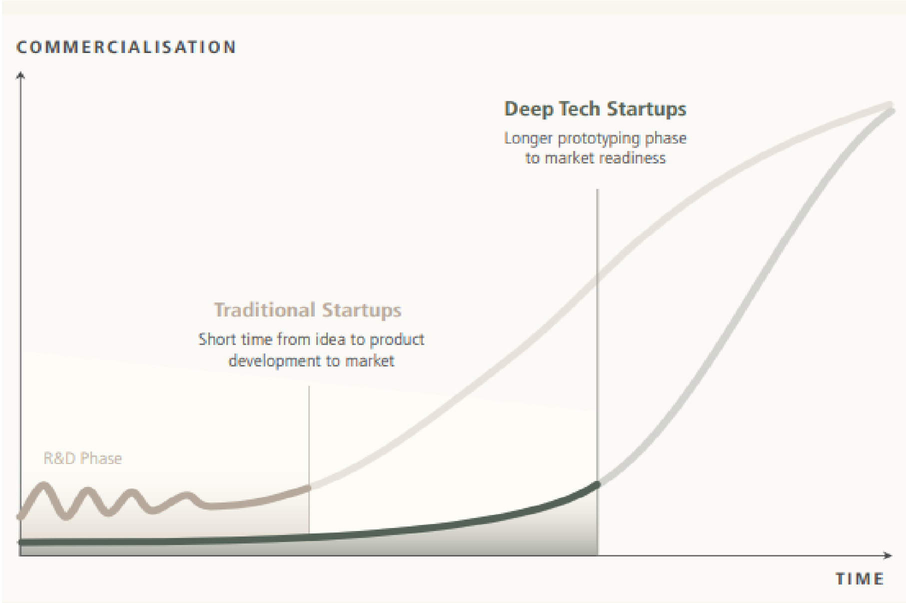

Figure 6. Commercialization time DT versus conventional (Schuh et al., 2022)

The primary differentiation between the DT and conventional startup model lies in the extended and components-intensive R&D phase. The literature highlights that DT growth tends to revolve more around the development of the product or technology (TRL), whereas the lifecycle of conventional startups is more focused on efficient organizational factors and scale-up of the product.

2.3.3 Risks and Challenges in DT Startups

In the previous subsection, the lifecycle model of DT startups was characterized and compared to that of conventional tech startups, revealing distinct differences in the associated risks. As highlighted by Smith and Doe, 2020, while there are similarities, DT startups face a unique risk profile compared to conventional startups. This is illustrated in Figure (7). A key risk is capital risk: Although conventional startups often rely on established technologies and can quickly commercialize within existing markets, DT startups face slower adoption due to the novel nature of their technologies. This slower diffusion contributes to the concept of the VoD, discussed earlier. The remaining risks, which will be explored in the next section, further underscore the differences between DT and conventional tech, helping to address the third and fourth subresearch questions.

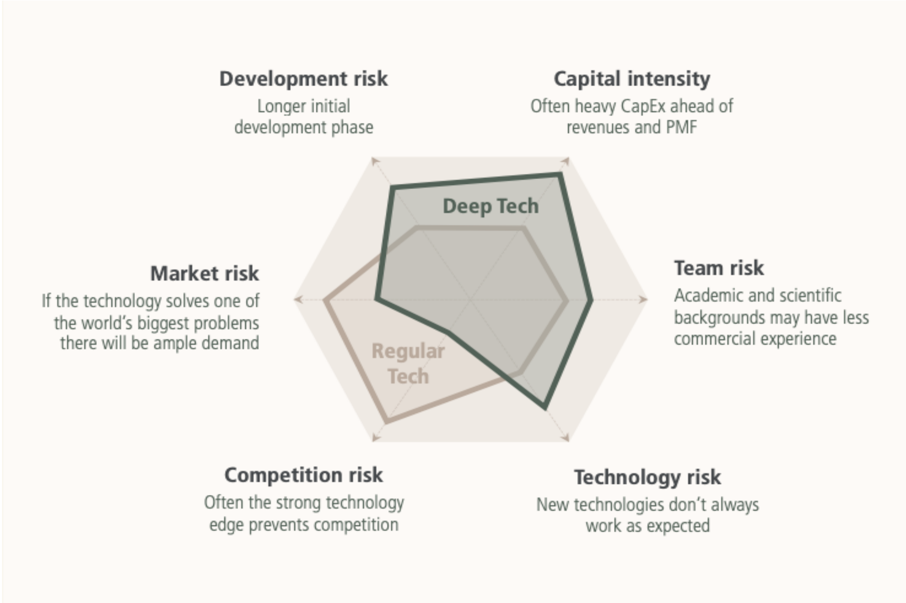

Figure 7. DT risk profile (Jacobs, 2023)

Technological Risks

As characterized in Section 2.3.1, DT refers to new technology without previous application. This leads to uncertain and long development times (Capatina et al., 2024; Hello Tomorrow and Bpifrance, 2019; Sadeh and Dvir, 2020) with the risk of VoD (McCarthy, 2014). A risk associated with the development of DT is that the technology cannot be translated into a practical application, limiting the ability to attract investment (Mossberg and S., 2018; Ray et al., 2018; Upadhyayula V.K. Gadhamshetty V. Shanmugam and Tysklind, 2018). Venture capitalists, while generally willing to assume institutional risks, often shy away from large technological risks (Weyant, 2011).

Development often proceeds through rigorous, structured testing, in contrast to agile, consumer-centric methods often used in shallow tech ventures (Rodríguez González et al., 2020). Poor technology development methods can significantly hinder progress, making it difficult for start-ups to transition from the research stage to commercialization (Ford and Dillard, 2018; N. Islam, 2017; Popp et al., 2017).

Financial Risks

Long timelines are a major challenge, as DT start-ups often require significant time to mature, particularly those that involve physical infrastructure like factories or advanced R&D. These timelines frequently exceed the typical startup fund lifecycle of 10 years (Nanda, 2020), making them less attractive to traditional startup investors. Additionally, high capital intensity for derisking poses a barrier, as these ventures often need to develop costly prototypes or scale technologies before market validation, often exceeding EUR 10 million to EUR 20 million in the first investment round (Corporation and BpiFrance, 2021), contrasting with the lower capital requirements of, for example, software-based startups.

Predicting production costs on an ongoing basis or gauging customer interest can be a very challenging task, increasing the perceived risk for investors (Corporation and BpiFrance, 2021). There is also a mismatch with startup models, as startup financing thrives on staged investments tied to achieving milestones, such as product-market fit. DT startups often lack early, cost-effective experiments to validate their potential, making them a poor fit for this structured approach (Nanda, 2020).

In addition, regulatory and market barriers hinder progress, as many DT sectors, such as energy and healthcare, are heavily regulated or involve large incumbent customers with significant market power, reducing profitability and investor appeal (Nanda, 2020). The past decade has also seen a decline in investment in fundamental innovation, with VC investments shifting toward software, consumer services, and IT. Sectors like energy, materials, healthcare and hardware have seen reduced share of investment, indicating systemic challenges in funding breakthroughs in these areas (Weyant, 2011).

Market & Competition Risks

Figure 7 shows that the risk of market and competition for DT start-ups is less critical than that for conventional start-ups. Unlike regular startups, DT companies have stronger defensibility to competition thanks to their cutting-edge technologies at their core, IP portfolio, and teams of technical expertise (Jacobs, 2023).

DT startups, like other technical startups, often face challenges in successfully commercializing their innovations. Success depends not only on their technical capabilities, but also on the ability to ensure contextual relevance. Variability in customer needs and substantial switching costs frequently pose significant barriers to adoption (Aarikka-Stenroos and Lehtimäki, 2014; Pynnönen et al., 2019). However, the transformative implications of DT technologies enable them to address pressing global issues, thus generating substantial demand (Jacobs, 2023). As Kruachottikul et al., 2023 highlights, DT startups often tackle unmet needs driven by megatrends, further strengthening their demand potential.

Regulatory Risks

Regulatory risks for DT startups come in the form of bureaucratic delays, institutional pressures, and the need for strong legal support. Bureaucratic delays can significantly hinder the progress of startups, especially in regulated industries such as medical devices and cleantech (Brooks, 2013; Collins et al., 2016; Ouchi and Watanabe, 2009). In the life sciences sector, scholars have stated that entry into the industry is complicated due to stringent regulations (S. A. Gbadegeshin, 2019). In addition, startups often face institutional pressures that can stifle innovation and decelerate the commercialization process (Earle et al., 2019; Jucevicius et al., 2016; Maia and Claro, 2013). In addition, there is a crucial need for assistance in intellectual property, legal, and regulatory matters, which are important to business strategy and can serve as obstacles. It is essential to provide startups with legal experts to navigate these complexities (Kruachottikul et al., 2023).

Collaboration Risks

Researchers in academic settings often prioritize publications and intellectual contributions, while industry partners focus on intellectual property protection and market readiness, leading to conflicts over the timing of publications and patent filings (Communications, 2020; Hudson and Khazragui, 2013; Kasenda et al., 2016; Merceret and et al., 2018; SpringerLink, 2018; Weyant, 2011; Zhu and et al., 2019). In addition, the success of DT ventures is dependent on the synergy between academic researchers and industry experts. The loss of key personnel can severely disrupt the development process, as these individuals often have unique expertise that is crucial to the advancement of the project (Forum, 2020; Weyant, 2011).

A recent study highlighted that 50% of startups rated their collaboration experience with companies as mediocre or worse, despite 82% of corporations considering these interactions crucial to their innovation strategy (Group, 2021). The lack of effective collaboration has been identified as a significant driver of VoD in new companies, and several scholars attribute this to poor collaboration between organizations, particularly with research institutes (Abereijo, 2016; Amonarriz and et al., 2018; Byrd et al., 2017; Chi-Han and Hung-Che, 2016; Jucevicius et al., 2016; Weggeman and et al., 2022). This issue is compounded by the conflicting logic between academia and business, where researchers are more focused on technology development, patent filings, and publications, while corporations prioritize profitability (Hudson and Khazragui, 2013; Merceret and et al., 2018; Pusateri and et al., 2017; Wong, 2019;

Zhu and et al., 2019).

Collaborations with larger companies introduce challenges such as misalignment of key performance indicators, regulatory differences, and potential issues between R&D and corporate venturing teams (Group, 2021; Weyant, 2011).

Human components Risk

Human components risks are a critical concern for DT start-ups, particularly in the context of navigating the VoD. New businesses fall into this stage due to insufficient expertise (Barr et al., 2009; Cummings et al., 2018). Entrepreneurship and leadership skills play a critical role in overcoming these challenges (Thompson, 2018). Startups must ensure that their teams possess the necessary skill sets, as well as access to adequate funds, appropriate facilities, and quality materials, to pass through the preclinical phases, especially in sectors such as medical technology ((CTTI), 2021; Friend and Zehle, 2018; Galendata, 2023).

Moreover, the selection and composition of the startup team play a pivotal role in determining success. As Gbadegeshin S. A. Gbadegeshin et al., 2022 points out, one of the primary reasons for startup failure is poor team selection. This puts importance on the necessity of assembling a team with diverse skills, including technical expertise, business acumen, and strategic vision. The absence of skillful personnel and necessary facilities significantly contributes to the failure of startups in the VoD (Barrable et al., 2014; Björk, 2006; Brooks, 2013; Byrd et al., 2017; Dobrenkov, 2014; Liotta and Painter, 2012; Maughan, 2019; Schoonmaker et al., 2013; Yadav, 2019; Zhu and et al., 2019).

Relationship between risk factors

It is interesting to recognize that different risks are often interdependent as is tabulated in table 3.

The risks relationship is shown in fig 8.

Risk	Effect on Other Risks	Citations	Risk Affected
Human components risk	Leads to delays in development, which in turn hinders technological progress and limits funding opportunities.	Thompson (2018), Cummings (2018), Liotta (2018)	Technological Risk
Technological risk	Prevents securing funding, leading to project incompletion or market delays.	Upadhyayula (2018), Mossberg (2018), Ray (2018)	Finance Risk, Market Risk
Finance risk	Causes project incompletion, affecting technological advancement, human components continuity, and market entry.	Henriksen (2012)	Human components Risk, Market Risk
Market risk	Increases financial strain, making it difficult to secure components and compete with established players.	Weyant (2011)	Finance Risk
Collaborative risks	Disruptions in partnerships or access to components further delay technological progress, leading to greater market and finance risks.	Henriksen (2012)	Technological Risk, Market Risk

Table 3. Risk Interdependencies in DT Startups

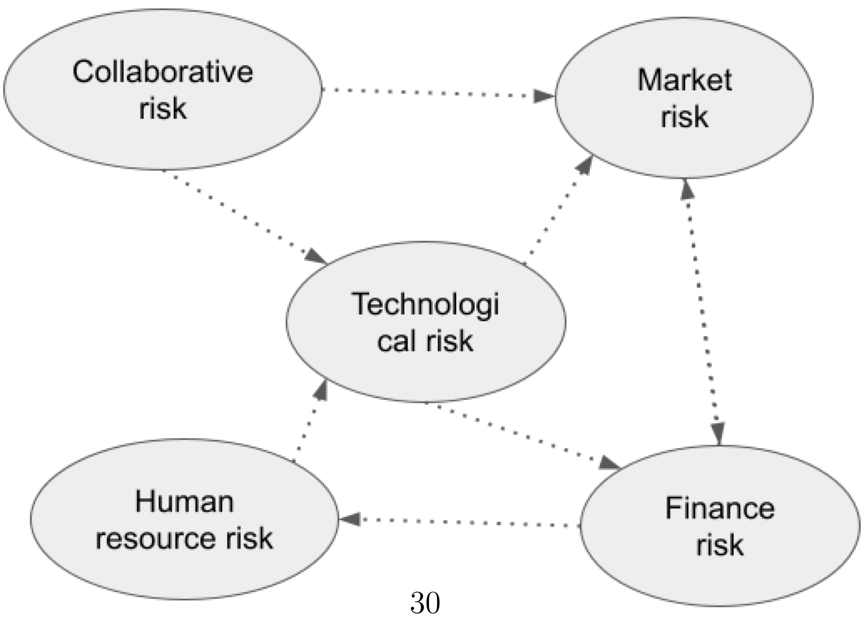

Figure 8. Risk relationship (Author's own elaboration)

2.4 Incubators and Their Role in Supporting Startups

This section aims to answer Subresearch Question 2: 'How do incubators currently support startups' by providing an overview of the current state of knowledge based on the literature on incubators. Business incubation has become a global phenomenon, with widespread implementation in various regions of the world. Bergek and Norrman, 2008 define incubation as enterprises that "facilitate the early-stage development of firms by providing office space, shared services, and business assistance." As the number of incubators has proliferated, diverse typologies have emerged, characterized by differences in sponsorship, incubation phases, strategic objectives, value creation, target markets and industries (Assenza, 2015; Bouncken and Reuschl, 2016; Capdevila, 2017; Zhang, 2022). Despite the diversity of incubators, all incubators share a common goal: to promote entrepreneurial activity through structured business incubation programs. These business incubation programs act as instruments for fostering innovation and driving economic development, Al Mubaraki and Busler, 2011, by offering value-adding activities that enhance the survival and growth of incubatees. Collectively, these activities are referred to as the "business incubation process," with various models and theories developed to explain how they work.

2.4.1 Support Organizations

To gain a clear understanding of the scope of an incubator as a support organization, it is essential to differentiate between the various types of support organizations that exist. References used to define each support mechanism are drawn from cocitation analyzes or systematic reviews, as presented in Table 4.

Table 4. Methods/Services Used to Support Startups and Their Lifecycle Stages

Method/Service	Description	Lifecycle Stage	Source
Start-up facilities & Free co-working space	Free co-working spaces like Aalto Entrepreneurship Society's initiative are essential for early-stage startups, providing flexible facilities to encourage entrepreneurial collaboration.	Early stage	Bouncken and Reuschl, 2016 Capdevila, 2015

Continued on next page

Table 4 – continued from previous page

Method/Service	Description	Lifecycle Stage	Source
Start-up Internship Program	Internship programs such as the Silicon Valley experience help students immerse in high-growth startup cultures, fostering entrepreneurial skills.	Early stage	Assenza, 2015 Bouncken and Reuschl, 2016
Incubator	Incubators for early-stage startups, including tech and innovation hubs, support ventures until market entry.	Early stage	Capdevila, 2017 Zhang, 2022
Accelerator Programs	Three-month accelerator programs, providing mentorship and investor access, are crucial for growth-stage startups.	Growth stage	Capdevila, 2015 Assenza, 2015
Venture Capital Fund (UT)	Venture capital initiatives support startups with international potential from the early to growth stages.	Early to Growth stage	Bouncken and Reuschl, 2016 Zhang, 2022
Idea Lab	Idea labs develop entrepreneurial talent by testing market potential and fostering innovative solutions.	Ideation stage	Bouncken and Reuschl, 2016 Capdevila, 2017
Awards	Award schemes recognize and support high-potential ideas, providing components for further development.	Ideation stage	Assenza, 2015 Capdevila, 2017
Government Innovation Facilitators	Government initiatives provide critical support for startups through knowledge transfer and collaboration schemes.	Ideation to Growth stage	Zhang, 2022 Capdevila, 2017
Public-Private Partnerships	These partnerships enable innovation districts that connect universities with private sector components for startup growth.	Growth stage	Capdevila, 2015 Bouncken and Reuschl, 2016
Digital Product School	Programs like digital product schools enhance digital solution development by integrating company professionals with startup teams.	Growth stage	Capdevila, 2017 Bouncken and Reuschl, 2016

Continued on next page

Table 4 – continued from previous page

Method/Service	**Description**	**Lifecycle Stage**	**Source**
Spin-off	University spin-offs commercialize research results, turning innovative ideas into market-ready products and services.	Early to Growth stage	Capdevila, 2015 Zhang, 2022

This study focuses on incubators whose primary objective is to promote the growth of startups, rather than on corporate incubators that aim to increase the value of the parent company (Bundl, 2023; Entrepreneur, 2023). Two types of organizations that are worth mentioning for their involvement in DT startups are venture builders and university spinoffs.

Venture Builder

A venture builder, unlike an incubator, is an organization that internally generates startup ideas, assembles teams, and builds companies from scratch, taking a hands-on approach throughout the entire process. Although incubators provide support to external startups for a limited period, venture builders control their ventures, offering long-term support and retaining significant equity stakes (Kiel and Arnold, 2021). Although a venture builder is different from an incubator, it is still very relevant to this research to incorporate the types of method a deep venture takes to support DT ventures through their startup phase.

Since 2019, at least seven Master Thesis has been conducted around the DT venture builder HighTechXL (Bunt, 2019; Hermsen, 2023; Mittelmeijer, 2020; Schutselaars, 2023; Van Andel, 2022; Van Rooij, 2023; Van Scheijndel, 2020). In particular, HighTechXL focuses exclusively on certain technologies that are deemed valuable to its corporate partners such as ASML, specifically in the areas of Photonics and Quantum Technologies (HighTechXL, 2024). The article A. G. L. Romme et al., 2023, gives a complete overview of the methods used by HighTechXL, described for future reference in Appendix A.3.

Univeristy Spin-offs

University spin-offs are considered economically significant firms that are formed to commercialize the research outputs of academic institutions (Bathelt et al., 2010;

Meoli and Vismara, 2013; Vincett, 2019). These spin-offs play a crucial role in the innovation ecosystem by transferring new technology to industry. The role of university spin-offs is significant in regard to DT start-ups, given their reliance on cutting-edge scientific research and advanced technologies coming primarily from universities (Baumann and Loeser, 2010; Bonardo et al., 2010). University spin-offs often develop from research projects that have significant commercial potential (Bonardo et al., 2015). These spin-offs gain from the intellectual property developed within universities (Pisano, 2010; Vincett, 2019). As such, they are well-positioned to advance DT innovations that require a strong scientific foundation.

2.4.2 Overview of Incubation Practices

Numerous studies have examined incubators. Article Colombelli et al., 2019 highlights their role in developing an entrepreneurial ecosystem due to the safe environment they provide. S. M. Hackett and Dilts, 2004 offers a broader definition, stating that incubators facilitate early-stage development by providing office space, shared services, and business assistance. A more abstract definition is given by S. M. Hackett and Dilts, 2004, defining incubators as enterprises that facilitate early stage development for firms by providing office space, shared services, and business assistance. Given the complexity and the need for specialized support in DT start-ups, the broader definition by Hausberg and Korreck, 2020 seems to be the most suitable. Here incubators are described as organizations that support the foundation and growth of new businesses as a central element of their organizational goal. The impact of incubators extends beyond only survival rates. Incubators create regional innovation ecosystems by developing cooperation and knowledge transfer between start-ups, established firms, and research institutions (Hochberg et al., 2015; Mas-Verdú and Roig-Tierno, 2015). In the US, startups use incubators for a wide range of activities, such as access to facilities (50%), talent (30%), business knowledge (25%) and technical expertise (20%) (Boston Consulting Group, 2024). Technology incubators are a crucial support system for start-ups during their early and vulnerable stages, helping them grow into self-sustaining businesses (Bala Subrahmanya Mungila Hillemane, 2019). The current incubator services given in the literature are summarized in Table (5).

The literature signals that startups usually remain with a incubator during the startups stage since they are closer to non-market oriented actors, such as universities, incubators, and business associations (Hillemane and Chandrashekar, 2019). Typically, startups remain in incubators for around 1 to 3 years (Amezcua, 2019;

Service	Description	Sources
Office Space	Providing physical space for startups to work, including desks, meeting rooms, and other facilities.	Mian and A., 1996, Wonglimpiyarat and Jarunee, 2016
Shared Services	Offering shared administrative services such as reception, IT support, and office equipment.	Hausberg and Korreck, 2020, Wonglimpiyarat and Jarunee, 2016
Business Assistance	Providing mentorship, training, and consultancy services to help startups grow.	S. M. Hackett and Dilts, 2004, Mas-Verdú and Roig-Tierno, 2015
Networking Opportunities	Facilitating connections with potential investors, partners, and other entrepreneurs.	Hochberg et al., 2015, van Rijnsoever, 2020
Access to Funding	Helping startups secure funding through venture capital, angel investors, and grants.	Hausberg and Korreck, 2020, Hochberg et al., 2015
Technical Support	Offering technical components and expertise to assist with product development and innovation.	Colombelli et al., 2019, Wonglimpiyarat and Jarunee, 2016
Legal and Regulatory Assistance	Providing support with legal issues, intellectual property, and regulatory compliance.	Hausberg and Korreck, 2020, Mas-Verdú and Roig-Tierno, 2015
Market Research	Assisting startups in understanding market trends and customer needs.	S. M. Hackett and Dilts, 2004, Wonglimpiyarat and Jarunee, 2016

Table 5. Documented Services Provided by Incubators

Stokan et al., 2015). Incubators maintain their operations for extended periods employing a combination of revenue-generating strategies. One approach is to take equity stakes in the startups they support. Typically, incubators claim 3-10% equity, aligning their financial success with that of the startups. This model allows the incubator to benefit from future growth and exits, such as acquisitions or IPOs (Muegge, 2019; Sivasubramanian and Thomas, 2023). In addition, incubators often rely on government grants and public funding to support early operations, especially in regions where innovation is prioritized as an economic driver (Muegge, 2019; Sivasubramanian and Thomas, 2023). Corporate sponsorship and partnerships are another revenue source, offering financial backing in exchange for early access to innovative startups (Sivasubramanian and Thomas, 2023). Finally, service fees for office space, equipment, or other resources provide a steady, though smaller, stream of revenue, allowing the incubator to cover its operational costs while maintaining its focus on long-term startup development (Clark, 2004).

2.5 Incubation Models

The following section presents the existing technical incubator models discussed in the literature, which aim to analyze incubation processes (Bhaskar and Phani, 2018; Chen and Wahid, 2024). By reviewing these models, this section addresses the second sub-question of the research. The insights gathered in this section will then be compared with the findings of the case studies to assess whether and how the needs of DT startups differ from the services currently provided by incubators.

The article by Bergek and Norrman, 2008, represents one of the first documented incubation models and has been cited more than 1800 times. The article has been deemed a strong incubator model by Flanschger et al., 2023. The framework of Bergek and Norrman consists of three main phases: Pre-incubation, Incubation Process, and Post-incubation. Pre-incubation, referred to as the "idea hatcher", focuses on the early assessment and refinement of ideas, where incubators employ a "survival-of-the-fittest" approach to filter and prepare appropriate concepts for further development. Although Bergek and Norrman's framework provides a thorough overview of the incubator process, the specific aspect of 'venture selection' falls outside the scope of this study. This limitation functions as a filter for assessing the relevant incubator frameworks for this study. The primary focus here is on the methods adopted by incubators to help start-ups.

The incubation process is the core stage where ventures receive support, referenced in the literature as intervention, resources, or enabling factors depending on the theory used (Crișan et al., 2019; Lose, 2021; Soetanto and Jack, 2016a; Sohail et al., 2023; Thursby and Thursby, 2018). A model depicting the incubation process is given in Figure 9. In its simplest form, this framework is based on CIMO theory. The model highlights the key interventions used by technology incubators and university technology transfer offices to facilitate the commercialization of knowledge and the growth of startups. The model includes interventions such as selection criteria for program entry, networking support, infrastructure provision, and training or coaching to assist with knowledge appropriation and transfer.

Based on the theory used by the literature, the components of incubator service are categorized into tangible and intangible factors (Lose, 2021; Yusubova et al., 2019), as shown in Table 6.

Both types of components are important but contribute to different aspects of a startup's growth. Tangible services, such as access to office space with internet

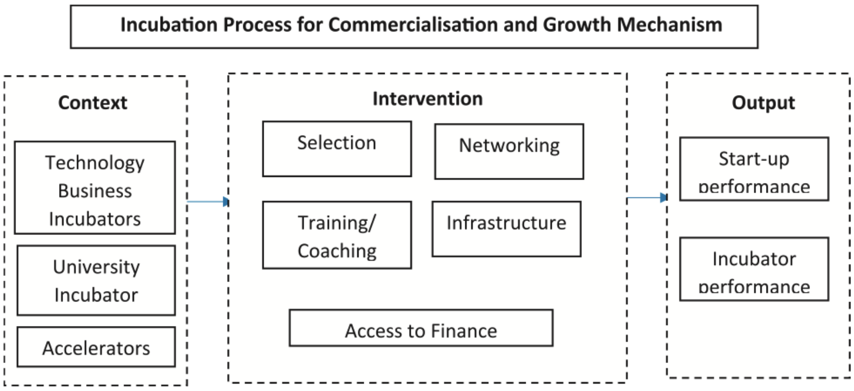

Figure 9. Incubation Process Model for tech start ups (Sohail et al., 2023)

Table 6. Incubator Support for Components Needs

Component Needs	Incubator Support
Tangible Components	Physical capital (office space, labs, etc.) Financial capital (seed capital, access to investors, etc.)
Intangible Components	Knowledge (technical & business knowledge, mentoring, coaching, etc.) Social capital (facilitates the creation of external & internal networks, etc.) Legitimacy (association with an established incubator, university with a proven track record, etc.)

services or specialized lab spaces, are straightforward and essential for startups. The rationale behind their necessity is clear—they help reduce operational costs, allowing startups to allocate resources to other activities, while intangible components often lead to long-term strategic advantages (Mohan and Chinchwadkar, 2022). Intangible support factors, which often come from outside the incubator, play an equally important role (Dagnino et al., 2016). The literature highlights that incubators, through their external networks, act as system builders (Stam, 2015; Van Weele et al., 2018a, 2018b). By orchestrating networks that would otherwise remain underdeveloped or even stillbirth without their involvement (Dagnino et al., 2016), they fulfill part of the intermediary role within innovation systems (Howells, 2006). Incubators have been described as brokers that connect startups with external actors who can provide valuable resources (Davidsson and Honig, 2003; Paquin and Howard-Grenville, 2013). The methods they use to facilitate this support are described in Table 7.

Most previous studies on incubation support focus on a single point in time, typically on the pre-start or launch stage (Soetanto and Jack, 2016b; Yusubova et al., 2019), and therefore overlook the fact that ventures' needs can vary significantly as they progress through different stages of development. Klaasa et al., 2019 addresses

Table 7. Incubator Support Mechanisms

Method	**Explanation**	**Citations**
Community-building	Deliberately connects incubated startups with each other to increase meeting chances and foster community within the incubator.	Van Weele et al., 2018b Bøllingtoft and Ulhøi, 2005 Hansen et al., 2000
Field-building	Introduces incubated startups to peers outside the incubator, enhancing opportunities for collaboration and knowledge sharing.	Amezcua et al., 2013 Bruneel et al., 2012 Eveleens et al., 2017
Peer-coupling	Increases the mating chances between startups by improving their ability to engage in relationships through workshops and coaching.	Niesten and Jolink, 2015 Van Weele et al., 2018b Schilke and Goerzen, 2010
Infrastructure support	Provides shared office space, facilities, and sometimes limited funding to reduce startup costs and free up time for seeking network partners.	Bruneel et al., 2012 Barrow, 2001
VC-networking	Acts as a network broker to introduce startups to VCs, increasing the likelihood of forming valuable relationships for investment.	Davidsson and Honig, 2003 Eveleens et al., 2017 Patton, 2013
Deal-making	Shortens the dating period between startups and VCs, speeding up the process of deal negotiations and increasing meeting chances.	De Clercq et al., 2006 Hallen and Eisenhardt, 2012 Malhotra, 2013
Business learning	Increases the attractiveness of startups to VCs through business knowledge transfer, mentoring, and consulting services.	Bruneel et al., 2012 Schwartz and Hornych, 2010 Rotger et al., 2012

this gap by developing a framework that adapts incubation models to the lifecycle stages of high technology startups, underscoring the importance of providing tailored support at each stage, as illustrated in Figure 10. This framework comprises three main stages: the bootstrapping stage, the seed stage, and the creation stage. During the bootstrapping stage, the focus is on building the startup's capabilities in business skills and knowledge. In addition, tech startups require a variety of support services, including mentorship, business advice, funding, and access to resources. The seed stage shifts attention to launching a new product, where mentorship, business advice, networks, funding, and innovation programs are crucial. Finally, the creation stage focuses on scaling the startup and expanding into global markets. Klaasa et al., 2019 highlights network building and funding as the critical support services during this stage.

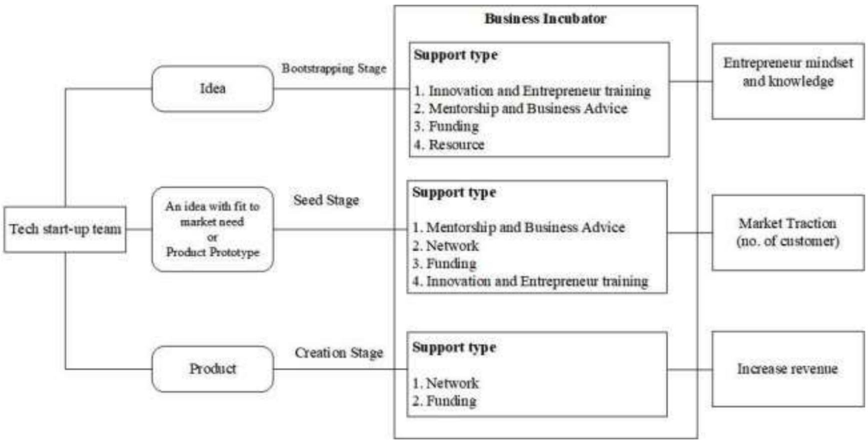

Figure 10. Framework focusing on incubation at each lifecycle stage (Klaasa et al., 2019)

2.6 Chapter Summary

In summary, the literature review highlights the distinctive nature of DT startups, particularly their need for specialized support and the prolonged, component-intensive development cycles they undergo. Unlike conventional startups, DT ventures face unique challenges, including technological complexity, extended time-to-market, and significant financial risks. These factors necessitate an incubation model that goes beyond traditional services. The literature review emphasizes the importance of specialized facilities, sustained funding, advanced technological knowledge, and strong university-industry linkages as critical components of support for DT startups. These elements are essential for navigating the VoD. Additionally, the review examines the roles of incubators in supporting startups, emphasizing the need for specialized incubation practices tailored to the specific demands of DT ventures. The chapter discusses various types of incubators and their services.

The incubation models outlined various incubator models and their roles in supporting DT startups, focusing on best practices for component allocation and proactive support. Key frameworks, including the comprehensive model by Bergek and Norrman, are discussed. Other frameworks, such as those by Marcon, Klaassen, and Rubin, highlight the need for tailored support at different startup lifecycle stages, leveraging both tangible and intangible components.

3 Theoretical Framework

Researchers have used various theoretical lenses to study the business incubation process. Table 8 highlights how the theory of incubation spans across multiple disciplines. However, much of the literature remains fragmented, often focusing on success stories and outcomes rather than cohesive theoretical frameworks, making much of the research atheoretical (S. A. Mian et al., 2016). For this study, the CIMO model serves as the best approach to developing an incubator framework, as illustrated in figure 9 of Section 2.5. The CIMO methodology aims to create prescriptive design proposition frameworks, such as the role of incubator context (country and incubator type), key driving mechanisms (purpose and vision), selection of the most suitable combination of interventions (services) and identification of the targeted outcomes depicting incubator performance (impact) (S. Cooper and Park, 2008).

The cases discussed in this research do not present the kind of abstract outcomes or results required for a full CIMO-based analysis, since the ventures have not yet been operational long enough to be able to make a clear measurement of outcomes. Instead, the theoretical framework will be developed within the context of incubators supporting DT startups. The intervention in this framework consists of service factors that align with the service components identified through the codification of the interview data. The mechanism refers to the positive relationship these services have with the needs of start-ups. This Theoretical model will provide a foundation for addressing Sub-questions 3 and 4.

Table 8. Theoretical lenses employed to study the business incubation process

Theoretical Lens	**Description**	**References**
New Venture Creation or Market Failure	The incubator compensates for perceived market imperfections, providing resources to mitigate the problems caused by inefficient resource allocation.	Bøllingtoft and Ulhøi, 2005
Resource-Based View (RBV)	The incubator as an organization providing a stock of tangible and intangible resources to client firms, which contributes to their development.	McAdam and McAdam, 2008; S. A. Mian et al., 2016; Patton, 2013

Continued on next page

Theoretical Lens	Description	References
Stakeholder Theory	Incubators act as bridging mechanisms to implement the interests of key regional stakeholders (e.g., triple helix, quadruple helix).	Etzkowitz and Leydesdorff, 2002; Mian and A., 1996
Structural Contingency Theory	Incubation mechanisms are configured to fit the external environment and tailored to local needs and norms.	Ketchen et al., 1993; Phan and Wright, 2005
Social Network Theory	Incubators increase client firms' external network density, hence facilitating social learning.	Hansen et al., 2000
Real Options View	Client firms are supported through a pool of available options, chosen based on the fit with the incubator strategy.	S. M. Hackett and Dilts, 2004
Dyadic Theory	An Interdependent Co-production Dyad, where incubation assistance is co-produced by both the incubator and the tenant entrepreneur.	Rice, 2002; Warren and Morse, 2009
Institutional Theory	The incubator's support mechanism, rules, and contracts offer a more structured approach to reducing uncertainty and risk, accelerating the incubation process.	Phan and Wright, 2005
CIMO Theory	The CIMO framework focuses on understanding how the context (C) and interventions (I) of an incubator influence the underlying mechanisms (M), which drive specific outcomes (O). This perspective highlights the importance of customized interventions based on contextual factors within the incubation process.	Denyer et al., 2008

Continued on next page

Theoretical Lens	Description	References
Virtual Incubation View	The incubator acts as a knowledge broker, offering information dissemination in the market space of ideas to develop innovative ventures.	Gans et al., 2003; Nowak and Grantham, 2000

In Section 2.3.1, the characteristics of DT startups are described and contrasted with conventional tech startups across various stages of lifecycle. The findings of the case study will also be contextualized according to their respective stages of lifecycle, as shown in Figure 10, based on the framework of Klaasa et al., 2019. Although this framework focuses on high-tech startups, for the purposes of this study, stages will be adapted according to the findings of Schuh et al., 2022, specifically including the early stage, R&D stage, growth stage, and the late stage.

The framework will enable categorization by placing services in tangible and intangible categories. Furthermore, the relationship of external actors to support services through the incubator will also be categorized according to the framework from Marcon and Duarte Ribeiro, 2021. Based on the suggestions of Hausberg and Korreck, 2020, the relationships between these service factors will also be analyzed, including whether their effects are positive or negative.

Based on table 5 the current incubator services found in the literature are summerized as:

- Shared office space and other physical facilities
- Shared support services (IT, admin, etc.)
- Business support: coaching, mentoring and training
- Access to the incubator's network
- Legitimacy and reputation

These points are then categorized in Table 9.

Table 9. Enabling Factors from Incubators

Category	Service Factor	Description	Lifecycle Phase	T/IT	Actor
Infrastructure					
	Office Space	Providing physical space for startups to work, including desks, meeting rooms, and other facilities	Early Stage	T	Incubator
	Shared support services	Access to shared IT, administrative, and other necessary services	All phases	T	Incubator
	Workspace	Having labs and appropriate work spaces for product development	All phases	T	Incubator
	Startup Ecosystem	Having startups located in close proximity, fostering connection and transfer of knowledge	Early phase	T	Incubator
Financial					
	Network	Helping startups secure funding through venture capital, angel investors, and grants	Early & R&D stage	IT	Financial Advisors
	Mentorship	Consulting on how to approach investors for startups	Early Stage	IT	Incubator
	Seed funding	Small grants given to startups	Early Stage	T	Incubator
Technical					
	Support	Offering technical components and expertise to assist with product development and innovation	R&D	IT	Technical Experts
	Legal and Regulatory Assistance	Providing support with legal issues, intellectual property, and regulatory compliance	All Phases	IT	Legal Advisors
	Market Research	Assisting startups in understanding market trends and customer needs	Growth	IT	Market Analysts
Human					
	Business support	Mentorship provided to incubatees for business growth	All Phases	IT	Mentors, Coaches, Trainers
	Networking Opportunities	Facilitating connections with potential partners, and other entrepreneurs	All Phases	IT	Network Partners

Matching with the Theoretical Framework

Table 9 is visualized using the concept map illustrated in figure 11. The framework consists of nodes (boxes) depicting support factors and arrows depicting the direction of the relationship between the concepts. The findings from the interviews will refine this model and indicate whether more factors need to be added and if the relationship has a positive or negative effect.

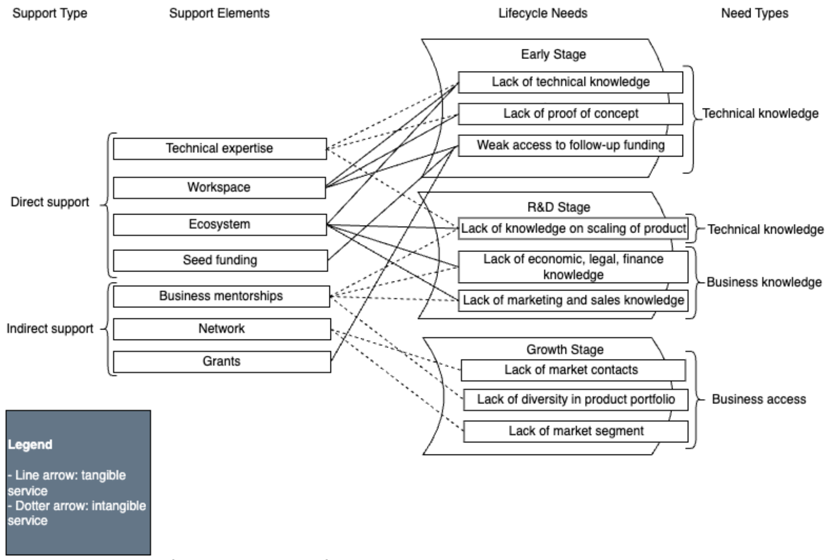

Figure 11. Theoretical framework for incubator support mechanisms based on the literature review

4 Methodology

In the previous chapter the incubation support factors found in the literature review are placed into a framework. The aim of following chapters is to build on this framework and explore support mechanisms from incubators for DT startups. This chapter describes and justifies the research methodology adopted for the aim of this study.

In this study, a qualitative research approach is adopted to explore how DT startups experience the incubation process, aiming to gain insights into the support mechanisms they require. Qualitative research is particularly suited for this investigation as it allows for an in-depth understanding of complex phenomena within their real-life contexts (Yin, 2009).

4.1 Case selection

A multiple-case study design is used, focusing on several DT startups to capture a diverse range of experiences and perspectives. This approach facilitates the identification of patterns and themes across different cases, enhancing the robustness of the findings (Eisenhardt, 1989).

DT startups provide a valuable environment for examining incubator support mechanisms, as they often involve a combination of high uncertainty, time constraints, and a strong drive for innovation (Grimaldi and Grandi, 2005). The selection focuses specifically on DT startups that have undergone an incubation period, particularly those that have faced the challenges of the VoD, where adjustments to critical decisions or external support are frequently required (Oakey, 2003).

Only startups that have recently completed incubation and thus reflect current support mechanisms will be considered. Interviews will be conducted with either a co-founder or an employee to gather detailed accounts of their experiences. In this study, these startups will be referred to as “cases”.

The case selection criteria include: 1) origin in the Netherlands, 2) completion of an incubation period, 3) at least one round of investment to indicate sustainability, 4) willingness to participate in the study, and 5) ability to provide access to rich data.

Table 10 lists the cases that were contacted for the aim of this study. In total, eighteen DT startups have been contacted. The response rate was too low in the beginning. Follow-up emails were sent to increase the number of cases, but due to time constraints, seven case studies responded and were chosen for this study. One case was excluded because while the startup was registered as DT, it did not meet the criteria of this study to be considered as such. The DT startups were selected from different sectors. The common denominator in five of the six startups is that they went through YesDelft! incubator (in addition to other incubators). While the other startup was part of a deep tech venture in the Netherlands.

Table 10. Selected DT Companies

Company Name	**Details**
Vibrotwist	Qualifies as Deep Tech: Yes Industry: Robotics Incubated: Yes Years Active: 2 years (2022)
SoundCell	Qualifies as Deep Tech: Yes Industry: Medical Devices Incubated: Yes Years Active: 3 years (2021)

Company Name	Details
IMSystems	Qualifies as Deep Tech: Yes Industry: Robotics Incubated: Yes Years Active: 8 years (2016)
A-Spax	Qualifies as Deep Tech: Yes Industry: Aerospace Incubated: Yes Years Active: 5 years (2019)
Lightyear	Qualifies as Deep Tech: Yes Industry: Renewable Energy Incubated: No Years Active: 8 years (2016)
Battolyser	Qualifies as Deep Tech: Yes Industry: Energy Storage Incubated: Yes Years Active: 6 years (2018)

4.2 Data Collection

This study specifically employs semi-structured interviews as the primary method (Yin, 2018). This method provides flexibility to explore specific areas of interest while maintaining consistency across interviews (Yin, 2009). The aim of data collection is to systematically investigate the subject, following the method outlined in Table 11.

Table 11. Main Steps in the Data Collection Process

Step	Description
Preliminary Investigation	Conducting initial research through internet searches and websites.
Case Selection	Establishing criteria for selecting cases.
Initial Contact	Sending emails to potential participants to introduce the study and request their involvement.
Interviews	Conducting interviews focusing on key aspects like startup evolution, challenges, milestones, and business model elements.

4.3 Interview Guideline

The interview conducted with the startups needed to follow the guidelines of a exploratory study. It is important that there are no guided questions and that the information received from the interviewees is a experience(Yin, 2003). From this experience themes are selected and coded into categories.

Table 12. Questions

Category	**Questions and Scope**
Growth Stages	What process did you go through from idea conception to sustainability? Explore the startup's journey from inception to sustainability.
Opportunity Recognition	How did your commercial thinking evolve over time? Trace the evolution of business acumen and market adaptation.
Entrepreneurial Commitment	How did you develop your entrepreneurial skills throughout your journey? Explore the learning curve and skill acquisition during the startup journey.
Credibility	How did you attract initial funding and investment? Understand the strategies used to gain credibility and secure financial backing.
Technological Risk	How did you address the high technological complexity in your product or system? Explore how technological challenges were managed.
Hurdles Along the Path	What were the major hurdles you faced along the journey, and how did you overcome them? Identify key obstacles and the strategies employed to navigate them.
Incubator Experience	How did the incubator contribute to your success, and what support was most valuable? Explore the incubator's role in providing resources, guidance, and networking.

4.4 Data Analysis

The interviews are transcribed using transcription software (with explicit permission from the interviewee). The transcription is then checked manually and observations are coded.

Each case analysis adopts a structured approach, capturing the unique challenges, opportunities, and components encountered throughout each startup's growth journey. The analyses begin with an interview overview, highlighting key aspects relevant to the research. Components are classified as tangible (T) or intangible (IT) and summarized in a table to provide a cohesive overview of the findings, using a coding system outlined below. By categorizing the internal and external components, the analysis offers a holistic view of the core needs of DT startups. The coding themes are based on the method outlined by Yusubova et al., 2019, as it provides a framework focused on incubator support factors.

- **BA - Business Access**: Refers to the startup's ability to connect with key industry players, investors, or partners. This could include gaining credibility with suppliers or potential customers.
- **BK - Business Knowledge**: Relates to the knowledge needed to navigate the business landscape, including developing pitches, aligning products with market needs, or planning funding strategies.
- **F - Finance**: Indicates the financial resources available or required, such as funding for R&D, employee wages, or scaling production.
- **TK - Technical Knowledge**: Represents access to specialized technical expertise, particularly in R&D or when transitioning to production stages.
- **T / IT - Tangible / Intangible**: Specifies whether the component or resource is a physical asset (e.g., labs or equipment) or a non-physical asset (e.g., knowledge or relationships).
- **+ - Positive Influence**: Indicates that a particular support element had a beneficial impact on the startup.
- **= - No Influence**: Denotes that the presence of a certain factor or resource did not notably impact the startup's progress.

4.5 Ethical Considerations

Throughout all stages of the study, ethical issues will be considered. Participants in the interview were informed about the goal and scope of the research and their express permission was acquired before involvement. Strict confidentiality rules were followed to guarantee anonymizing all personal information and replies. This consideration of moral research methods safeguards participants' rights and privacy, therefore strengthening the validity and confidence in the results of the study.

4.6 Ensuring Validity and Reliability

Validity in case research is defined by three dimensions, according to Voss et al., 2002 and Yin, 2003: construct validity, internal validity, and external validity. Construct validity was addressed through several means. Firstly, a theoretical framework was developed to ground the study and data collection. Additionally, all participants had experienced incubation to avoid misconceptions or confusion.

External validity was ensured during the research design by conducting multiple case studies following a replication logic (Yin, 2003). Cross-case analyses were performed to strengthen the generalizability of findings. For internal validity, during data collection, interviewees were asked to explain which actors participated in each lifecycle phase and how they impacted startups' innovation, thereby establishing cause-effect relationships (Voss et al., 2002). After the interviews, participants were debriefed and asked to correct potential misunderstandings. During data analysis, pattern matching was applied as recommended by Voss et al., 2002.

Reliability was achieved through the development of a case study database and the use of a case study protocol for data collection. Each startup received a report of the findings for validation. Regarding intercoder reliability, instead of applying a quantitative measure, the researcher performed independent analyses as outlined by Benitez et al., 2020 and Goffin and Mitchell, 2019. Codifications from initial interviews were, when possible, discussed in follow-up interviews with other respondents to ensure unbiased interpretations and a shared understanding.

Finally, following Campbell et al., 2013's recommendations, challenges related to discriminant capability were addressed. Discriminant capability focuses on coders' ability to categorize text content unambiguously in complex coding schemes. To reduce coding complexity, cases were coded once if they pertained to the creation phase and twice for the R&D phase. In the latter, the first coding focused on the creation phase, and the second on the development phase. This recoding technique reduced cognitive load and minimized potential bias or errors during the coding process.

5 Research Results

In this section, we explore a selection of DT startups, drawing insights from semi-structured interviews with representatives from six different startups. Each case analysis begins with an introduction to the startup, providing context and background. The analysis then identifies and describes the specific needs of the startup, incorporating relevant excerpts from the interview transcriptions when they provide valuable support. The key codes derived from the analysis are highlighted in bold and systematically compiled into a table presented at the end of each case study.

Vibrotwist

Vibrotwist focuses on revolutionizing vibration control and stabilization technology for offshore structures. Founded in 2022 by a TU Delft PhD candidate with extensive experience in engineering and the offshore industry, the company aims to address the limitations of traditional systems with innovative smart materials. Its prototype improves stability and sustainability for offshore structures, offering a cutting-edge solution for harsh marine environments.

The cofounder had difficulty planning the time needed to overcome obstacles in the DT startup journey.

"In theory a obstacle is very different than in reality, especially the element of time" **(Vibrotwist, cofounder)**

The technical hurdles, took much longer to overcome. The step from theoretical to being able to have a working model and applying it had unforseen issues **(BK+, R&D stage)**. For example, find a supplier to customize a needed part. Even with the cofounder network, getting ahead in the supplier order list took much longer than expected, because the needed customization was complex **(BA+, R&D stage)**. The self funding was sufficient to cover the costs of funding the research, but with the prolonged time, funding was needed to pay the salary wages of the small team **(F+, Growth stage)**.

The grants gave Vibrotwist breathing room to continue operations. The cofounder had difficulty reaching investors. Highlighting that he missed the knowledge on how to present the need for a complex technology to investors or partners **(BK+, R&D**

stage). Although Delft Enterpises facilitated seminars and courses for business know-how, this was geared toward startups dealing with a product for which there is straightforward application.

"While I knew that you could apply for grants, I was not aware of the criteria needed, nor how to best present myself and the idea to be eligible for such a grant. Delft Enterprises helped me with the negotiations of the deal terms" **(Vibrotwist, cofounder)**

Vibrotwist had a vision that did not necessarily align with the customer needs, pivoting this vision to market expectation was a need **(BK+, Early stage)**. while YesDelft! supplies the service of startup courses, these are best aligned with software, or tech that is readily commercialized.

"Delft Enterprises gave me access to business courses offered by YesDelft! which were geared toward tech startups. However, the information was trivial. I already knew how to set up a business plan or how a balance sheet works." **(Vibrotwist, cofounder)**

Vibrotwist started during the Covid. This also made it difficult to gain credibility **(BA+, Growth stage)** and hindered getting a suitable partner for testing.

The support of access to a network of industry contacts **(BA+, R&D stage)**, establishing credibility, and facilitating needed crucial connections could have accelerating development for Vibrotwist during the pandemic. The last obstacle which also stemmed through the pandemic was finding employees **(TK+, Early stage)**.

"It was very difficult to find the right people to help us move forward. We needed people specialized in the field that believed in the vision of the company. Even though we secured the additional HER+ subsidy, we could not afford the full time wages of specialized employees. Especially not through the Covid pandemic. Delft Enterprises tried publishing vacancies with our requirements, but this was not sufficienct to attract talent." **Vibrotwist, cofounder**

At the time of the interview, only the cofounder was actively involved in Vibrotwist, which was in the product development phase. The company has secured a partner and garnered interest from a potential client, but still faces challenges in overcoming technical hurdles. The cofounder noted that as they approached a viable prototype, their funding needs also increased. In fact, the required investment has tripled compared to when they first started at Delft Enterprises, primarily because of the cost and expertise associated with bringing the product closer to validation.

Table 13. Analysis Vibrotwist

Need Type	Need	T/IT	Lifecycle phase
Business Access	Lack of access to suppliers	T	R&D phase
	Lack of credibility	IT	R&D stage
	Lack of industry partner	T	R&D stage
Business Knowledge	Lack of visibility	IT	Early phase
	Specific pitch presentation for DT	IT	Early phase
	Lack of market alignment	IT	Early stage
Finance	Lack of funding for wages.	T	R&D stage
	Lack of funds for prototype adhering to validation standards	T	R&D stage
Technical Knowledge	Lack of employees (mechanical engineers) with specialized expertise	T	Early phase, R&D phase

Soundcell

SoundCell is a start-up in MedTech in Delft, specializing in the rapid diagnosis of bacterial infections to improve the precision of antibiotic prescriptions. Founded in 2022, the company has developed a technology that uses graphene, a two-dimensional material, to measure the nanomotion of single bacterial cells. This approach allows for the determination of antibiotic sensitivity in just a few hours, significantly faster than traditional methods that can take several days. Soundcell has been part of the incubator YesDelft! since the company started.

Soundcell benefited from internal networking and highlighted the importance of maintaining motivation during their DT journey. This need for ongoing inspiration was addressed by Yes!Delft, which strategically co-located DT startups within the same facility. By creating a collaborative startup ecosystem, Yes!Delft fostered an environment where being in the same space enables startups to support each other, helping to sustain their momentum. On the topic of network, the cofounder did express the need to have access to a more specialized network **(BK +, early stage)**.

"Being surrounded in a building and physically having access to other DT startups that have gone through VoD and can share experiences and give guidance is a great motivator to continue believing in your vision." **Soundcell, cofounder**

The cofounder also noted that, given the complexity of their technology, the technical expertise of an incubator would probably not have significantly accelerated development for DT startups **TK=, R&D stage)**.

Initially, Soundcell started with just the founders, the external network access from YesDelft! helped them grow the team to nine members by 2023 **(BA+, R&D stage)**.

"Yes, tripled from two people and now we are nine. They helped us find the talents. The talents were quite helpful." **(Soundcell, cofounder)**

Financially, Soundcell secured early-stage investments in September 2022. Although Soundcell did not need help to directly assist in securing grants, the incubator played an important role in developing Soundcell's pitching skills, needed to attract investment **(BK +, early stage)**. Moreover, YesDelft! facilitated investor rounds, where startups like Soundcell had the opportunity to connect with potential investors **(F+, Early stage)**.

Soundcell realized the importance of customer visibility as they advanced in developing their technology. Although they were invested in refining their technology, they faced challenges in translating it into a format that met customer expectations, particularly in hospitals. Although their solution offered a strong value proposition, Soundcell learned that their customers prioritized simplicity and ease of integration over complex usability. During the 2023 testing phase, when Soundcell finally connected with a client, concerns were raised about the system's usability and compatibility. The hospital emphasized the need for the operating system to be Windows-based to ensure seamless integration with existing systems and requested a simplified interface that could be easily used by any staff member with minimal instruction. This feedback highlighted the importance of not only focusing on technological advancements, but also ensuring that the end product is user-friendly and adaptable to the customers' operational environments **(BK+,**

R&D stage).

YesDelft! provided Soundcell with a dedicated space to develop their prototype. However, while the space was useful, it did not fully meet the needs of a MedTech startup. If the facility had been equipped with specialized MedTech appliances, such as cleanrooms, sterilization equipment, or advanced 3D printers, it would have helped overcome VoD. Having a facility already equipped with these components would have meant fewer logistical hurdles, less costs, and faster progress **(T+, R&D stage)**.

"Setting up a cleanroom or getting access to 3D printers was something we had to figure out early on. If you already have those components in place, it can really accelerate your progress." **(Soundcell, cofounder)**

Table 14. Analysis Soundcell

Need Type	Need	T/IT	Lifecycle phase
Business Knowledge	Lack of specialized ecosystem	T	Early phase, R&D phase
	Lack of customer alignment	IT	Early phase
Business Access	Received access to personnel qualified with expertise	T	R&D phase
	Lack of access to custom labs	T	R&D stage
	Lack of industry partner	T	R&D stage
Finance	Lack of funding for wages	T	R&D stage
	Lack of funds for prototype adhering to validation standards	T	R&D stage
Technical Knowledge	Lack of employees (mechanical engineers) with specialized expertise	T	Early phase, R&D phase
Infrastructure	Lack of access to custom labs	T	R&D phase

IMSystems

IMSystems is a DT company that specializes in the development of high-precision transmission systems that are focused on revolutionizing the traditional gearbox industry. Founded as a spin-off from Delft University of Technology, the company is known for the Archimedes Drive, a transmission system that is capable of significant improvements in efficiency, precision, and reliability over conventional gearboxes. IMSystems gears its application towards the robotic industry.

MSystems was founded in 2016 by a team of four who connected through entrepreneurship courses at Delft University, sponsored by the Yes!Delft incubator. There, they encountered patents and, through market research, developed a business plan, realizing the potential of gear technology. Yes!Delft also facilitated connections with angel investors, which helped them get started **(EF+, Early stage)**.

"YesDelft! facilitated angel investors. Got us started and on the right track." **(IMSystems, cofounder)**

The team was well balanced, with each member bringing specialized expertise to the table. YesDelft! played a important role in the early stage of IMSystems by offering guidance on navigating the startup landscape **(BK+,ES)**. The support from YesDelft! helped IMSystems craft a business plan and provided assistance in preparing their pitch for the first round of investment.

"YesDelft! was good kind of in terms of forming an initial structure of the company." **(IMSystems, cofounder)**

In mid-2016, IMSystems entered the R&D stage and recognized that their customer base would primarily come from the robotics sector. To better align with this market, they chose to relocate to RoboValley, a hub specializing in robotics innovation**(BA+, R&D stage)**.

"One of the critiques we had about YesDelft! is that, although it is a university-affiliated incubator, it's still very broad. It caters to everyone from the university—whether you're developing an app, designing glasses or headphones, or even working on quantum computers. It covers a wide spectrum of tech but doesn't focus on any specific field. In contrast, Robo Valley was specialized in robotics, which is exactly the area we were moving into. This specialization, along with its extensive industry connections, made RoboValley a better fit for us." **(IMSystems, cofounder)**

RoboValley, now known as Robohouse, is an accelerator specialized in robotics and AI. A typical accelerator, functions as a fast track growth program for startups to provide them with mentorship, funding and components in a short-term time frame, usually lasting 3 to 6 months (Cohen and Hochberg, 2014). Yet, IMSystem remained in the Robohouse program for 3 years **(TM-, R&D stage)** before moving to their own office in The Hague. Robohouse was specifically useful for making connections with the industry.

IMSystems faced challenges in gaining traction with suppliers for parts.

"The problem in the early stages, we would go to one of our suppliers, Hong Kong gear. It's a high precision gearbox manufacture and we ask can you make five of these parts? And can we have it by next month? It already takes months to get recognized as a client let alone to begin production" **(IMSystems, cofounder)**

As explained by the cofounder, in his experience, establishing credibility **(BA+, R&D stage)** for DT companies is essential to ensure that their requests are prioritized by suppliers, which often deal with highly complex and expensive components and have a long list of orders.

It wasn't until 2020 that IMSystems had a fully functional gearbox that could be tested for durability, marking their first significant positive performance results. Before then, they had no commercial product. The only way they managed to survive this period and focus on their technology was through securing funding **(F+, R&D stage)**.

"To bridge over the VoD for 4 to 5 years of DT R&D, where you don't have a commercial product, you need a substantial amount of funding that is not typical in the startup environment." **(IMSystems, cofounder)**

The cofounder also mentioned that during their journey, they realized that while securing investments is a well-known necessity in DT **(BA+,R&D stage)**, finding the right investors is also important. Unlike conventional tech, where investors often seek quick returns, DT requires a longer timeline, making it challenging to attract investors who understand and are committed to the extended development process.

"You also need to find the right investors because most investors are looking for quick returns. They want to invest in your company and see a return in two or three years. But for us, we needed investors who were in it for a longer period. It's not about getting a return in two or three years; it's more like five to ten years before

they actually see any return on their investment." **(IMSystems, cofounder)**

When asked to elaborate on the investor landscape for this magnitude of investment and how it differs from earlier-stage funding, the cofounder mentioned Series A investment rounds. Series A investments typically range from $2 million to $15 million (Club, 2021). According to the cofounder, such investments are common for DT startups in the R&D stage, as they are needed to fund the complexity of development, including components and, most critically, the wages of the team in this phase. These investments usually expect a return over a period of 5 to 7 years. The most common return-on-investment method in Series A rounds is equity (Failory, 2024). The cofounder explains that you would need to travel to the specific hub of the industry to get these kinds of investment. In the case of IMSystems, frequent trips must be made to Japan, a pioneer in the robotic industry.

The cofounder concluded the interview by outlining his vision of an ideal incubator, shaped by his experiences and the challenges faced in acquiring customers. He stressed the importance of an incubator that not only has strong industry connections, but also has a deep understanding of the specific sector in which the startup operates **(TK+, Early + R&D stage)**. In the case of DT, the primary challenge is demonstrating its potential to customers. Test cases are crucial, yet often, as seen with IMSystems, potential customers have not developed products that require the new technology. The ideal incubator would recognize this gap and still connect the startup with customers engaged in cutting-edge applications **(BA+, R&D stage)**. Moreover, access to specialized facilities and equipment would help reduce development time. The incubator should also have the expertise to assist DT companies in pivoting when necessary, such as guiding them toward consulting through their IP to sustain development during extended R&D periods **(IP+, Early stage)**. To offer this level of support, the incubator must be highly specialized and have in-depth industry knowledge.

Table 15. Analysis IMSystems

Need Type	**Need**	**T/IT**	**Lifecycle stage**
Business Knowledge	Need guidance in how to navigate the startup landscape	IT	Early stage
Business Access	Need to have access to customer	IT	R&D stage
	Need access to suppliers due to credibility	IT	R&D stage

Need Type	Need	T/IT	Lifecycle stage
	Need access to investors willing to dedicate themselves on a long trajectory, without proof of product	IT	R&D stage
Finance	Needs funding for wages	T	R&D
	Needs funding for travel	T	R&D
	Needs funding for production	T	R&D
Time to market	Does not function well with short acceleration programs	IT	R&D
Technical Knowledge	Need environment that is specialized in specific industry	IT	Early phase, R&D
Infrastructure	Need access to university labs for the latest academic research and technology	T	R&D
IP	Need aid in overcoming the slow length of IP process	IT	Early stage

A-Spax

A-Spax, also known as Affordable Space Access B.V., is a Dutch aerospace company based in Delft. The company focuses on enabling in-space manufacturing and research by providing infrastructure for experiments and production in microgravity environments. A-Spax's key innovation is their Climate Box, a system designed to maintain optimal environmental conditions for manufacturing processes in space, such as fiber optic production. This system is integrated into commercial space stations and features precise temperature and pressure control to enhance production efficiency. Additionally, A-Spax is working on a reentry spacecraft that will safely bring payloads back to Earth after space-based production. The company collaborates with various space industry partners and has been recognized among Europe's top DT startups.

A-Spax was founded in 2019 by a team of engineers, led by its cofounder, who is featured in this interview. The company's main mission was to develop reusable rockets. The founders recognized the importance of being located physically in a aerospace environment and achieved this by relocating to Delft, a key hub for aerospace technology **(BA+, Early stage)**.

"At the time when we first started, we felt we were missing the energy of being around other startups with similar goals. That's why we made the decision to move to Delft, which is a major hub for aerospace." **(A-Spax, cofounder)**

Through the Aeorspace Incubation Center, A-Spax received affordable office space **(BA+, Early stage)**. The founders did not need external investment in the early stage because they could finance the venture themselves and the focus was solely on developing the technology **(F=,Early stage)**. The incubator did provide networking opportunities, voucher and coaching programs. A-Spax also received mentorship from experts, including CEOs of other aerospace companies **(TK+, Early stage)**. Most important was that through the guidance received from the incubator, A-Spax realized that they needed to pivot from their original idea **(BK+, Early stage)**.

"Being part of the Aerospace Incubation Center gave us exposure to the latest developments, which inspired us to make a large pivot." **(A-Spax, cofounder)**

The pivot led to the development of a climate box in 2022. Although A-Spax received funding in the form of incubator vouchers, they were mostly self-funded. However, the cofounder emphasized the importance of securing alternative funding in DT **(F+, R&D stage)**.

"And yes, incubator, played a role. So we received money from the TU Delft incubator. The Aerospace Innovation Hub. It was a small amount. Securing just one investment is not enough. Especially for DT companies." **(A-Spax, cofounder)**

The cofounder noted that during production, they did not encounter any development issues related to waiting on external factors, such as suppliers, due to their credibility.

In 2023, A-Spax was recognized as one of the top 100 DT startups in Europe by DT Momentum, a specialized bootcamp aimed at accelerating early-stage startups in the DT sector. This program connected A-Spax with different inventors **(BA+,R&D stage)** enabling A-Spax to accelerate operations for its re-entry capsule.

Throughout 2023, A-Spax encountered various challenges, particularly in the area of financial sustainability. The cofounder mentioned that the company required financial and legal expertise for short-term projects. However, the need was not substantial enough to justify hiring full-time employees in these areas. As a solution, they sought part-time advisors, but given the company's small size and limited credibility, it was difficult to secure advisors for extended periods. This added another layer of complexity to the company's growth during this stage **(TK+,R&D stage)**.

"Ultimately, getting experts to commit long-term was a big challenge for a small team like us." **(A-Spax, cofounder)**

Although A-Spax chose not to patent their technology in order to remain concealed from the market, the cofounder highlighted the often overlooked challenges that startups face when it comes to trademarking **(IP+, Early stage)**.

Currently, A-Spax is working to pivot its company direction. The cofounder highlighted the challenges of leading an inexperienced team that relies solely on investment rounds, without a clear commercialization strategy or actual customers. He also emphasized the company's specific needs when it comes to working with incubators.

*"We faced two major challenges: securing funding and establishing credibility **(BA+,R&D stage)**. As a young and inexperienced team, it was difficult to gain the trust of investors, even though we had solid ideas. Funding was a constant struggle to sustain us long-term. To address the credibility gap, we brought in two experienced advisors, one with business expertise and another with technical know-how, which helped us refine our strategy and boost our credibility. However, even with their support, the funding process was still challenging due to our limited experience, creating a cycle that slowed our growth."* **(A-Spax, cofounder)**

Table 16. Analysis A-Spax

Need Type	Need	T/IT	Lifecycle stage
Business Knowledge	Need check-ins to pivot early and stay aligned with the market	IT	Early stage
Business Access	Need to be in a ecosystem with startups from the same industry	IT	Early stage
	Need affordable office space	IT	Early stage
	Need to be connected to specialized personnel to accelerate operations	IT	R&D stage
	Need credibility qualified personnel on team to get credibility	IT	R&D stage
Finance	Need funding to sustain waiting phases, or pivot phases	T	R&D stage
Technical Knowledge	Need to get in contact with leaders from companies in the same industry	IT	Early stage
	Access to temporary personnel that has high expertise on the industry	IT	R&D stage
	IPNeed support with IP setup	IT	R&D stage

Lightyear & PhotonDelta
The following interviewee brings a combination of experience as a cofounder of the DT startup Lightyear and as a fund manager for an ecosystem builder specializing in DT startups focused on integrated photonics.

Lightyear is a DT company based in The Netherlands, focused on solar-powered electric vehicles. Founded in 2016, Lightyear aims to integrate advanced solar technology directly into its cars, allowing them to charge from sunlight and significantly extend their range. They were able to produce two vehicles, flagship 0 and flagship 1.

PhotonDelta is a Dutch foundation and ecosystem builder focused on advancing integrated photonics. Invest in early-stage companies to help develop and commercialize photonic chips, working closely with hardware accelerators and venture builders like HighTech XL to create ventures leveraging this technolog. PhotonDelta differs from traditional incubators in that it focuses on investment and ecosystem growth rather than direct mentorship or components.

The cofounder's journey began in 2013 when he participated in the World Solar Challenge, where he was responsible for the battery management system. Afterward, he pursued a master's degree and, in 2015, while working in ASML's power electronics department, the Volkswagen Emission Scandal occurred. This scandal caused frustration, as it highlighted the lack of interest in alternative technologies such as solar powered cars to address emissions issues. This frustration sparked the idea for Lightyear, and the cofounder eventually took on the role of CFO.

Lightyear joined an incubator to help them develop a business plan tailored to investors and scale up their operations **(BK+, Early stage)**. However, their time in the incubator was short-lived. In 2017, they were approached by HighTechXL, a DT venture builder (explained in section 2.4), which was then in its early stages as an incubator. Despite the opportunity, the team chose not to join due to the equity stake HighTechXL required **(BK+, Early stage)**.

"My experience is mixed. Sometimes it works. It really depends on what the value proposition is of the incubator, but also the ambitions of the startup. In the beginning of Lightyear we joined an incubator, the workshops helped with giving us perspective." **(cofounder & Fund Manager))**

In the years following 2016, Lightyear made enough investments to grow the company to 120 employees. However, the automotive industry had a lack of enthusiasm. In early 2023, lightyear faced a shortfall of 10-15 million euros, which was crucial for implementing the final testing and validation of the cars **(F+, Growth stage)**. This lack of funds prevented them from bringing the car to the market. Currently, Lightyear is still active, but in a very small form with less than 20 employees.

The cofounder highlights financial sustainability as the most critical need for DT startup success. Reflecting on VoD, he emphasizes that cash flow is key to navigate through this challenging phase **(BK+, R&D stage)**. He further explains that the current issue with incubators is their inability to solve the VoD problem. Instead of helping startups overcome it, they simply identify the stage of the VoD the startup is in **(BK+, R&D stage)**, without providing the financial support needed to bridge the gap.

In 2020, the cofounder stepped down from the CFO role. He then joined PhotonDelta as a fund manager.

During his time at PhotonDelta, he had the opportunity to work with many DT startups in the photonics industry. The cofounder then turned fund manager emphasizes that DT startups require patience, access to high-risk capital **(BA+, R&D stage + Growth stage)**, and a strong appetite for risk. He believes that it is better to fail early and pivot, rather than commit to investments for several years before realizing that you are heading for bankruptcy **(BK+,Growth stage)**.

"The worst thing for a startup, and this happened to Lightyear, is to get halfway through the Valley of Death, and then the money runs out. That just makes the Valley even deeper because you are scrambling for plan B, plan C, talking to more and more investors, which takes time and focus away from the actual product development." **(cofounder & Fund Manager))**

The fund manager explains that many DT startups tend to be technology-driven 'push' companies, focusing on their innovations rather than aligning with the actual solutions the market needs **(BK+, R&D stage)**.

"90% of the time, DT tends to be IP- or hardware-driven, pushing technology with the mindset 'I have the solution, now let's find the problem'. Ideally, incubators should have stable connections with industry, markets, and real-world problems. They should be able to properly identify problems that can be solved with hardware, so DT companies can develop their solutions based on that knowledge and experience. There is an element of expertise needed to understand what companies have on their roadmaps and how they can get closer to their customers." **(cofounder & Fund Manager))**

Table 17. Analysis Lightyear & PhotonDelta

Need Type	Need	T/IT	Lifecycle stage
Business Knowledge	Needed support in planning business plan tailored to investors	IT	Early stage
Business Access	Need partner models that do not involve equity	IT	Early stage
	Need qualified personnel on team to get credibility	IT	R&D stage
	Need access to investor strategy models that offer a positive cashflow	IT	R&D stage
	Need of active strategies to overcome VoD, instead of analysis on why in the VoD	IT	R&D stage
Finance	Need high risk capital investors	T	R&D stage, Growth stage
	Need to take early risks and pivot quickly, while having a confident plan for the long development trajectory	T	R&D stage, Growth stage
	Need of larger funding strategies for scaling for market production	T	Growth stage
	Need access to investor models that offer a positive cashflow	IT	R&D stage
Technical Knowledge	Need focus on aligning with market needs rather than pushing out technology and hoping for an application	IT	R&D stage

Battolyser Systems

Battolyser Systems was invented in 2018 by a team at TU Delft and is a hybrid technology designed to store electricity and produce hydrogen. This device (named Battolyser) combines the functions of a battery and an electrolyzer, allowing for flexible use depending on the needs of the energy grid. When there is a surplus of electricity, the Battolyser stores energy like a traditional battery, and when that storage is full, it can switch to producing hydrogen by splitting water molecules. This makes it an ideal solution for renewable energy systems. The Battolyser interviewee has the current role of a business developer. He has been with Battolyser systems since the beginning of 2018 and was the first employee hired. He will be referenced in the remaining of this analysis as BD.

The concept for Battolyser Systems originated from a professor at TU Delft within Delft Enterprises, as required by the university at the time. However, this association with Delft Enterprises was brief. Battolyser Systems continued as part of Proton Ventures (an established DT company specializing in ammonia), with whom the professor collaborated closely, leveraging their expertise and infrastructure **(BA+, Early stage)**. Although Delft Enterprises played a role in the early stages, most of the initial funding from the company came from private investors, supported by Proton Ventures. The conducted interview was with the second employee the company took on, now the company has grown to 120 employees.

"Battolyser Systems resulted through a power of networking and credibility" **(Battolyser Systems, BD)**

Battolyser Systems has maintained its growth primarily through investor funding. According to the BD, the company now has a megawatt commercial demonstrator, but before reaching this milestone, they were entirely dependent on external funding. The interviewee emphasized the challenges that DT startups face, particularly those in the B2B space, in attracting investors without a reference product in operation **(F+, R&D stage)**. This dilemma was aptly described as the "chicken and egg problem."

"We don't have a business to consumer product that you can launch quickly; our focus is on business-to-business solutions in a regulated environment. As you mentioned, being a DT startup means that our development process takes time. It's not like building an app where you get user feedback in three months and roll it out. It requires patience." **(Battolyser Systems, BD)**

Furthermore, the BD explains that even when the technical side is correct, obtaining the necessary permits can be a significant challenge **(BK+, R&D stage)**. These delays create a cyclical issue: You need resources to obtain permits, but to get those resources, you need a working product that has already gone through the permitting process.

When Battolyser Systems transitioned to the development phase, securing funding became a priority. As the BD explained, it was not necessary to deliver a highly detailed pitch to investors. Investors approached by companies such as Battolyser Systems typically already understand the potential of technology, as they are experienced in the industry. In most cases, the founders of DT companies already have established contacts in their respective industry, so by the time they reach the development stage, investors are already aware of their work **(F+, Growth stage)**. These investors often provide a different kind of funding, known as "patient capital".

"I don't think a lot of extra push is needed to attract investors in DT. When a company has a strong, qualified team and is well recognized, that naturally draws in investors on its own." **(Battolyser Systems, BD)**

One of the key challenges was attracting employees. For a period, BD was the only employee, and it proved difficult to find suitable candidates who were excited about the company's vision. This created a bottleneck as it took time to onboard new hires, causing progress to slow down in certain areas. In addition, BD provided information on the type of investment that falls under patient funding. Explain that patient funding is mainly correlated with type A investments. Citing that regular trips are made to the state of Texas and New York for investor conferences **(BA+, R&D stage)**. This type of investment was needed by Battolyser Systems specifically when scaling from laboratory-scale to pilot-scale manufacturing.

*"It is difficult to progress alone. This is a problem for DT. As a founder in DT you are already on the edge of the spectrum. Especially if you reach bottlenecks in the technology **(BA+, R&D stage)**."* **(Battolyser Systems, BD)**

BD emphasized that acquiring the right talent is a critical step to advance the development of DT. A potential solution, according to BD, is to create partnerships between DT startups and PhD candidates in relevant fields, while promoting these startups within universities. BD views universities as a key enabler of DT progress **(TK+, R&D stage)**.

The Battolyser system is currently, as the BD phrased, "entry into the growth stage". A prototype is on display and is being validated. The BD finished the interview stating that in his experience, incubators are very selective to certain startups that already show promise and have a team formed. Thus, selecting companies that are well in the development of an application that stems from that technology **(BK-,**

growth stage).

"An incubator exists to create value for society in general. Being selective in a startup that you know will flourish is looking at your own success, which I understand from an incubator performance perspective, but then only selected technology gets attention." **(Battolyser Systems, BD)**

Table 18. Analysis Battolyser Systems

Need Type	**Need**	**T/IT**	**Lifecycle stage**
Business Access	Need to be linked with another DT company in the same industry from the start to balance ideas	IT	Early stage
	Need partnerships with experienced individuals to extend expertise	IT	R&D stage
	Need to have investors types that do not only want equity returns	T	Growth stage
	Need to have insight on international market	T	R&D stage
Finance	Support in attracting investors without having a reference product	IT	R&D stage
	Need strategies to gain investments for a vision that has not yet been validated	IT	R&D stage
	Type A investment for lab-scale to pilot scale for prototype	T	R&D stage
Technical Knowledge	Need access to specialized talent through university programs	IT	R&D stage
Business Knowledge	Need to be in an open selection process	IT	Growth stage
	Finding and attracting employment through university PhD programs	IT	R&D stage

5.1 Cross-Case Analysis

In the following subsection, the key similarities and differences across the cases will be presented. These will then be discussed in relation to the current findings in the literature in the next chapter.

Components Analysis

As none of the selected ventures had reached the growth stage during the incubation period, only the needs and support elements for the early and R&D stage are presented. At the end of the section, we contrast the different cases and investigate how the support elements in the different development stages have affected the startup.

Table 19 consolidates the needs identified in each interview, with an additional column indicating the frequency (freq) of the occurrence of each need in the different interviews. In particular, business access and business knowledge emerge as the most frequently mentioned category.

Table 19. Consolidated Cross-Sectional Analysis

Need Type	Need	T/IT	Lifecycle	Freq
Business Access	Need to be linked with another DT company in the same industry from the start to balance ideas	IT	Early stage	1
	Need partnerships with experienced individuals to extend expertise	IT	R&D stage	1
	Need qualified personnel on team to get credibility	IT	R&D stage	2
	Need access to suppliers	T	R&D phase	1
	Need to be connected to specialized personnel to accelerate operations	IT	R&D stage	1
	Need industry partners	T	R&D stage	2
	Need high risk capital investors	T	R&D stage, Growth stage	1
	Need employees (mechanical engineers) with specialized expertise	T	R&D phase	2
Finance	Need funding for wages	T	R&D stage, Growth stage	3
	Need funding for prototype adhering to validation standards	T	R&D stage	2
	Need funds for travel	T	R&D stage	1

Need Type	Need	T/IT	Lifecycle	Freq
	Need funding to sustain waiting or pivot phases	T	R&D stage	1
Technical Knowledge	Need access to specialized talent through university programs	IT	R&D stage	1
	Need an environment specialized specific industry	IT	Early stage, R&D stage	1
Business Knowledge	Need support in attracting investors without having a reference product	IT	R&D stage	2
	Need strategies to gain investments for a vision that has not yet been validated	IT	R&D stage	1
	Need larger funding strategies for scaling market production	T	Growth stage	1
	Need guidance in navigating the startup landscape	IT	Early stage	2
	Need check-ins to pivot early and stay aligned with the market	IT	Early stage	1
	Need market alignment	IT	Early stage	2
	Need to be in an open selection process	IT	Growth stage	1
	Need active strategies to overcome VoD, rather than analysis on why in the VoD	IT	R&D stage	1
Legal Knowledge	Need support with IP setup	IT	Early stage	1
Infrastructure	Lack of access to custom labs	T	R&D phase	4
	Need affordable office space	IT	Early stage	1

The needs can be translated into tangible and intangible service factors, as illustrated in Figure 12.

Business Access: Access to specialized industry networks and partnerships is critical for DT startups to navigate unique technical and developmental challenges. Battolyser Systems initially benefitted from funding through Delft Enterprises but only gained significant traction after partnering with Proton Ventures. This partner-

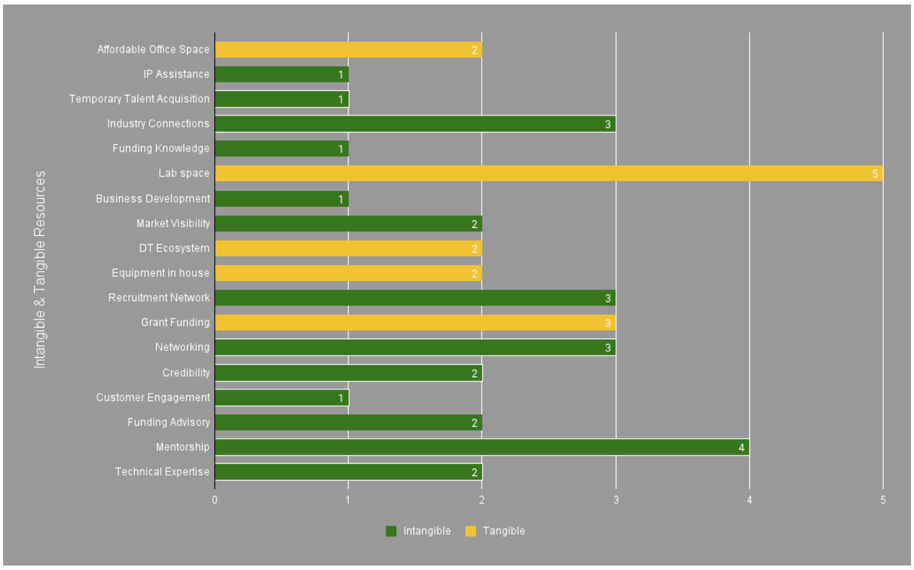

Figure 12. Tangible and Intangible components

ship provided the specific expertise and infrastructure needed to overcome technical obstacles, demonstrating that DT start-ups require the support of established players within their specific industries.

IMSystems, after an early stage with YesDelft!, experienced a similar need for specialized support in the R&D phase. They transitioned to RoboValley, a robotics-focused incubator, where they gained insight into market applications for their Archimedes Drive and connected with potential investors more attuned to robotics. This specialized environment allowed them to strategically assess where their technology could fit in the industry and access a targeted network of overseas investors.

Likewise, A-Spax improved significantly after establishing a relationship with the CEO of another aerospace company, underscoring the importance of sector-specific networks. For Vibrotwist, access to networks and personnel geared toward DT's unique needs was crucial, as general incubator guidance often fell short for DT. The experience of Soundcell further highlights the value of aligning with customer requirements from the beginning. The company's late-stage adjustments to meet client needs underscored that earlier access to relevant customer feedback would have streamlined their design process. Similarly, Lightyear's cofounder, now at PhotonDelta, emphasized that DT startups should prioritize identifying customer needs over merely navigating the VoD, a change that accelerates product-market fit and resource allocation.

Finance: Funding is a challenge for DT startups, particularly during the R&D and growth stages. High-risk capital is often needed to bridge the VoD, as illustrated by companies such as Lightyear and PhotonDelta. The importance of sustainable financial models was emphasized, particularly in industries requiring long timelines and complex technologies. In the growth stage, companies such as Battolyser noted that substantial funding was necessary to cover wages and meet prototype validation standards. Series A investments, typically with long-term returns, were crucial to support scaling and commercial production efforts. Vibrotwist and Soundcell further emphasized that different stages require different funding approaches, highlighting the need for patient capital and strategic funding sources that align with the long-term development needs typical of DT startups. Interesting to note is that funding becomes a greater need in the later stages.

Technical Knowledge: IMSystems faced challenges in securing specialized engineering expertise due to the niche requirements of their field. Notably, they emphasized that this technical expertise was sourced outside the incubator. Soundcell highlighted that the high level of expertise needed was beyond the scope of incubators, as DT founders are often at the forefront of their technology. Battolyser Systems added that a larger expert team enhances credibility. Partnerships with university programs were commonly mentioned as an effective way to bridge these technical knowledge gaps. In addition, DT startups frequently require industry-specific work environments. Both A-Spax and IMSystems stressed that access to specialized facilities, such as labs designed for fields such as aerospace or robotics, significantly accelerates development during the early and R&D stages.

Business Knowledge: The cases highlighted a need for diverse business knowledge, especially in financial management, industry-specific pitching strategies, and scaling techniques. Battolyser Systems noted that although DT investors often seek them out due to their specialized field, startups generally lack the expertise to deliver customized pitches to these backers. This gap was highlighted in all cases, with the consensus that both the financial and pitch strategies must align with the distinct expectations of the DT investors. IMSystems and Soundcell emphasized the importance of mastering financial language and capital management for sustained growth. Although IMSystems benefited from a cofounder with a business background, they still faced challenges in understanding complex, long-term investor contracts, an essential skill given the binding nature of DT investments. Vibrotwist echoed this, identifying contract comprehension as a critical yet frequently missing resource for DT teams.

Their cofounder suggested that incubators should focus on adapting standard business knowledge to DT-specific demands, enabling startups to build robust financial strategies and investor relations suited to the complex and capital-intensive DT sector.

Legal Knowledge: Two of the three cases highlighted the importance of establishing and managing IP and legal frameworks, especially in the early stages. For example, Vibrotwist required support for IP setup to protect its innovative solutions, while Battolyser Systems emphasized how IP is essential for credibility and survival. IMSystems also faced challenges in securing IP and benefited significantly from the guidance of YES!Delft in navigating this process. Similarly, Soundcell sought insights from other DT startups that had gone through the IP journey to optimize their approach.

Infrastructure: The need for specialized infrastructure, including custom labs and equipment, is a recurring theme among DT startups, especially in R&D stages. Soundcell, for instance, faced challenges due to a lack of access to MedTech-specific equipment like cleanrooms, which presented logistical hurdles in their R&D phase. Affordable office space within DT ecosystems was also cited as a valuable resource for early-stage startups to alleviate financial stress. Companies such as A-Spax and Vibrotwist highlighted the benefits of operating within collaborative environments that support growth and R&D activities, emphasizing the incubator's role in offering accessible and industry-aligned facilities.

5.1.1 Differences among cases

The performance of ventures and the influence of incubator support throughout the development stages is illustrated by the cases of Vibrotwist, Soundcell, IMSystems, A-Spax, and Battolyser Systems. Each of these ventures encountered unique technical and business challenges shaped by their respective incubation environments.

Vibrotwist faced significant R&D delays attributed to supplier issues, a common hurdle in DT ventures. Despite the support of Delft Enterprises, which helped secure grants, Vibrotwist lacked specialized business training to manage complex technology. The founder highlighted that while basic training was available, it was unable to address the unique challenges of DT commercialization. This lack of tailored business knowledge created a gap in aligning the vision of the venture with market expectations.

Soundcell advanced rapidly with initial financial backing, allowing the team to quickly develop a prototype. However, adjusting the product based on user feedback became essential because of usability issues in real-world healthcare settings. YesDelft! played a crucial role in expanding Soundcell's network and talent pool, but the startup noted a need for specialized MedTech resources and more targeted mentorship, which would have been beneficial for navigating regulatory and integration challenges in hospitals.

IMSystems faced challenges in building credibility with suppliers essential to their product development. RoboValley's specialized robotics support enabled IMSystems to bridge some of these gaps, but the mismatch between investor timelines and the prolonged R&D phase hindered their progress. The experience of IMSystems underscores the value of patient capital in DT, as typical investors often seek faster returns, which can lead to delayed development when timelines are not aligned.

A-Spax benefited from the feedback from the mentors, leading to a pivotal shift from reusable rockets to space-based manufacturing. This pivot, heavily supported by the Aerospace Innovation Hub, enabled A-Spax to capitalize on emerging market trends and access specialized networks in the aerospace industry. However, A-Spax faced challenges in securing long-term advisors with industry-specific expertise, which was crucial for credibility-building in the R&D phase.

Battolyser Systems leveraged academic partnerships and industry support to grow, although hiring specialized talent became a bottleneck as they scaled. The company's focus on B2B solutions meant that aligning their technology with market needs was critical. The founder highlighted the challenge of accessing investors who understand the complexities of DT timelines and are willing to provide patient capital, a need often unmet by traditional funding models.

The impact of the support elements varied significantly across stages. In the early stage, incubators such as YesDelft! and Aerospace Innovation Hub were instrumental in business planning and networking for companies like Soundcell and A-Spax. In the R&D stage, credibility with suppliers and access to funding were pivotal for Vibrotwist and IMSystems, highlighting how DT ventures often require tailored support not typically offered in standard incubator programs. In the growth stage, the challenges of customer alignment became evident for Soundcell and Battolyser Systems, underscoring the importance of integrating customer feedback early in product development.

The stages of the lifecycle of these DT ventures illustrate the critical need for targeted support in navigating technical, financial, and strategic hurdles, following suggestions from (Schuh et al., 2022), as detailed in Table 20.

Table 20. Life Cycle Stages mapped according to the interview cases

Stage	**Key Activity**	**Description**
Early Stage	Pre-Seed	Identify a far-reaching problem, form a core team, and conduct fundamental research.
	Seed	Assess market viability, develop a business plan, and raise capital for R&D.
	Start-up	Provide proof of concept, advance technology development, and establish R&D structures.
R&D	First Stage	Build a prototype, test functionality, identify target markets, and define value propositions.
	Second Stage	Transform the prototype into a Minimum Viable Product (MVP) and demonstrate practicality.
	Third Stage	Develop the MVP to series maturity, establish scalable processes, and set up pilot production.
Growth Stage	Fourth Stage	Launch the production-ready product, implement marketing and sales strategies, and prepare for IPO.
	IPO	Penetrate core markets, expand production and logistics, and intensify sales and marketing activities.
	Emerging Growth	Expand and improve existing activities, explore adjacent markets, and seek economies of scale.

In terms of overall achievements, Vibrotwist was able to continue operations due to grant support, though it struggled with investor alignment. Soundcell expanded rapidly, but had to make product modifications for usability. IMSystems gained long-term viability through RoboValley's specialized support, while A-Spax successfully pivoted, showing the value of strong mentorship. Battolyser Systems scaled up but faced hiring challenges due to the specialized nature of its work.

Components Analysis

Based on the case studies, incubators typically provide a combination of internal and external components. Internal components are often intangible, such as guidance in navigating the business landscape, regulatory mentorship, IP management, and strategic decision-making support, as shown in Table 12. Mentorship, a key internal component, can help with pitch preparation, business pivots, and other critical decisions. Credibility plays a significant role in attracting high-quality mentors and expert advisors, accelerating startup growth.

External components, such as access to networks, facilities, and investors, were consistently highlighted as having more impact. All cases emphasized the importance of funding as critical to maintaining operations. In addition, access to external networks was mentioned in every case, including testing facilities and laboratories, which can significantly reduce costs for startups.

The relationships between the support components and external actors in all cases are illustrated in Figure 13. It is evident that credibility and networking emerged as the two most recurring themes from the cases, reflecting the essential needs of DT startups.

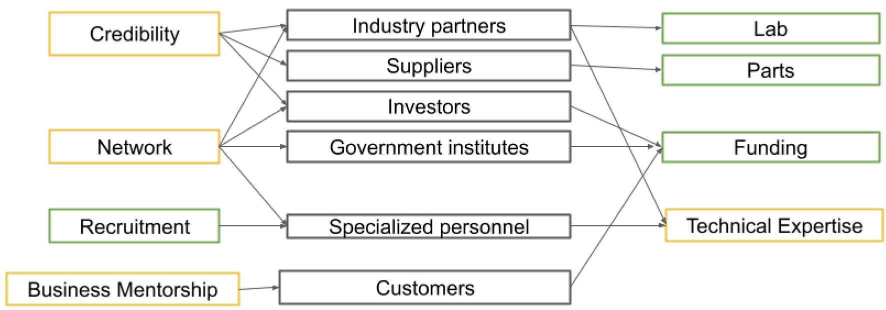

Figure 13. Most common relations

6 Discussion

This chapter presents a detailed discussion of the findings of this study. First, the chapter discusses the results through a comparison with the existing literature in Subsection 6.1. Then, Section 6.2 describes the key contributions of this study. Finally, Subsection 6.3 discusses the limitations and generalizability of the study.

6.1 Discrepancies and Similarities with Existing Theory

The current study examines the services provided by a specialized incubator for DT, with a focus on addressing the unique needs of DT startups. To this end, a qualitative analysis was conducted based on six interviews, which resulted in a prospective framework for DT incubators illustrated in Figure 14. The theoretical framework is categorized according to the framework presented in Yusubova et al., 2019. The themes categorized from the interviews are business knowledge, business access, legal knowledge, and infrastructure. In the following section the themes highlighted by the framework will be discussed and compared to the literature review. On first glance, one notices that the support mechanisms consist of mostly intangible elements. This perspective aligns with the literature on new generation technology incubators, which increasingly focus on providing intangible resources to better support tenant startups and drive innovation (Kautonen et al., 2017; Pauwels et al., 2016; Theodorakopoulos et al., 2014).

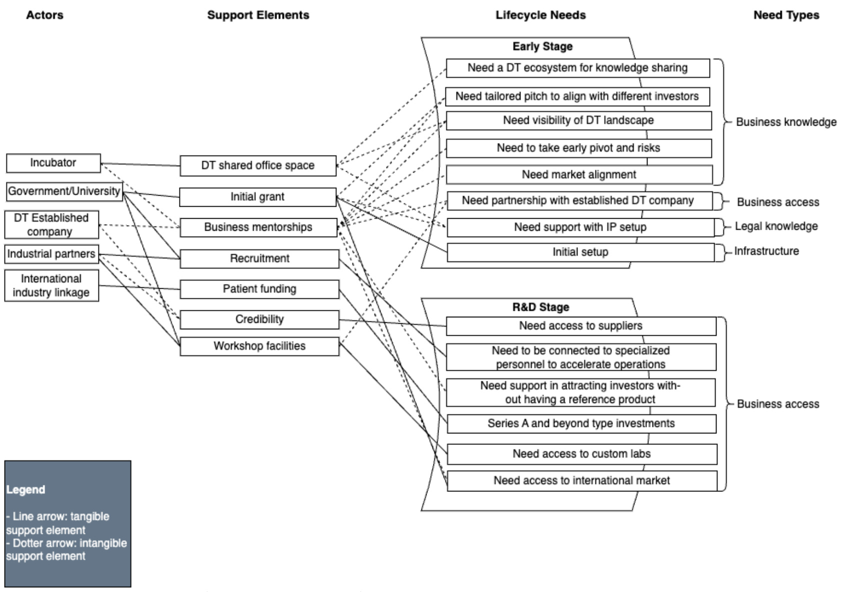

Figure 14. Theoretical framework for incubator support mechanisms based on research results

Business Access

The predominant theme highlighted by DT startups is business access, emphasizing the role of incubators as bridges to external actors. Previous research corroborates the importance of intermediaries in fostering startup success (Soetanto and Jack, 2016b; Yusubova et al., 2019), particularly in establishing early connections with industry partners during the early stages of the lifecycle.

The DT market is characterized in the literature by limited competition and strong demand (M. Islam et al., 2018; Magruk, 2016; Nalivaychenko and Kirilchuk, 2017). However, the findings demonstrate that DT startups often face challenges due to a narrow and highly specific customer base, leading to potential misalignment. For example, Soundcell's late identification of its target customers resulted in costly reengineering efforts. Although conventional incubation models focus on market entry during commercialization (Colombelli et al., 2019; S. A. Mian et al., 2016), DT startups benefit from early-stage validation with prospective customers to avoid costly pivots later.

External networks play a crucial role in bridging the gap between technology creation and application, helping DT startups integrate innovations into customer workflows. Although studies (Bollingtoft and Ulhøi, 2005; Peters, Rice, and Sundararajan, 2004) highlight the importance of direct engagement with incubator management for product development, external partnerships are more effective in mitigating risks such as market misalignment and lack of visibility. For instance, the early partnership between Battolyser Systems and Proton Venture demonstrates how partnerships enable smoother integration into client workflows. These findings suggest that incubators should adopt a proactive role as brokers, facilitating industry connections rather than focusing solely on infrastructure or mentorship (Stam, 2015; Van Weele et al., 2018a, 2018b). This aligns with prior research (Scillitoe and Chakrabarti, 2010; Yusubova et al., 2019), which emphasizes the value of incubator-facilitated networks for both technological and business development.

In the R&D stage the specialized nature of DT manufacturing processes requires access to advanced technical facilities. Although incubators play a role in offering workspaces (Barrow, 2001; Bruneel et al., 2012) or fostering partnerships with universities, Vibrotwist highlighted the challenges of maintaining highly specialized and costly equipment. Instead, companies like IMSystems and Lightyear stressed the value of leveraging industry partnerships to gain access to facilities. These partnerships not only provide necessary resources, but also ensure production aligns with market needs, emphasizing a business-oriented perspective. Unlike conventional tech companies that market online and rely on distributors (Mohr et al., 2010), DT startups such as IMSystems and Soundcell focus on promoting their technology to create industry impact. As Battolyser noted, this approach draws customers without push strategies. To achieve this, DT startups often attend conferences and tech meet, often held overseas. For example, IMSystems regularly travels to Japan for the robotics industry, illustrating the importance of incubators in helping DT startups access such markets.

Diverse expertise is also needed for development. While the founders have knowledge of the core technology, expertise is needed in areas such as manufacturing methods, advanced engineering, and economics, to align the product with customer needs. For example, the founders of IMSystems had experience in gears and established their target customers in the robotics industry, but also needed top-level experience in robotics to fit their product to the requirements of the industry.

Business Knowledge

The early stage of DT startups is dominated by the need for business knowledge. This contrasts with the existing literature Klaasa et al., 2019; Yusubova et al., 2019, which suggests that business knowledge becomes important during the commercialization stage and emphasizes the need for technical knowledge in the early stage. The results reveal that founders of DT startups, often at the cutting edge of academic and technological advancements, have less need for technological expertise from incubators.

Every interview highlighted a common challenge: losing sight of business viability by becoming overly focused on technological development (through an academic lens). This underscores the need for specific mentorship to help startups balance technological innovation with creating a sustainable and practical business path. In addition, personalized financial management advice is crucial.

The startups interviewed have all been operational for more than three years, yet only one, Soundcell, has developed a working prototype. Despite this, all of the startups interviewed have left the incubation process without fully commercialized products. The unique trajectory of DT, marked by a prolonged development phase of approximately five years (A. G. L. Romme et al., 2023), highlights a critical challenge: managing investor resources effectively over an extended period while maintaining strategic focus and building toward a competitive and self-sustaining business. Traditional mentorship models offered by incubators, typically designed for shorter timelines, within 3 years (Amezcua, 2019; Stokan et al., 2015), and faster commercialization, are not fully suited to addressing these needs.

IMSystems and Vibrotwist emphasized the importance of acquiring specific business knowledge in crafting tailored pitches for investors and customers. They noted that each customer requires a unique, customized approach. Although the literature broadly discusses business mentorship, this need is distinctly specific to DT start-ups. As IMSystems explained, their customer base consists of organizations with complex hierarchies that involve various stakeholders that each need to be convinced of the potential value of an unvalidated product, unlike a conventional pitch backed by a working prototype.

Finance

Seed funding is consistently highlighted in the literature as a key support element for start-ups (Klaasa et al., 2019; Soetanto and Jack, 2016b; Sohail et al., 2023). Although generally considered essential in the early stages, its role for DT startups extends beyond being a financial resource. Seed funding acts as a significant milestone, validating the concept of the startup and improving its credibility. Unlike conventional technology startups, which prioritize rapid product development and commercialization Blank, 2013, DT startups emphasize long-term technology development. For example, companies like Soundcell and A-Spax benefited from initial grants, but this funding did not translate into immediate acceptance by prospective end users. Instead, early funding primarily supports wages and hardware expenses R. Brown and Mason, 2017, while serving the larger purpose of validating technological ideas and attracting interest. However, the funding provided by incubators is typically limited to the early stage. By the R&D stage, the required funding often escalates to the magnitude of Series A investments, which exceeds the financial capabilities of most incubators.

Infrastructure

Another significant value that incubators provide is infrastructure, particularly through access to specialized office spaces (Wonglimpiyarat and Jarunee, 2016). Co-located workspaces foster collaboration and resource sharing, offering a tailored approach to help DT startups overcome challenges unique to the DT landscape.

However, in the context of DT, it is especially beneficial when all the startups are centered around the same industry, as this enhances synergy and knowledge exchange.

IP management

Finally, a robust intellectual property strategy is particularly critical for DT startups to protect cutting-edge advancements. While IP is important for all companies, DT startups face unique challenges in this area. Incubators with a traditional, less tech-focused approach may lack the resources to fully support these needs. The ability to assist in developing strong IP strategies is, therefore, a valuable service for DT startups.

Lifecycle stages

The literature indicates that technology incubators typically view startups as progressing through a development stage, commercialization, and growth stages (Klaasa et al., 2019), over a timeline of 1-3 years (Amezcua, 2019; Stokan et al., 2015). However, none of the DT startups analyzed have reached the growth stage, despite being operational for more than three years. Except for Soundcell, all startups have exited incubation and no longer require its support. This suggests that DT startups do not exit at a specific lifecycle stage but rather when they secure a strong team and sustainable funding strategy. Notably, incubation is crucial during the early and R&D stages.

The literature emphasizes the focus on marketing and commercialization strategies during the growth stages (Bhaskar and Phani, 2018; Smilor, 1987; Yusubova et al., 2019). For DT startups, with products targeting niche markets, the emphasis shifts to securing impact investments in international markets. Credibility is the necessity that needs to be created through an incubator in the growth stages. The results show that credibility reduces manufacturing and validation wait times, thereby shortening development cycles and funding needs. Employing specialized academics is essential at this stage to build credibility.

The literature identifies the commercialization or seed stage, marked by the development of a prototype, as the next phase after the early and R&D stages (Hausberg and Korreck, 2020; Klaasa et al., 2019). At this stage, technical startups require economic, legal, and sales expertise, with incubators offering coaching and training services (Sohail et al., 2023). For DT startups, interviews revealed that stage graduation is typically signaled by securing investment, aligning with DT lifecycles outlined by Schuh et al., 2022. Interviews also highlighted that the R&D stage demands the most support. Schuh et al., 2022 further subdivides this stage into three phases, which align with the VoD challenges faced by DT startups (Natsheh and Gbadegeshin, 2021; A. G. L. Romme et al., 2023; Weggeman and et al., 2022). For instance, IMSystems splits its team into commercial and technical groups during this stage.

The literature suggests that during the growth stage, incubators should provide access to team members, follow-up funding, and market opportunities (Klaasa et al., 2019). Although none of the cases, except Lightyear, have entered the growth stage, it is clear that all cases do not require incubation at this point. Most cases, except Soundcell, are still within the incubation process. Interestingly, many characteristics typically associated with the growth stage are needed in the R&D stage. The BD of Battolyser Systems highlights that incubators should serve DT startups for a defined period, offering clear support with a specific timeframe. Soundcell, the only DT startup still using an incubator after the three year mark, primarily does this for the cheaper office space.

7 Conclusion

In this chapter, the main research question is answered. The limitations of this study are then offered, including recommendations for further research. Finally, a reflection on the relevance is presented.

Answer to the Main Research Question

The primary objective of this research was to analyze the specific needs of DT start-ups and to determine how incubators can tailor their support to address these requirements effectively. The central research question that guided this study was the following:

> *How do the needs of DT startups differ from those of other types of startups in their engagement with incubators, and what implications does this have for tailoring the services provided by incubators?*

To address this question, the research adopted a qualitative approach based on multiple case studies, focusing on six DT startups. Semi-structured interviews were conducted with founders and stakeholders, providing in-depth insights into their unique needs, challenges, and the role of incubators in their journeys. This was complemented by a comprehensive review of the literature to establish a theoretical basis and identify existing gaps in incubation practices. Data were analyzed thematically, using a lifecycle-based framework to map startup needs in the following development phases. A cross-case analysis also highlighted patterns, commonalities and differences, contributing to the development of an actionable incubator framework.

Key Findings

While conventional incubators offer office space, mentoring, and funding, these services may be too generic for the needs of DT. This study shows that DT startups differ from conventional startups in various aspects. Technology and product development seems to be of great interest for DT startups, especially in the early stages of their existence. Although other start-up companies proceed in similar life cycles, for DT startups there is a compression and deviating focus within the stages due to the associated high R&D requirements. Taking this characteristic into account, this study found that DT start-ups value intangible support measures most during incubation.

The ability of the incubator to provide support to its tenant ventures depends on three underlying capabilities: (1) its business access, (2) its internal knowledge, and (3) its specialization. In particular, this study declares that a DT incubator must prioritize identifying and connecting a DT startup with an industrial partner from the early stage to help develop and align with the market. DT incubators need to be able to create an ecosystem of DT startups by having them physically next to each other. Incubators must be able to provide specific mentorship on how to approach investors and how to navigate and sustain the specific financial landscape of DT.

This study advances beyond a static view of incubators by addressing the dynamic needs of DT start-ups, responding to Colombelli et al., 2019's call for a specialized DT incubation framework. Validates the findings of Colombelli et al., 2019; Kruachottikul et al., 2023; A. Romme, 2022 that incubators improve market access and resources through strong corporate partnerships. Furthermore, it aligns with the recommendation of S. A. Mian et al., 2016 for a tailored incubation process, showing that startups face distinct lifecycle-stage-specific needs best supported through business access and knowledge.

7.1 limitations of Research and Recommendations for Future Research

This section presents the limitations of the research and offers recommendations for future studies.

The study was limited in time and had a low response rate of six participants. More time could have allowed for in-person visits to startups, potentially increasing responses. With more feedback, a wider range of factors that influence DT incubation could have been identified. With more responses, a broader set of factors could have been identified influencing DT incubation. This limitation also relates to the regional scope, which was confined to the Netherlands. Although the Netherlands provides a solid representation of incubators, different regions have different cultural and operational nuances, which can affect incubation processes.

Secondly, the startups interviewed were primarily incubated through YesDelft!, which may lead to homogeneous results. Including startups from various incubators might have produced different, even conflicting, findings. In this study, many experiences and identified factors were similar, but exploring other incubators could have yielded more diverse insights.

The third limitation concerns the qualitative research design. A qualitative approach was chosen, by relying on the knowledge and perceptions of interviewees to inform us, it enabled us to inductively identify incubation practices that have the potential to address the challenges faced by DT startups. Given that we derived these practices from incubators in successful entrepreneurial ecosystems, we believe that these practices are an important first step towards more effective incubators. However, our qualitative approach did not allow us to verify the effectiveness of these practices. Consequently, we encourage future research to take the next step by quantitatively testing if incubators in general, and the incubation practices that we identified in particular, indeed address the challenges that we identified, and thereby contribute to the success of DT start-ups.

Fourth, only university-supported and government-supported incubators were examined. Exploring corporate incubators would clarify the differences in their environments and practices.

Finally, only one researcher conducted the interviews and the coding of the transcripts, raising concerns about reliability. Single-coder studies can introduce bias and reduce intercoder reliability (Campbell et al., 2013). As this is a solo project, involving additional researchers was not feasible. The in-depth nature of the interviews may have resulted in different phrasing of the questions, leading to varied discussions between interviews. However, this does not suggest that participants disagreed with the themes raised by others.

Future research could address these limitations by including multiple incubators, regions, and researchers to improve reliability. Furthermore, validating responses through follow-up interviews with the same or new participants could strengthen the findings.

Scientific Contribution

This thesis enhances technology management literature by examining the specific needs of DT startups and the necessary adaptations for incubators to support them. Filling a research gap, the study analyzes the unique challenges faced by DT ventures, including longer development cycles, higher technological risks, and specialized resource needs, in contrast to traditional startups.

The theoretical framework outlines essential components for DT start-ups, such as ongoing funding, specialized mentoring, and customized infrastructure. Based on qualitative data from interviews with DT founders, this study offers practical insights and suggests ways to improve incubator-startup interactions (Hausberg and Korreck, 2020; A. G. L. Romme et al., 2023; Sadeh and Dvir, 2020). The framework serves as a practical tool for refining DT incubation approaches and lays the foundation for future research on adapting incubation models to meet the specific needs of DT ventures.

In contributing to the incubation literature, this research situates incubators within the broader entrepreneurial ecosystem, emphasizing their role in facilitating network development for DT startups. The supporting elements proposed in the theoretical framework can be further validated through quantitative studies to assess their efficacy in driving the development and success of DT startups.

This study also adds to the scientific discourse by highlighting that DT startups typically target niche customer markets, contrasting with the broader customer bases of conventional startups. This observation creates an opportunity for further investigation into the segmentation of the customers of DT ventures across different industries.

Moreover, this research illustrates that the lifecycle of DT startups differs significantly from that of conventional startups. Specifically, DT progress is often gauged by investment rounds rather than immediate commercial success. This insight invites further theoretical exploration into how commercial success is defined and measured within the context of DT, offering a novel perspective to complement the existing literature.

Although there is ample literature on generic methods for incubation, this study documents specific needs from incubators by DT startups. This builds on the current literature on DT. Harmonizing certain notions of DT such as the minimum development time and the hardship with the market. This study identifies DT gaps that can be investigated further.

Practical Implications

This research provides a framework for designing and managing DT incubators, offering actionable insights for incubator managers and policy makers. Managers can use this framework to prioritize enabling factors, mitigate barriers critical to DT startup growth, and tailor support strategies to specific lifecycle stages and startup needs.

The study highlights the importance of collaboration governance in DT incubation. A “triple-helix” approach, as proposed by A. Romme, 2022, integrates industry, academia, and government to drive innovation through shared resources, risk mitigation, and international collaborations. Effective governance is essential to sustain long-term partnerships D’Amico and et al., 2018; Rencher, 2017, while clear management of stakeholder expectations ensures mutually beneficial relationships Kruachottikul et al., 2023. Legal oversight, as noted by Kruachottikul et al., 2023, helps prevent conflicts of interest, and gatekeepers facilitate network access and connections at critical stages (Yusubova et al., 2019).

DT incubators must also address the need for specialized infrastructure, such as clean rooms and advanced labs, which are often beyond their direct capacity. Collaborations with universities and industry labs can fill this gap. Field-building activities, including networking events and pitch challenges, offer cost-effective mechanisms to foster ecosystem collaboration and innovation (Rubin et al., 2015; Van Weele et al., 2018b).

This research serves as a roadmap for incubator managers to better support DT start-ups, focusing on customized approaches. In the early stages, managers should connect startups with government grants for technology rather than generic entrepreneurial courses. They should leverage existing relationships to enable faster validation through collaboration while safeguarding intellectual property via R&D partnerships supported by government incentives. Later, targeted pitching and financing mentorship can be introduced. Incubators should recognize and address VoD startups by fostering peer ecosystems of DT startups with shared experiences and creative financing strategies to sustain development.

References

Aarikka-Stenroos, L., & Lehtimäki, T. (2014). Networks for the commercialization of innovations: A review of how divergent network actors contribute. *Industrial Marketing Management*, *43*(3), 365–381. https://doi.org/10.1016/j.indmarman.2013.12.002

Abbasi, E., Amin, I., & Siddiqui, S. (2022). Towards developing innovation management framework (imf) for ict organizations at pakistan. *Journal of Innovation and Entrepreneurship*. https://doi.org/10.1186/s13731-022-00231-6

Abereijo, I. (2016). Challenges of collaboration in the commercialization of technology innovations in nigeria. *Technology in Society*, *47*(1), 31–39.

Al Mubaraki, H., & Busler, M. (2011). The development of entrepreneurial companies through business incubation programs: A comparative study of the united states and middle eastern countries. *International Journal of Emerging Sciences*, *1*(2), 95–107. https://www.researchgate.net/publication/283072195_The_Development_of_Entrepreneurial_Companies_through_Business_Incubation_Programs_A_Comparative_Study_of_the_United_States_and_Middle_Eastern_Countries

Albort-Morant, G., & Ribeiro-Soriano, D. (2016). A bibliometric analysis of international impact of business incubators. *Journal of Business Research*, *69*(5), 1775–1779. https://doi.org/10.1016/j.jbusres.2015.10.054

Amezcua, A. S., Grimes, M. G., Bradley, S. W., & Wiklund, J. (2013). Organizational sponsorship and founding environments: A contingency view on the survival of business-incubated firms. *Academy of Management Journal*, *56*(6), 1628–1654.

Amezcua, A. S. (2019). Organizational performance of business incubators and their emergent models: Testing a configuration approach. *Journal of Business Venturing*, *34*(5), 105908. https://doi.org/10.1016/j.jbusvent.2018.10.002

Amonarriz, C., & et al. (2018). Collaboration dynamics in technology commercialization: A case study. *Journal of Business Venturing*, *33*(6), 1–12.

Assenza, P. (2015). The influence of spatial configuration on social and cognitive functioning in entrepreneurial co-working spaces. *Journal of Management Policy and Practice*, *16*(3), 35–48.

Association, D. I. (2023). About the dutch incubation association [Accessed: 2024-09-11].

Bala Subrahmanya Mungila Hillemane, D. C., Krishna Satyanarayana. (2019). Technology business incubation for start-up generation: A literature review toward a conceptual framework. *International Journal of Entrepreneurial Behavior Research*, *25*(7). https://doi.org/doi.org/10.1108/IJEBR-02-2019-0087

Barr, S., Baker, T., Markham, S., & Kingon, A. (2009). Bridging the valley of death: Lessons learned from 14 years of commercialization of technology education. *Acad. Manag. Learn. Educ.*, *8*, 370–388.

Barrable, B., Thorogood, N., Noonan, V., Tomkinson, J., Joshi, P., Stephenson, K., & Burns, K. (2014). Model for bridging the translational "valleys of death" in spinal cord injury research. *J. Healthc. Leadersh.*, *6*, 15–27.

Barrow, C. (2001). *Incubators: A realist's guide to the world's new business accelerators*. John Wiley Sons.

Bathelt, H., Kogler, D. F., & Munro, A. K. (2010). A knowledge-based typology of university spin-offs in the context of regional economic development. *Technovation*, *30*(9-10), 519–532. https://doi.org/10.1016/j.technovation.2010.04.003

Baumann, S., & Loeser, R. (2010). *Value-adding web applications and their impacts on decision-making: A study of small and medium-sized enterprises* (tech. rep.) (Accessed: 2024-05-12). RWTH Aachen University. https://publications.rwth-aachen.de/record/888920/files/888920.pdf

Benitez, J., Ray, G., & Henseler, J. (2020). It-enabled dynamic capabilities in the dark side of it usage: An empirical study. *European Journal of Information Systems*, *29*(3), 322–352.

Berbegal-Mirabent, J., Link, A. N., & Marozau, R. (2023). Developing business incubation process frameworks: A systematic review and research agenda. *Journal of Business Research*, *165*, 115085. https://doi.org/10.1016/j.jbusres.2023.115085

Bergek, A., & Norrman, C. (2008). Incubator best practice: A framework. *Technovation*, *28*(1-2), 20–28.

Bhaskar, R. A., & Phani, B. V. (2018). Generic framework of a business incubator model for a sustainable innovation ecosystem. In *Sustainable innovation and entrepreneurship* (pp. 209–230). Springer. https://doi.org/10.1007/978-981-13-1894-8_12

Biggam, J. (2020). *Succeeding with your master's dissertation: A step-by-step handbook* (4th). Open University Press.

Björk, L. (2006). How to cross the valley of death-reflections on communication. *Journal of Sustainable Forestry*, *21*(2-3), 45–52.

Blank, S. (2013). Why the lean start-up changes everything. *Harvard Business Review*, *91*(5), 63–72.

Bøllingtoft, A., & Ulhøi, J. P. (2005). The networked business incubator—leveraging entrepreneurial agency? *Journal of Business Venturing*, *20*(2), 265–290.

Bollingtoft, A., & Ulhøi, J. P. (2005). The networked business incubator—leveraging entrepreneurial agency? *Journal of Business Venturing*, *20*(2), 265–290.

Bonardo, D., Paleari, S., & Vismara, S. (2010). The ma dynamics of european science-based entrepreneurial firms. *The Journal of Technology Transfer*, *35*(3), 361–389. https://doi.org/10.1007/s10961-009-9129-0

Bonardo, D., Paleari, S., & Vismara, S. (2015). Valuing university-based firms: The effects of academic affiliation on ipo performance. *The Journal of Technology Transfer*, *40*(3), 485–508. https://doi.org/10.1007/s10961-014-9386-3

Borini, F. M., dos Santos, F. J., Gomes, L., & Tommaso, S. (2024). The cumulative transitions of the deep tech entrepreneur. *RAUSP Management Journal*, *59*(1), 67–72. https://doi.org/10.1108/RAUSP-02-2024-277

Boston Consulting Group. (2024). *From tech to deep tech* (Accessed: 2024-07-25). Boston Consulting Group. https://media-publications.bcg.com/from-tech-to-deep-tech.pdf

Bouncken, R. B., & Reuschl, A. J. (2016). Coworking spaces: How a phenomenon of the sharing economy builds a novel trend for the workplace and for entrepreneurship. *Review of Managerial Science*, 1–18.

Brooks, M. (2013). Accelerating innovation in climate services: The 3 e's for climate service providers. *Bull. Am. Meteorol. Soc.*, *94*(6), 807–819.

Brown, R., & Mason, C. (2017). Looking inside the spiky bits: A critical review and conceptualisation of entrepreneurial ecosystems. *Small Business Economics*, *49*(1), 11–30.

Brown, T. (2009). *Change by design: How design thinking creates new alternatives for business and society*. Harper Business.

Bruneel, J., Ratinho, T., Clarysse, B., & Groen, A. (2012). The evolution of business incubators: Comparing demand and supply of business incubation services across different incubator generations. *Technovation*, *32*(2), 110–121. https://doi.org/10.1016/j.technovation.2011.11.003

Bundl. (2023). *Corporate incubators: The expert guide* [Accessed: 2023-10-25]. https://www.bundl.com

Bunt, S. (2019). *High-tech startup maturity: Design of an evidence-based decision-support tool to assess the maturity and economic viability of high-tech ventures* [Master's thesis]. Eindhoven University of Technology.

Byrd, J., Herskowitz, O., Aloise, J., Nye, A., Rao, S., & Reuther, K. (2017). University technology accelerators: Design considerations and emerging best practices. *Technol. Innov.*, *19*(1), 349–362.

Campbell, J. L., Quincy, C., Osserman, J., & Pedersen, O. K. (2013). Coding in-depth semi-structured interviews: Problems of unitization and intercoder reliability and agreement. *Sociological Methods Research*, *42*(3), 294–320.

Capatina, Alexandru, Bleoju, G., & Kalisz, D. (2024). Falling in love with strategic foresight, not only with technology: European deep-tech startups' roadmap to success. *Journal of Innovation & Knowledge*, *9*, 100515. https://doi.org/10.1016/j.jik.2024.100515

Capdevila, I. (2015). Co-working spaces and the localised dynamics of innovation in barcelona. *International Journal of Innovation Management*, *19*(03), 28 pp.

Capdevila, I. (2017). Knowing communities and the innovative capacity of cities. *City, Culture and Society*.

Chan, K. F., & Lau, T. (2005). Assessing technology incubator programs in the science park: The good, the bad, and the ugly. *Technovation*, *25*(10), 1215–1228. https://doi.org/10.1016/j.technovation.2004.03.010

Chen, C., & Wahid, F. (2024). How to support innovative small firms? bibliometric analysis and visualization of start-up incubation. *Journal of Innovation and Entrepreneurship*. https://doi.org/10.1186/s13731-024-00212-x

Chi-Han, I., & Hung-Che, W. (2016). Where does the source of external knowledge come from? a case of the shanghai ict chip industrial cluster in china. *Journal of Organizational Change Management*, *29*(2), 150–175.

Clark, T. J. (2004). Revenue models for business incubators: Service fees and operational sustainability. *Economic Development Quarterly*, *18*(4), 300–316. https://doi.org/10.1177/089124240401800405

Club, H. (2021). *Understanding series a funding* [Accessed: YYYY-MM-DD]. https://www.huntclub.com/blog/understanding-series-a-funding

Cohen, S. L., Bingham, C. B., & Hallen, B. L. (2019). The role of accelerator designs in mitigating bounded rationality in new ventures [Accessed: 2024-08-25].

Administrative Science Quarterly, *64*(4), 810–854. https://doi.org/10.1177/0001839218782131
Cohen, S. L., & Hochberg, Y. V. (2014). Accelerating startups: The seed accelerator phenomenon. *SSRN Electronic Journal*.
Collins, J., Reizes, O., & Dempsey, M. (2016). Healthcare commercialization programs: Improving the efficiency of translating healthcare innovations from academia into practice. *IEEE J. Transl. Eng. Health Med.*, *4*, 1–7.
Colombelli, A., Paolucci, E., & Ughetto, E. (2019). Hierarchical and relational governance and the life cycle of entrepreneurial ecosystems. *Technological Forecasting and Social Change*, *148*, 119734. https://doi.org/10.1016/j.techfore.2019.119734
Colombo, M. G., & Delmastro, M. (2002). How effective are technology incubators? evidence from italy. *Research Policy*, *31*(7), 1103–1122. https://doi.org/10.1016/S0048-7333(01)00178-0
Communications, N. (2020). The patenting versus publishing dilemma. *Nature Communications*. https://www.nature.com/articles/s41467-020-14567-7
Conforto, E. C., Amaral, D. C., & da Silva, S. L. (2014). Agile project management and stage-gate model—a hybrid framework for technology-based companies. *Journal of Engineering and Technology Management*, *31*(1), 55–77. https://doi.org/10.1016/j.jengtecman.2013.11.003
Cooper, R. G. (2016). Agile–stage-gate hybrids: The next stage for product development [Accessed: 2024-05-17]. *Research-Technology Management*, *59*(1), 21–29. https://doi.org/10.1080/08956308.2016.1117317
Cooper, S., & Park, J. S. (2008). The impact of 'incubator' organizations on opportunity recognition and technology innovation in new, entrepreneurial high-technology ventures. *International Small Business Journal*, *26*(1), 27–56. https://doi.org/10.1177/0266242607084658
Corporation, I. F., & BpiFrance. (2021, November). Financing deeptech [Accessed: 2024-05-17]. https://observatoire-europe-afrique-2030.org/wp-content/uploads/2021/11/Financing-DeepTech-IFC-BpiFrance-Novembre-2021.pdf
Crișan, E. L., Salanță, I. I., Beleiu, I. N., Bordean, O. N., & Bunduchi, R. (2019). A systematic literature review on accelerators. *The Journal of Technology Transfer*, *46*(1), 62–89. https://doi.org/10.1007/s10961-019-09754-9
(CTTI), C. T. T. I. (2021). Study startup report. https://ctti-clinicaltrials.org/wp-content/uploads/2021/07/CTTI_Study_StartUp_Report.pdf
Cummings, J. R., C., & Roeder, W. (2018). The price of progress: Funding and financing alzheimer's disease drug development. *Alzheimer's Dement.*, *4*, 330–343.
Dagnino, G. B., Levanti, G., Minà, A., & Picone, P. M. (2016). Inter-organizational network and innovation: A bibliometric study and proposed research agenda. *Journal of Business Research*, *69*(5), 1887–1892.
D'Amico, M., & et al. (2018). Collaboration in technology commercialization: Challenges and opportunities. *Journal of Technology Transfer*, *43*(3), 456–471.
Davidsson, P., & Honig, B. (2003). The role of social and human capital among nascent entrepreneurs. *Journal of Business Venturing*, *18*(3), 301–331.

de Jong, E. J. (2011). *Foundations for multilingualism in education: From principles to practice*. Caslon Publishing. https://www.springer.com/gp/book/9781934000069

de Tommaso, S. (2024). Thinkbox: The cumulative transitions of the deep tech entrepreneur. *RAUSP Management Journal*, *59*, 67–72. https://doi.org/10.1108/RAUSP-02-2024-277

De Clercq, D., Sapienza, H. J., & Zaheer, A. (2006). Firm and group influences on venture capital firms' involvement in new ventures. *Journal of Management Studies*, *43*(7), 1169–1190.

De la Tour, A., Soussan, P., Harlé, N., Chevalier, R., & Duportet, X. (2017). *From tech to deep tech: Fostering collaboration between corporates and startups* (tech. rep.). Report by BCG and Hello Tomorrow. http://media-publications.bcg.com/from-tech-to-deep-tech.pdf

dealroom.co. (2023, January). *The european deep tech report* [Online report]. dealroom.co. https://dealroom.co/uploaded/2023/01/Dealroom-deep-tech-report-2023-europe.pdf

Denyer, D., Tranfield, D., & van Aken, J. E. (2008). Developing design propositions through research synthesis. *Organization Studies*, *29*(3), 393–413.

Dobrenkov, e. a., K. (2014). Therapeutic innovations: Translational research and the valley of death. *Trends in Pharmacological Sciences*, *35*(1), 1–7.

Earle, A., Merenda, M., & Davis, J. (2019). Strategy-as-process in a technology venture: A case study of pivots, pauses, partners, and progress. *Technol. Innov. Manag. Rev.*, *9*(1).

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550.

Ellwood, P., Williams, C., & Egan, M. (2022). Crossing the valley of death: Five underlying innovation processes. *Technovation*, *109*, 102349. https://doi.org/10.1016/j.technovation.2021.102349

Entrepreneur. (2023). *What corporate incubators and accelerators can mean for your business* [Accessed: 2023-10-25]. https://www.entrepreneur.com

Etzkowitz, H., & Leydesdorff, L. (2002). The dynamics of innovation: From national systems and "mode 2" to a triple helix of university–industry–government relations. *Research Policy*, *29*(2), 109–123.

The european deep tech report 2023 [Available online at https://dealroom.co/reports/the-european-deep-tech-report-2023]. (2023, November). *Lakestar, Dealroom.co, Walden Catalyst Ventures.*

e.V., B. D. S.-u. (2018). *German startup monitor 2018*. https://startupmonitor.de/

Eveleens, C., van Rijnsoever, F., & Niesten, E. (2017). How network-based incubation helps startups develop their business models. *International Entrepreneurship and Management Journal*, *13*, 605–629.

Failory. (2024). Incubators in the netherlands: Insights and overview [Accessed: 2024-09-11].

Fattorini, G., & Regoli, C. (2020). Role of the environment in covid-19 transmission: A modelling approach [Accessed: 2024-08-25]. *Waste Management*, *117*, 141–145. https://doi.org/10.1016/j.wasman.2020.08.015

Fiaschi, M. (2024). Deep tech: Europe's new wave of innovation? [Accessed: May 13, 2024].

Fini, Grimaldi, R., A., Marzocchi, & Wright, M. (2018). The foundation of entrepreneurial intention. *Small Business Economics*, *51*(1), 101–127. https://doi.org/10.1007/s11187-017-9933-x

Flanschger, A., Heinzelmann, R., & Messner, M. (2023). Between consultation and control: How incubators perform a governance function for entrepreneurial firms. *Accounting, Auditing & Accountability Journal*, *36*(9), 86–107. https://doi.org/10.1108/AAAJ-09-2020-4950

Ford, D., & Dillard, J. (2018). Crossing the valley of death: The case of the mdusv. *Proceedings of the 15th Annual Acquisition Research Symposium. Monterey, California. Naval Postgraduate School*.

Forum, W. E. (2020). World economic forum annual meeting 2020 [Accessed: 2024-08-08].

Frick, J., & Meusburger, P. (2013). Startup dynamics and organizational change. *Management Science*, *59*(6), 1265–1285.

Friend, G., & Zehle, S. (2018). *Writing business plans for a life science startup or clinical program*. Academic Entrepreneurship for Medical; Health Sciences. https://academicentrepreneurship.pubpub.org/

Galendata. (2023). 2023 investor environment for medical device startups. https://www.galendata.com/blog/2023-investor-environment-for-medical-device-startups

Gans, J. S., Stern, S., & Hsu, D. H. (2003). When does start-up innovation spur the gale of creative destruction? *The RAND Journal of Economics*, *33*(4), 571–586.

Gbadegeshin, S. A. (2019). The effect of digitalization on the commercialization process of high-technology companies in the life sciences industry. *Technology Innovation Management Review*, *9*(1), 49–63.

Gbadegeshin, S. A., Al Natsheh, A., Ghafel, K., Mohammed, O., Koskela, A., Rimpiläinen, A., Tikkanen, J., & Kuoppala, A. (2022). Overcoming the valley of death: A new model for high technology startups [This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)]. *Sustainable Futures*, *4*, 100077. https://doi.org/10.1016/j.sftr.2022.100077

Goffin, K., & Mitchell, R. (2019). *Innovation management: Effective strategy and implementation*. Macmillan International Higher Education.

Grimaldi, R., & Grandi, A. (2005). Business incubators and new venture creation: An assessment of incubating models. *Technovation*, *25*(2), 111–121.

Grimm, P. W., Grossman, M. R., & Cormack, G. V. (2021). Artificial intelligence as evidence. *Northwestern Journal of Technology and Intellectual Property*, *19*(1), 9. https://scholarlycommons.law.northwestern.edu/njtip/vol19/iss1/2/

Group, B. C. (2021). *Deep tech and the great wave of innovation* (Accessed: 2024-05-17). https://web-assets.bcg.com/19/4a/932b307a4732b9d583d041725046/bcg-deep-tech-and-the-great-wave-of-innovation-mar-2021.pdf

Hackett, S. M., & Dilts, D. M. (2004). A systematic review of business incubation research. *The Journal of Technology Transfer*, *29*(1), 55–82. https://doi.org/10.1023/B:JOTT.0000011181.11952.0f

Hackett, S., & Dilts, D. (2004). A systematic review of business incubation research. *The Journal of Technology Transfer*, *29*, 55–82. https://doi.org/https://doi.org/10.1023/B:JOTT.0000011181.11952.

Hahn, U., & Schnedler, T. (2019). Strategic objectives for startups. *Journal of Business Venturing*, *34*(3), 487–508.

Hallen, B. L., & Eisenhardt, K. M. (2012). Catalyzing strategies and efficient tie formation: How entrepreneurial firms obtain investment ties. *Academy of Management Journal*, *55*(1), 35–70.

Hansen, M. T., Chesbrough, H. W., Nohria, N., & Sull, D. N. (2000). Networked incubators: Hothouses of the new economy. *Harvard Business Review*, *78*(5), 74–84.

Hausberg, J. P., & Korreck, S. (2021). Business incubators and accelerators: A co-citation analysis-based, systematic literature review. *The Journal of Technology Transfer*, *45*(1), 176–207. https://doi.org/10.1007/s10961-018-9651-y

Hausberg, J. P., & Korreck, S. (2020). Business incubators and accelerators: A co-citation analysis-based, systematic literature review. *The Journal of Technology Transfer*, *45*, 151–176. https://doi.org/10.1007/s10961-018-9651-y

Hello Tomorrow & Bpifrance. (2019). How to build a successful deep tech acceleration program [Accessed: 7 April 2022]. https://hello-tomorrow.org/wp-content/uploads/2019/11/How-to-build-a-succesful-deep-tech-acceleration-program-Hello-Tomorrow-Bpifrance-1.pdf

Hermawan, A., Azis, Y., Effendi, N., Fahmi, H., & Hermanto, B. (2019). Performance factors for successful business incubators in indonesian public universities. *Technological Forecasting and Social Change*, *148*, 119740. https://www.sciencedirect.com/science/article/pii/S0040162519303865

Hermsen, O. W. (2023, November). *Developing a framework for assessing venture opportunities in deep tech venture building* [Master's thesis]. Eindhoven University of Technology. https://research.tue.nl/en/studentTheses/bc4ffa9c-57cc-4f6c-94ee-6b74790bb626

HighTechXL. (2024). Technologies and ecosystem [Accessed: August 26, 2024]. https://hightechxl.com/technologies

Hillemane, S., & Chandrashekar, R. (2019). Funding success in startup incubators: The impact of incubation on nascent ventures' growth and sustainability. *International Journal of Science and Research Archive*, *11*(01), 1418–1432.

Hochberg, Y. V., Fehder, & C., D. (2015). Accelerators and ecosystems. *Science*, *348*(6240), 1202–1203. https://doi.org/10.1126/science.aab1055

Howells, R. (2006). *Visual culture* (2nd). Polity Press.

Hudson, J., & Khazragui, H. F. (2013). Into the valley of death: Research to innovation. *Drug Discovery Today*, *18*(13), 610–613.

In, B. (2024). *What is deep tech?* [Accessed: 2024-05-17]. https://builtin.com

InnovationQuarter. (2018). Yes!delft recognized as europe's best university business incubator [Accessed: 2024-08-26]. https://www.innovationquarter.nl/en/yesdelft-recognized-europes-best-university-business-incubator/

Islam, M., Fremeth, A., & Marcus, A. (2018). Signaling by early stage startups: Us government research grants and venture capital funding. *J. Bus. Ventur.*, *33*, 35–51.
Islam, N. (2017). Crossing the valley of death: An integrated framework and a value chain for emerging technologies. *IEEE Trans. Eng. Manag.*, *64*(3), 389–399.
Jacobs, S. (2023, November). *The european deep tech report* [Online report]. Lakestar. https://dealroom.co/uploaded/2023/09/The-European-Deep-Tech-Report-2023.pdf
Jucevicius, G., Juceviciene, R., Gaidelys, V., & Kalman, A. (2016). The emerging innovation ecosystems and "valley of death": Towards the combination of entrepreneurial and institutional approaches. *Inz. Ekon.*, *27*(4), 430–438.
Jun, W., Nasir, M. H., Yousaf, Z., Khattak, A., Yasir, M., Javed, A., & Shirazi, S. H. (2022). Innovation performance in digital economy: Does digital platform capability, improvisation capability and organizational readiness really matter? *European Journal of Innovation Management*, *25*(5), 1309–1327. https://doi.org/10.1108/EJIM-10-2020-0422
Kasenda, B., von Elm, E., You, J. J., Blümle, A., Tomonaga, Y., Saccilotto, R., & Briel, M. (2016). Agreements between industry and academia on publication rights: A retrospective study of protocols and publications of randomized clinical trials. *PLOS Medicine*, *13*(6), e1002046. https://doi.org/10.1371/journal.pmed.1002046
Kautonen, M., Pugh, R., & Raunio, M. (2017). Transformation of regional innovation policies: From 'traditional' to 'next generation' models of incubation. *Eur. Plan. Stud.*, *25*, 620–637.
Ketchen, D. J., Snow, C. C., & Hoover, V. L. (1993). Research on competitive dynamics: Recent accomplishments and future challenges. *Journal of Management*, *19*(2), 295–326.
Kiel, D., & Arnold, C. (2021). Venture builders as a new business model in the digital age: Evidence from the german startup ecosystem. *Journal of Business Models*, *9*(2), 1–19.
Klaasa, P., Thawesaengskulthai, N., & Vaiyavuth, R. (2019). Factors to support a new tech start-up for business incubation [Retrieved from http://www.ajouronline.com/]. *Asian Journal of Applied Sciences*, *7*(3), 320–327.
Kovacs, B., Shane, S., & Harms, R. (2019). Novelty, impact, and disruption: An analysis of research in the field of management. *Journal of Management*, *45*(1), 350–385.
Kruachottikul, P., Dumrongvute, P., Tea-makorn, P., Kittikowit, S., & Amrapala, A. (2023). New product development process and case studies for deep-tech academic research to commercialization. *Journal of Innovation and Entrepreneurship*, *12*, 48. https://doi.org/10.1186/s13731-023-00311-1
Kuhlmann, S., & Rip, A. (2018). Next-generation innovation policy and grand challenges. *Science and Public Policy*, *45*(4), 448–454. https://doi.org/10.1093/scipol/scy023
La Tour, J., Smith, A., & Johnson, R. (2022). Attracting venture capital to help early-stage, radical cleantech ventures bridge the valley of death: 27 levers to

influence the investor perceived risk-return ratio. *Journal of Cleaner Production*, *376*, 133983. https://doi.org/10.1016/j.jclepro.2022.133983
Lee, S. S., & Osteryoung, J. S. (2004). The impact of incubator assistance on the performance of university spin-offs. *Journal of Technology Transfer*, *29*(1), 93–108. https://doi.org/10.1023/B:JOTT.0000011185.12025.7a
Lin, Y., Evans, J., & Wu, L. (2021). Novelty, disruption, and the evolution of scientific impact. *Knowledge Lab, University of Chicago.*
Liotta, L. A., & Painter, P. C. (2012). Translational sciences: Bridging the valley of death for tbi to better outcomes. *Brain Injury*, *26*(4-5), 453–472.
Lose, T. (2021). Business incubators in south africa: A resource-based view perspective. *Academy of Entrepreneurship Journal*, *27*(Special Issue 1), 443–456.
Magruk, A. (2016). Uncertainty in the sphere of the industry 4.0: Potential areas to research. *Bus. Manag. Educ.*, *14*(2), 275–291.
Maia, C., & Claro, J. (2013). The role of a proof of concept center in a university ecosystem: An exploratory study. *J. Technol. Transf.*, *38*(5), 641–650.
Malhotra, N. (2013). Trust, belief, and confidence in decision making. *Journal of Business Research*, *66*(1), 117–125.
Mankins, J. C. (2009). Technology readiness assessments: A retrospective. *Acta Astronautica*, *65*(9-10), 1216–1223. https://doi.org/10.1016/j.actaastro.2009.03.059
Marcon, A., & Duarte Ribeiro, J. L. (2021). How do startups manage external resources in innovation ecosystems? a resource perspective of startups' lifecycle. *Technological Forecasting and Social Change*, *171*, 120965. https://doi.org/10.1016/j.techfore.2021.120965
Marques, R. (2023). Cultivating invisible impact with deep technology and creative destruction. *Journal of Innovation Management*, *8*(3), 1–12. https://journalengineering.fe.up.pt/index.php/jim/article/view/2183-0606_008.003_0002/459
Masutha, Mahlatse, & Rogerson, C. M. (2019). Business incubation for small enterprise development: South african pathways. *Urban Forum*, *30*, 385–402. https://link.springer.com/article/10.1007/s12132-019-09367-3
Mas-Verdú, D., F.and Ribeiro-Soriano, & Roig-Tierno, N. (2015). Firm survival: The role of incubators and business characteristics. *Journal of Business Research*, *68*(4), 793–796. https://doi.org/10.1016/j.jbusres.2014.11.030
Maughan, T. e. a. (2019). Funding models for innovative technologies in healthcare. *International Journal of Health Economics and Management*, *19*(1), 13–35.
McAdam, M., & McAdam, R. (2008). High tech start-ups in university science park incubators: The relationship between the start-up's lifecycle progression and use of the incubator's resources [Accessed: 2024-08-25]. *Technovation*, *28*(5), 277–290. https://doi.org/10.1016/j.technovation.2007.07.012
McCarthy, S. (2014). How to write a competitive proposal for horizon 2020 [Retrieved from www.hyperion.ie]. *Hyperion.*
Meoli, M., & Vismara, S. (2013). University support and the creation of technology and non-technology academic spin-offs. *Small Business Economics*, *41*(4), 923–939. https://doi.org/10.1007/s11187-012-9450-2

Merceret, K., & et al. (2018). Conflicting logics in technology commercialization: The role of academia and business. *Journal of Business Venturing*, *33*(5), 1–9.

Meyer, M. H. (2003). Performance management and metrics in incubators: Linking small business success to management systems. *International Journal of Entrepreneurship and Innovation*, *4*(4), 179–187. https://doi.org/10.5367/000000003101299428

Mian & A., S. (1996). The university business incubator: A strategy for developing new research/technology-based firms. *The Journal of High Technology Management Research*, *7*(2), 191–208.

Mian, S. A., Lamine, W., & Fayolle, A. (2016). Technology business incubation: An overview of the state of knowledge. *Technovation*, *50-51*, 1–12. https://doi.org/10.1016/j.technovation.2016.10.003

Mishanin, I. (2023). 10 hurdles of building a deep tech startup in the age of chatgpt [Retrieved from KDnuggets].

MIT REAP. (2022). What is deep tech? https://reap.mit.edu/assets/What_Is_Deep_Tech_MIT_2022.pdf

Mittelmeijer, H. G. (2020). *Verticle: An innovative financial mechanism to bridge the valley of death* [Master's Thesis]. Eindhoven University of Technology.

Mohan, V., & Chinchwadkar, R. (2022). Technology business incubation: A literature review and gaps. *International Journal of Global Business and Competitiveness*, *17*, 53–63. https://doi.org/10.1007/s42943-022-00048-w

Mohr, J. J., Sengupta, S., & Slater, S. F. (2010). *Marketing of high-technology products and innovations*. Pearson.

Mossberg, J. S. P. H. H., & S., N. (2018). Crossing the biorefinery valley of death? actor roles and networks in overcoming barriers to a sustainability transition. *Environ. Innov. Soc. Trans.*, *27*, 83–101.

Muegge, S. (2019). The rise of uber and regulating the disruptive innovator. *Technology Innovation Management Review*, *9*(10), 5–20. https://www.timreview.ca/article/1258

Nalivaychenko, E., & Kirilchuk, S. (2017). The development of methods for the innovation infrastructure progress in crimea region. *J. Adv. Res. Law Econ.*, *8*(4), 1226–1240.

Nanda, R. (2020). Financing "tough tech" innovation [Accessed from WIPO Publication, October 2020.]. In I. Cornell University & WIPO (Eds.), *Global innovation index 2020: Who will finance innovation?* (pp. 113–119). World Intellectual Property Organization.

Natsheh, A., & Gbadegeshin, A. (2021). The causes of valley of death: A literature review. *Proceedings of the INTED2021 Conference*, 9289–9298. https://doi.org/10.21125/inted.2021.1943

Nedayvoda, A., Mockel, P., & Graf, L. (2020). *Deep tech solutions for emerging markets* (No. 34859). World Bank Group. https://openknowledge.worldbank.org/bitstream/handle/10986/34859/Deep-Tech-Solutions-for-Emerging-Markets.pdf?sequence=1

Niesten, E., & Jolink, A. (2015). The impact of alliance management capabilities on alliance attributes and performance: A literature review. *International Journal of Management Reviews*, *17*(1), 69–91.

Nowak, M. J., & Grantham, C. E. (2000). The virtual incubator: Managing human capital in the software industry. *Proceedings of the 33rd Hawaii International Conference on System Sciences*, 10.

Oakey, R. (2003). Funding innovation and growth in uk new technology-based firms: Some observations on contributions from the public and private sectors. *Venture Capital*, *5*(2), 161–179. https://doi.org/10.1080/1369106032000087294

Osimo, David, Kombe, Nancy, & Gitau, S. (2019). "Hub" organisations in Kenya: What are they? What do they do? And what is their potential? *Journal of Innovation and Entrepreneurship*, *8*(1), 1–20. https://link.springer.com/article/10.1186/s13731-019-0102-1

Ouchi, N., & Watanabe, C. (2009). Co-evolutionary domestication for self-propagating functionality development: Lessons from mobile phone business ventures. *J. Serv. Res.*, *9*(1), 69–86.

Paquin, R. L., & Howard-Grenville, J. (2013). Blind dates and arranged marriages: Longitudinal processes of network orchestration. *Organization Studies*, *34*(11), 1623–1653.

Parmentola, A., et al. (2021). Exploring the university-industry cooperation in a low innovative region. what differences between low tech and high tech industries? *International Entrepreneurship and Management Journal*, *17*, 1469–1496. https://doi.org/10.1007/s11365-020-00671-0

Passaro, R., Rippa, P., & Quinto, I. (2016). The start-up lifecycle: An interpretative framework proposal [Accessed: 2024-10-25]. *XVII Annual Scientific Meeting of the Italian Association of Management Engineering (AiIG)*.

Patton, D. (2013). Realizing potential: The impact of business incubation on the absorptive capacity of new technology-based firms. *International Small Business Journal*, *31*(5), 524–539.

Pauwels, C., Clarysse, B., Wright, M., & Van Hove, J. (2016). Understanding a new generation incubation model: The accelerator. *Technovation*, *50-51*, 13–24.

Peña, Ignacio, & Jenik, M. (2023). *Deep tech: The new wave* (Accessed: 2024-05-17). Inter-American Development Bank. https://publications.iadb.org/en/deep-tech-new-wave

Perelmuter, G. (2021). *Present future: Business, science, and the deep tech revolution*. Fast Company.

Peters, L., Rice, M., & Sundararajan, M. (2004). The role of incubators in the entrepreneurial process. *Journal of Technology Transfer*, *29*(1), 83–91.

Peters, L., Rice, M., & Sundararajan, F. (2004). The role of incubators in the entrepreneurial process. *The Journal of Technology Transfer*, *29*(1), 83–91. https://doi.org/10.1023/B:JOTT.0000011182.82350.df

Phan, D. S., P. H.and Siegel, & Wright, M. (2005). Science parks and incubators: Observations, synthesis and future research. *Journal of Business Venturing*, *20*(2), 165–182. https://doi.org/10.1016/j.jbusvent.2003.12.001

Pisano, G. P. (2010). The evolution of science-based business: Innovating how we innovate. *Industrial and Corporate Change*, *19*, 465–482.

Popp, J., Matthews, D., Martinez-Coll, A., Mayerhöfer, T., & Wilson, B. (2017). Challenges in translation: Models to promote translation. *J. Biomed. Opt.*, *23*(2), 021101.

Portincaso, M., A., de la Tour, & Soussan, P. (2019). The dawn of the deep tech ecosystem. *BCG Henderson Institute*. https://www.bcg.com/publications/2019/dawn-deep-tech-ecosystem

Pusateri, T., & et al. (2017). Barriers to successful collaboration between academia and industry in technology commercialization. *Journal of Technology Transfer*, *42*(4), 812–829.

Pynnönen, M., Hallikas, J., & Immonen, M. (2019). *Innovation commercialisation: Processes, tools and implications*. Palgrave Macmillan. https://doi.org/10.1007/978-3-319-78075-7

Rakic, P. (2020). Breakthrough versus disruptive innovations: Definitions and impact on corporations. *European Journal of Innovation Management*, *23*(3), 380–396.

Rathore, R. S., & Agrawal, R. (2023). Measuring performance of business incubators: A literature review and theoretical framework development. *SSRN*. https://ssrn.com/abstract=3765641

Ray, L., Bujarski, S., Roche, D.J.O., & Magill, M. (2018). Overcoming the 'valley of death' in medications development for alcohol use disorder. *Alcohol.*, *42*, 1612–1622.

Rencher, L. (2017). Collaboration dynamics in high-tech ventures: An empirical analysis. *Journal of Business Venturing*, *32*(4), 1–12.

Review, H. B. (2023). Where is tech going in 2023? [Accessed: 2024-05-17]. *Harvard Business Review*. https://hbr.org/2023/01/where-is-tech-going-in-2023

Rice, M. P. (2002). Co-production of business assistance in business incubators: An exploratory study. *Journal of Business Venturing*, *17*(2), 163–187.

Ries, E. (2011). *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses*. Crown Business.

Rodríguez González, S., de la Prieta Pintado, F., García Coria, J., & Casado Vara, R. (2020). The role of artificial intelligence and distributed computing in iot applications. *Ediciones Universidad de Salamanca*, *Aquilafuente*(September), 149.

Romasanta, A., Ahmadova, G., Wareham, J., & Priego, L. P. (2023). *Deep tech: Unveiling the foundations* (tech. rep. No. 276) (Accessed: 2024-05-19). ESADE Business School, Ramon Llull University, Barcelona, Spain; University of Navarra, IESE Business School, Barcelona, Spain. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3717129

Romme, A. G. L., & Reymen, I. M. M. J. (2018). Entrepreneurial learning: New insights. *Journal of Small Business Management*, *56*(1), 1–13. https://doi.org/10.1111/jsbm.12376

Romme, A. G. L., Bell, J., & Frericks, G. (2023). Designing a deep-tech venture builder to address grand challenges and overcome the valley of death. *Journal of Organization Design*, *12*(4), 217–237. https://doi.org/10.1007/s41469-023-00144-y

Romme, A. (2022). Against all odds: How eindhoven emerged as a deeptech ecosystem. *Systems*, *10*(4), 119. https://doi.org/10.3390/systems10040119

Rotger, G. P., Gørtz, M., & Storey, D. J. (2012). Assessing the effectiveness of guided preparation for new venture creation and performance: Theory and practice. *Small Business Economics*, *39*(2), 463–481.

Rubin, H., T., Aas, Helge, T., & Stead, A. (2015). Knowledge flow in technological business incubators: Evidence from australia and israel. *Technovation*, *41-42*, 11–24.

Sadeh, A., & Dvir, D. (2020). Navigating the challenges of deep tech innovation. *Journal of Technology Management*, *35*, 102–120.

Schilke, O., & Goerzen, A. (2010). Alliance management capability: An investigation of the construct and its performance implications. *Academy of Management Journal*, *53*(5), 1199–1219.

Schoonmaker, M., Carayannis, E., & Rau, P. (2013). The role of marketing activities in the fuzzy front end of innovation: A study of the biotech industry. *J. Technol. Transf.*, *38*(6), 850–872.

Schuh, G., Studerus, B., & Hämmerle, C. (2022). Development of a life cycle model for deep tech startups. *Journal of Production Systems and Logistics*, *2*(5). https://doi.org/https://doi.org/10.15488/11730

Schutselaars, J. (2023). *Communicating the value proposition of new deep-tech ventures to investors: A design science study to help new deep-tech ventures better communicate their value proposition to investors* [Master's thesis]. Eindhoven University of Technology.

Schwartz, M., & Hornych, C. (2010). Cooperation patterns of incubator firms and the impact of incubation phase on firm benefits. *Technovation*, *30*(9-10), 439–449.

Scillitoe, J. L., & Chakrabarti, A. K. (2010). The role of incubator interactions in assisting new ventures. *Technovation*, *30*(3), 155–167.

Siegel, J., & Krishnan, S. (2020). Cultivating invisible impact with deep technology and creative destruction. *Journal of Innovation Management*, *8*(3), 6–19.

Silva, R., Andrade, Hugo, & Leitao, J. (2019). The role of business incubators for start-ups development in brazil and portugal. *International Journal of Entrepreneurship and Small Business*, *38*(4), 476–491. https://www.inderscience.com/info/inarticle.php?artid=104317

Siota, J., & Prats, F. (2021). Title of the article. *Journal Name*, *10*(2), 123–145. https://doi.org/10.1234/journal.v10i2.123

Sivasubramanian, R., & Thomas, J. (2023). Equity and funding structures in business incubators: Aligning financial success with startups. *Journal of Business Incubation*, *15*(2), 89–103. https://doi.org/10.1007/s10843-023-0135

Smilor, R. W. (1987). Managing the incubator system: Critical success factors to accelerate new company development. *IEEE Transactions on Engineering Management*, *34*(3), 146–155.

Smith, J. (2020). The rise of uber and regulating the disruptive innovator. *Journal of Business Ethics*, *162*(2), 1–15.

Smith, J., & Doe, J. (2020). The challenges and strategic solutions of emerging technology entrepreneurship: A systematic literature review. *Journal of Entrepreneurship and Innovation*, *15*(2), 123–145. https://doi.org/10.1000/xyz123

Soetanto, D., & Jack, S. (2016a). The incubatees' perspective on identifying priority enabling factors for technology business incubators. *Technovation*, *50-51*, 32–43. https://doi.org/10.1016/j.technovation.2015.09.001

Soetanto, D., & Jack, S. (2016b). Network ties and entrepreneurial orientation: A social capital perspective on the innovation performance of small and medium-sized enterprises. *Journal of Small Business Management*, *54*(3), 714–731. https://doi.org/10.1111/jsbm.12164

Sohail, K., Belitski, M., & Christiansen, L. C. (2023). Developing business incubation process frameworks: A systematic literature review. *Journal of Business Research*, *162*, 113902. https://doi.org/10.1016/j.jbusres.2023.113902

SpringerLink. (2018). Academia and industry collaborations: A research and professional perspective. *SpringerLink*. https://link.springer.com/article/10.1007/s11606-018-4379-1

Stam, E. (2015). Entrepreneurial ecosystems and regional policy: A sympathetic critique. *European Planning Studies*, *23*(9), 1759–1769.

Stokan, E., Thompson, L., & Mahu, R. J. (2015). Testing the differential effect of business incubators on firm growth. *Economic Development Quarterly*, *29*(4), 317–327. https://doi.org/10.1177/0891242415597065

Taylor, D., & Anderson, R. (2022). Effective incubation practices for high-tech startups. *Technovation*, *20*(6), 345–359. https://doi.org/10.1016/j.technovation.2022.005

Tech, R. (2018). *Financing high-tech startups: Using productive signaling to efficiently overcome the liability of complexity* [Accessed: 2024-10-25]. Springer.

TechCrunch. (2023). Commercializing deep tech startups: A practical guide for founders and investors [Retrieved from TechCrunch].

Theodorakopoulos, N., Kakabadse, N., & McGowan, C. (2014). What matters in business incubation? a literature review and a suggestion for situated theorising. *J. Small Bus. Enterp. Dev.*, *21*, 602–622.

Thompson, S. (2018). Scientific innovation's two valleys of death: How blood and tissue banks can help to bridge the gap. *J. Bus. Ventur.*, *33*, 35–51.

Thursby, J., & Thursby, M. (2018). Research alliances and the role of research consortia in innovation: The case of the semiconductor research corporation. *Industry and Higher Education*, *32*(6), 355–366. https://doi.org/10.1080/10429247.2018.1540225

Upadhyayula V.K. Gadhamshetty V. Shanmugam, N., K. Souihi, & Tysklind, M. (2018). Advancing game changing academic research concepts to commercialization: A life cycle assessment (lca) based sustainability framework for making informed decisions in technology valley of death (tvd). *Resour. Conserv. Recycl.*, *133*, 404–416.

Utrecht University. (2018). Utrechtinc ranks among world's top business incubators [Accessed: 2024-08-26]. https://www.uu.nl/en/news/utrechtinc-ranks-among-worlds-top-business-incubators

UtrechtInc. (2024). Utrechtinc recognized as a top incubator globally for its impact [Accessed: 2024-08-26]. https://www.utrechtinc.nl/en/news/utrechtinc-recognized-as-a-top-incubator-globally-for-its-impact/

van Rijnsoever, F. J. (2020). Meeting, mating, and intermediating: How incubators can overcome weak network problems in entrepreneurial ecosystems. *Research Policy*, *49*(1), 103884. https://doi.org/10.1016/j.respol.2019.103884

Van Andel, R. (2022). *Challenge-based deep-tech venture building: Design of an evidence-based framework for venture building aimed at solving deep-tech innovation challenges* [Master's thesis]. Eindhoven University of Technology.

Van Rooij, B. (2023). *Improving the performance environment of new deep-tech ventures: Design of evidence-based improvements in the performance environment of new deep-tech ventures* [Master's thesis]. Eindhoven University of Technology.

Van Scheijndel, R. (2020). *Recruiting young talent in deep-tech venture building: Design of an evidence-based framework to recruit young talent in new deep-tech venture team formation* [Master's thesis]. Eindhoven University of Technology.

Van Weele, M., van Rijnsoever, F. J., & Nauta, F. (2018a). Resource constraints of external stakeholders and the performance of university spin-offs. *Journal of Technology Transfer*, *43*(4), 841–859.

Van Weele, M., van Rijnsoever, F. J., & Nauta, F. (2018b). You can't always get what you want: How entrepreneur's perceived resource needs affect the incubator's assertiveness. *Technovation*, *59*, 18–33.

Vincett, P. (2019). The development, growth, and performance of university spin-offs: A critical review. *The Journal of Technology Transfer*, *43*(5), 1571–1600. https://doi.org/10.1007/s10961-018-09714-9

Voss, C. A., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations Production Management*, *22*(2), 195–219.

Warren, L., & Morse, E. A. (2009). Co-production in business support networks: An analysis of the uk business incubator network. *Entrepreneurship & Regional Development*, *21*(4), 371–391.

Weggeman, M., & et al. (2022). The role of collaboration in overcoming the valley of death in technology commercialization. *Sustainable Futures*, *4*(100077), 1–20.

Weyant, J. P. (2011). Accelerating the development and diffusion of new energy technologies: Beyond the "valley of death". *Energy Economics*, *33*(4), 674–682.

Williams, D., Smith, J., & Taylor, K. (2019). A framework for understanding the role of innovation in sustainable development. *Technological Forecasting and Social Change*, *148*, 119712. https://www.sciencedirect.com/science/article/pii/S0040162519303865

Williams, T., & Nguyen, L. (2021). High-tech startup support: Lessons from the field. *Entrepreneurship Theory and Practice*, *18*(4), 250–267. https://doi.org/10.1123/etp.2021.004

Wohlin, C. (2014). Guidelines for snowballing in systematic literature studies and a replication in software engineering. *Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering*, 1–10. https://doi.org/10.1145/2601248.2601268

Wong, T. Y. (2019). The dynamics of collaboration between academia and industry: A case study. *International Journal of Innovation and Technology Management*, *16*(2), 194–212.

Wonglimpiyarat & Jarunee. (2016). The innovation incubator, university business incubator and technology transfer strategy: The case of thailand. *Technology in Society*, *46*, 18–27. https://doi.org/10.1016/j.techsoc.2016.04.002

Yadav, S. e. a. (2019). Emerging trends in high-tech entrepreneurship: A review and research agenda. *Journal of Small Business Management*, *57*(S2), 295–322.

Yin, R. K. (2003). *Case study research: Design and methods*. SAGE Publications.

Yin, R. K. (2009). *Case study research: Design and methods*. Sage Publications.

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th). SAGE Publications.

Yusubova, A., Andries, P., & Clarysse, B. (2019). The role of incubators in overcoming technology ventures' resource gaps at different development stages. *R&D Management*, *49*(4), 638–653. https://doi.org/10.1111/radm.12352

Zhang, Y. (2022). Incubator programs and their role in supporting early-stage startups in tech industries. *Entrepreneurship Theory and Practice*, 1–20.

Zhu, H., & et al. (2019). The impact of conflicting logics on collaboration between academia and industry. *Research Policy*, *48*(2), 436–449.

Appendix

A Literature Review

A.1 Sorted Citations by Time used

Citation Title	Author	Date	Times Used	Section Used
Entrepreneurial learning: New insights	Romme, A. G. L., & Reymen, I. M. M. J.	2018	3	2.3, 5
Accelerating the development and diffusion of new energy tech	Weyant, J. P.	2011	3	2.3, 5
Navigating the challenges of deep tech innovation	Sadeh, A., & Dvir, D.	2020	3	2.3, 2.5
Role of incubators in venture building	Bergek, A., & Norrman, C.	2008	3	2.5, 2.5.4
Designing a deep-tech venture builder to address grand challenges	Romme, A. G. L., Bell, J., & Frericks, G.	2023	2	2.3.2, 5
The lean startup: How today's entrepreneurs use continuous innovation	Ries, E.	2011	2	2.3, 5
Collaboration dynamics in high-tech ventures	Rencher, L.	2017	2	2.4
Crossing the valley of death	Ellwood, P., Williams, C., & Egan, M.	2022	2	2.3.3
Incubating startups in the digital and tech sector	Kruachottikul et al.	2023	2	2.5, 5
Business Incubators and Accelerators: A Co-Citation Analysis	Hausberg and Korreck	2020	2	2.4
Knowledge flow in technological business incubators	Rubin et al.	2015	2	2.4, 5

Citation Title	**Author**	**Date**	**Times Used**	**Section Used**
Communicating the value proposition of new deep-tech ventures	Schutselaars, J.	2023	2	2.5.4
Mittelstandsmanagement: Einführung in theorie und praxis	Reinemann, H.	2019	2	2.3.2
Philanthropic investments in deep tech start-ups	Rudat, S.	2022	2	2.5.5
Navigating deep tech challenges	Capatina et al.	2024	2	2.3.3
Business incubators and startup sustainability	Adegbite, O.	2001	2	2.4
Against all odds: How Eindhoven emerged as a deeptech ecosystem	Romme, A. G. L.	2022	1	2.5.4, 2.5.5
What is an emerging technology?	Rotolo, D., Hicks, D., & Martin, B. R.	2015	1	2.3.1
Systems of innovation	Mankins, J.	2009	1	2.3.1
The role of marketing activities in the fuzzy front end of innovation	Schoonmaker, M., Carayannis, E., & Rau, P.	2013	1	2.3, 5
The role of artificial intelligence and distributed computing	Rodríguez González, S. et al.	2020	1	2.3.3
Exploring the University-Industry Cooperation	Parmentola et al.	2021	1	2.5
Intrapreneurship: Eine empirische analyse	Schonebeck, G.	2010	1	2.3.2
DT Startups in The Netherlands	Various Authors	2023	1	4
How to Avoid the Valley of Death	McCarthy, J.	2014	1	2.3.3
A lifecycle model for deep tech startups	Schuh et al.	2022	1	2.3.2

Citation Title	**Author**	**Date**	**Times Used**	**Section Used**
Business accelerators: Co-Citation Study	Hausberg et al.	2017	1	2.4.2
Communicating value to investors	Schutselaars, J.	2023	1	2.5.4
Cultivating invisible impact with deep technology	Siegel, J. & Krishnan, S.	2020	1	2.3, 2.5
Lessons from biotech innovation	Siegel, D. S., & Wright, M.	2007	1	2.4
Deep tech: Unveiling the foundations	Romasanta, A., Ahmadova, G., Wareham, J.	2023	1	2.3.1
Cultivating tech ecosystems	Hellmann, T., & Puri, M.	2008	1	2.3, 2.5.5
Dynamic capabilities for tech ventures	Faccin, K. & Martins, B.	2018	1	2.5.5
Supporting sustainable innovation ecosystems	Pfeffer, J. & Salancik, G.	1978	1	2.5
Creating tech-based competitive advantage	Barney, J.	1997	1	2.5.4

Table 21. Sorted Citations by Time used

A.2 Deep Tech dimensions and criteria

Table 22. Adjusted Deep Tech Criteria Based on Two Articles

Dimensions	**Definitions and Characteristics**	**References**
Deep as Fundamental	Based on significant scientific discoveries or engineering innovations. Technologies are unique and protected by IP.	Siegel and Krishnan, 2020; Nedayvoda et al., 2020
Deep as Problem-Oriented	Aims to solve large, DT is often developed to address unprecedented technical challenges beyond the scope of market-ready solutions.	Portincaso et al., 2019; Nedayvoda et al., 2020
Deep as Technologically Advanced	Utilizes advanced existing or emerging technologies such as AI, quantum computing, synthetic biology, or advanced materials.	Siegel and Krishnan, 2020; Nedayvoda et al., 2020
Deep as developed by highly qualified entrepreneurs	Initiated by entrepreneurs with advanced degrees (PhDs or postgraduates) and deep expertise in their fields.	Siegel and Krishnan, 2020; A. G. L. Romme and Reymen, 2018
Deep as Complex and Interdependent	Requires understanding of various interdependencies and advanced integration of different scientific disciplines.	Siegel and Krishnan, 2020; Nedayvoda et al., 2020
Deep as Requiring Long Development Cycles	Involves extensive research and development phases before reaching the market, with longer development timelines.	Nedayvoda et al., 2020; Conforto et al., 2014
Deep as Profound Impact	Instead of targeting specific markets, deep tech tends to create entire markets. Best described by Smith and Doe, 2020 as 'a new paradigm' of market creation.	Kuhlmann and Rip, 2018; Fini et al., 2018; Grimm et al., 2021; Jun et al., 2022
Deep as Collaborative Ecosystem	Engages with a broad ecosystem including universities, research institutions, government bodies, and other enterprises due to the complexity and scale of innovations.	Portincaso et al., 2019; de Jong, 2011; A. G. L. Romme and Reymen, 2018

A.3 HighTechXL

Table 23. HighTechXL Services and Corresponding Lifecycle Stages

Service/Method	Lifecycle Stage
Building alliances with corporate partners and leveraging the Eindhoven Startup Alliance.	Incubation/Preparation
Connecting venture teams with local technical and market experts.	Incubation/Preparation
Using facilities of partners like TNO and Philips for prototype testing.	Incubation/Preparation
Implementing a structured recruitment and selection process for entrepreneurial talents.	Team Formation & Development
Using a four-phase process that includes self-assessment tools and interviews.	Team Formation & Development
Developing a talent acquisition framework based on criteria like innovativeness, risk-taking, and proactiveness.	Team Formation & Development
Creating financial instruments such as the DeepTechXL investment fund.	Seed Funding & Investment
Exploring innovative financial mechanisms, including blockchain-based instruments.	Seed Funding & Investment
Running FasTrackathons to match technologies with entrepreneurial talent.	Startup Creation
Forming venture teams and incorporating them as legal entities with initial equity distribution.	Startup Creation
Implementing a DTV (Deep-Tech Venture) journey model with nine maturity levels.	Growth & Scaling
Regular assessments of venture progress across business model, market, financial support, product development, etc.	Growth & Scaling
Providing access to mentors who offer strategic guidance and support.	Scaling & Development
Offering workshops, pitch training, and networking opportunities with experts.	Scaling & Development
Corporate talent mentoring program that immerses professionals in the venture-building process.	Scaling & Development

A.4 Theoretical Framework

Hereby the development mechanisms for the stage-gate framework.

- Agile Development: Emphasizes adaptive planning, iterative progress, and flexibility, allowing the project team to break down the development process into small, manageable tasks, rapidly test hypotheses, and adjust to feedback quickly (R. G. Cooper, 2016).

- Lean Startup: Focuses on building a Minimum Viable Product (MVP) quickly, followed by continuous testing and learning through user feedback, to validate or pivot the business idea before committing significant resources (Ries, 2011).
- Design Thinking: Involves understanding user needs deeply and creating prototypes that are iteratively tested and refined to ensure the final product aligns with real-world user requirements (T. Brown, 2009).

Table 24. Pain points and recommendations incorporated in the Augmented Stage-Gate framework

Pain Points	**Recommendations**
Unclear business requirement and lack of yet-to-be-developed commercial applications	Encourage startups to set up a market hypothesis and then test, measure, and learn with target users through a faster, more iterative, and inexpensive process.
Lack of entrepreneurship knowledge and skills, and no time to commit to a new full-time business venture	Provide a flexible and systematic entrepreneurial development program and innovation clinic to help increase skills, confidence, and an entrepreneurial mindset before setting up a new venture.
Lack of business network	Connect startups to a network of mentors and alumni with business backgrounds in the same domain.
Require large amounts of financing	Encourage startups to develop awareness, strategies, and be active in fundraising activities from the beginning.
Unclear research-to-commercialization journey leading to loss of confidence and morale	Provide a network of process management specialists and mentors to guide the entire journey. Apply the concept of Agile development processes.
Need strong help on IP, legal, and regulatory-related issues	Provide legal experts to assist.

Continued on next page

Table 24 – *Continued from previous page*

Pain Points	**Recommendations**
Complex technology and research that are difficult for out-of-domain stakeholders to assess and understand	Encourage startups to quickly develop and demonstrate a user-facing prototype, even if non-functional at the beginning, to measure customer satisfaction or purchase intent. Provide assessment tools for startups and committees to evaluate and communicate development progress in terms of technology and business.
Lengthy time-to-market	Encourage startups to apply the concepts of adaptive, flexible, and Agile development. Also, find a quick-win strategy to split tasks and set goals for both short-term and long-term objectives.

B Methodology

B.1 Companies contacted

Company Name	**Qualifies as Deep Tech**	**Industry**	**Incubated**	**Years Active**
Delft Cymatics	Yes	Acoustics	No	1 year (Founded 2023)
Q Bird	Yes	Communication	No	2 years (Founded 2022)
SonoSilicon	Yes	Semiconductors	No	[Information not found]
Hypersoniq	Yes	Aeronautics	No	[Information not found]
Vibrotwist	Yes	Robotics	No	2 years (Founded 2022)

Ore Energy	Yes	Renewable Energy	No	[Information not found]
SoundCell	Yes	Medical Devices	No	[Information not found]
Exculture	Yes	Biotechnology	No	[Information not found]
Imsystems	Yes	Robotics	Yes	[Information not found]
Qphox	Yes	Quantum Computing	Yes	4 years (Founded 2020)
Councyl	Yes	Biotechnology	Yes	[Information not found]
Lightyear	Yes	Renewable Energy	Yes	[Information not found]
APTA Technologies	Yes	Healthcare	Yes	[Information not found]
Whiffle	Yes	Meteorology	Yes	[Information not found]
VSParticle	Yes	Materials Science	Yes	[Information not found]
Umincorp	Yes	Waste Management	Yes	[Information not found]
Stokhos	Yes	Emergency Services	Yes	[Information not found]
BlueGen.ai	Yes	Data Privacy	No	[Information not found]
Innatera Nanosystems	Yes	Microprocessors	Yes	[Information not found]
Delft Advanced Biofuels	Yes	Biofuels	No	[Information not found]
Battolyser	Yes	Energy Storage	Yes	[Information not found]

Table 25. List of Deep Tech Companies with Years Active