Success Factors of Deep Tech Incubators: A Qualitative Study

Dario Meyer[1], Francesco Colonna[2] and Rolf Meyer[1]
[1]University of Applied Sciences and Arts Northwestern Switzerland
[2]Stäubli Electrical Connectors AG, Switzerland

dario.meyer@fhnw.ch
f.colonna@staubli.com
rolf.meyer@fhnw.ch

Abstract: Deep tech start-ups, characterized by their focus on groundbreaking technologies and scientific advancements, face unique challenges that demand specialized support systems for their development and market entry. This paper presents a qualitative analysis based on ten interviews with managers of deep tech incubators, exploring the services offered, critical success factors, challenges and anticipated future changes. The services provided by incubators are comprehensive, ranging from technical and business mentorship to assistance in regulatory processes and access to financial resources. The study identifies that the success of deep tech incubators depends on customized support for start-ups, access to expertise and facilities, and a strong ecosystem and community network. Customized support ensures that the unique needs of each start-up are met, while access to technical resources and a vibrant network facilitates innovation and growth. Challenges such as cultural and mindset differences, operational difficulties, and regulatory navigation underscore the complex landscape in which these incubators operate. Anticipated changes within the next few years include a shift in investment focus towards projects with significant societal impact, an increase in international collaboration, and a deeper recognition of deep tech's role in solving global challenges. This paper contributes to the understanding of deep tech incubation, highlighting the support required to foster innovation in this sector. The insights from this study can inform policymakers, investors, and managers of deep tech incubators on fostering a conducive environment for innovation and growth in the deep tech sector.

Keywords: Incubator, Entrepreneurship, Start-ups, Deep tech, Start-up support

1. Introduction

The number of incubators has risen tremendously over the past 50 years and so has the number of research published on the topic. Incubators provide support services and resources to early-stage companies to help them grow and succeed. The definition and approach to incubators varies greatly and therefore, also the research is fragmented and the impact often difficult to compare (Aernoudt, 2004). As the landscape evolves, new models of incubation are emerging, tailored to specific industries and technologies, further diversifying their impact and reach.

A remarkable example is the so-called deep tech-sector, which has risen to prominence over the past decade. Start-ups in this sector work on disruptive technologies that require big capital investments and have traditionally long research and development processes (Kask & Linton, 2023). As with start-ups itself, also the number of incubators focusing on deep tech have increased.

There have been studies on the success factors of support programmes for start-ups in various contexts, for example general business incubators (Theodorakopoulos et al., 2014), accelerators (Mann et al., 2020) or science and technology parks (European Commission, 2014). We are not aware, however, of a study looking at the niche of deep tech-incubators. Therefore, we focus on deep-tech incubators with the following research questions:

- What is success for a deep tech-incubator?
- What are the success factors of deep tech incubators?
- What are challenges and barriers for deep tech incubators?
- What are the expected changes in the field of deep tech-incubators?

This paper firstly reviews literature on the state of knowledge and to clarify the different usage of the deep tech terminology, proposing an analytical definition. Secondly, the methodology is described on how the ten interviews were conducted and analysed. After, the results are presented followed by a discussion and conclusion.

2. Background

2.1 Towards a Definition of Deep Tech

The term deep tech has been used for about a decade by start-ups, venture-capital firms, and policymakers to indicate a special class of high-tech companies. Earlier uses of the term “deep technology“ do exist (Storms 1998,

Lee, 1999, Christensen 2002) but do not seem to be directly related to the current usage of this term. Despite its interest and wide usage, a discussion on the notion of deep tech is missing in the scientific (academic) literature. By comparing four definition attempts (Chaturvedi 2015; De la Tour et al. 2017; Portincaso et al., 2019; European Startups 2021) we notice that some basic aspects of deep technologies appear in all cases, but as a mix of business and technological characteristic attributes, for example the quality and novelty of the technology, its innovation potential, and the impact and the risk characteristics of the business built around it. However, a such characterization is in our view insufficient as clear, analytical, definition.

The other apparent feature in the current use of the term, is that per se it does not refer or restrict to a specific industry, although some industrial sector seems are naturally associated with deep technology, as shown in table 1 (Chaturvedi, Swati, 2015, Portincaso et al. 2019, European Startups 2021). We propose to systematise the existing definitions by defining deep technology based only on substantial features of the technology itself (intrinsic definition), and subsequently derive a definition of deep tech business, however keeping it separated of all the typical traits of it (characterization), which are usually but not always or not entirely associated to it.

Table 1: Own definition of deep tech for this research

Intrinsic Definitions: **Deep technology & deep tech business**	**Typical traits Deep tech business (Characterization)**	**Examples of Industry**
Deep technologies: based on substantial and unique scientific or engineering advances, either with protected IP or hard-to-reproduce. Deep tech-business: addresses an unmet market need or disrupts and existing market by leveraging on deep technology.	- Usually result of intense R&D. - Require a significant amount of capital in R&D and beyond: R&D, industrialization, commercialization - Take a long time to reach market-ready maturity - High market risk, as the market demand for the product is not proven - Expected to have a big impact (economic, societal, environmental)	- Advanced materials - Artificial intelligence - Biotechnology/life-sciences - Blockchain - Cleantech& energy - Drones and robotics - Medtech - Photonics and electronics - Space - Quantum Technologies

We adopted a definition of high-tech businesses that does not assume a high market risk, although it implies it as a usual trait. With the intrinsic definition we adopted, strictly speaking there is not a deep tech industry per se, but rather industries that are more or less likely to be impacted by deep tech technologies, and markets more or less likely to be entered or even disrupted by deep tech companies. Although similar traits are present in terms of technology development, market risk and needs for investment and business support, there is also a significant in-group diversification. For example, Biotech has a higher need for investment in all stages, while Artificial intelligence start-ups need relatively low financing in early phases. Hardware-oriented startups rely predominantly on non-equity funding until the prototype phase, while the needs of investment differ hugely in later phases (Portincaso 2019). We therefore propose a secondary categorization of deep-tech based enterprises based on their industry-related growth needs:

- Hardware: Advanced materials, drones and robotics, cleantech& energy, medtech, photonics and electronics, space, quantum technologies (sensing), computing hardware
- Software: Blockchain, quantum technologies (computing, simulations, quantum information), artificial intelligence
- Biotech: Biotechnology, life-sciences

2.2 Incubators

The terms incubator and accelerator have often been used interchangeable, as they both focus on the development of early-stage businesses. Taking the overall topic of deep technology into consideration, also the

term science park is added, as it is often used in connection with tech start-ups and has its own incubation programmes.

There are many definitions of incubators and the services a typical incubator offers, many of them similar. In general, "business incubation is regarded as an entrepreneurship development tool for promoting innovation, economic growth, and employment generation" (Theodoarkopoulos et al, 2014). Incubators support early-stage businesses in their development to become market-ready through a combination of offerings. The goal is to get proof-of-concept, set up the start-up team and minimise the risks around the newly founded company (Miller & Stacey, 2014). While there are differences in some aspect, such as the financing model, there are also typical recurrent traits in membership requirement and offer. Membership is usually open-ended, without a fixed duration, and the admission process is less strict. The following elements are usually offered by incubators (Bergek & Norman, 2008; Bone et al. 2017; van Weele, 2020):

- 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

Accelerators offer many similar services like incubators, but usually have a fixed duration for which participants can apply until set dates and include a financial contribution of the accelerator, often in return for equity (Bone et al., 2017). Additionally, Cohen & Hochberg (2014) distinguish accelerators from incubators through "its intensity, the provision of a stipend and services and the cohort-based nature of accelerator program" with a highly selective admission process (Cohen & Hochberg, 2014; Bone et al. 2017). Accelerators can also be associated to different organisations. Early programmes were mostly set up by venture capitalists and business angels. Today, also governments, corporations, universities, or NGO's run accelerators. (Cohen & Hochberg, 2014) They mostly do not charge fees to the start-ups, but rather finance themselves through equity of the participants. Therefore, accelerators look for scalable businesses to finance their activities.

Science parks have the offerings of a traditional incubator, but typically also have additional services, especially on transfer of and collaborations within R&D as they focus on technologies as well (IASP, n.d.). Science parks may or may not have a focus on a particular industry, based on their partner institutions. The main technology sectors that are based within science parks are ICT & communications, biotechnology, computer science and hardware, electronics, software engineering, health & pharmaceuticals. (IASP, 2018) They are usually funded by the organisation that they are affiliated with and through private and corporate sponsors.

2.2.1 Success factors of incubators

Various success factors have been identified by scientific works on incubators:

- The selection and admission policy of the incubatees (Alzaghal & Mukhtar, 2017)
- The exit / graduation policy (Theodorakopoulos et al., 2014).
- The provided resources (often as shared office space and other shared resources)., including mentorship for example on regulations or technologies. (Theodorakopoulos et al., 2014; Alzaghal & Mukhtar, 2017)
- Access to capital, either through incubators' own fund or through relationships with business angels and venture capitalist (Theodorakopoulos et al., 2014)
- Networking opportunities (Alzaghal & Mukhtar, 2017; Mann et al., 2020)
- The competences of the team, the methodology and the organisational setup of the incubator (Theodorakopoulos et al., 2014).
- And lastly the monitoring of the performance of the incubated firms (Theodorakopoulos et al., 2014).

2.3 Deep Technology Incubation Programme

When compared to a traditional incubator, a deep-tech incubator shows major differences. The most evident is the focus: while many incubators do have a specific industry focus, deep tech incubators focus – as the name suggest – on deep technologies. Moreover, deep tech incubators have some additional services regarding to R&D and knowledge transfer, such as access to lab spaces. Also, deep tech incubators are connected to universities, research institutions or a corporate with a strong R&D-department, while none-deep tech incubators can have ties to universities or other corporations, but many also stand alone. A study analysed the needs of deep tech start-ups and where they would most likely go for to satisfy them (Harlé & Sousson, 2017).

Incubators and accelerators are the preferred partner for business knowledge and expertise, access to facilities and talent acquisition. For market access, the start-ups would choose corporations as partners, for funding business angels and venture capitalists, while universities are preferred for technical knowledge and expertise. Through the connection to universities and corporations, deep tech incubators can offer a broad range of the services required by deep tech start-ups.

In the present study we focus on deep tech incubators based on the following definition. Deep tech incubators:

- are an entrepreneurship development tool for start-ups that are based on substantial and unique scientific or engineering advances, either with protected IP or hard-to-reproduce, and address an unmet market need or disrupts an existing market by leveraging on deep technology.
- typically offer mentoring, training, office and lab space, access to the incubator's network, access to funding and technical support.
- are associated with a university or another research institution, including corporations.

3. Methodology

3.1 Sample and Data Gathering

This qualitative study focuses on European deep tech incubators. A sample of 23 incubators from 13 countries (list available from the authors) has been constructed. to include examples of incubators affiliated to European big science networks, as well as to leading research institutes or universities and with a clear history of success. The sampling also took care to be able to discriminate between incubation models, and to represent several of the major and most innovative European Countries. All incubators were contacted via e-mail and where possible via phone. Ten incubators agreed to be interviewed.

The interviews were semi-structured and were conducted online. The interviews lasted between 45 and 60 minutes. They were recorded and transcribed to allow a detailed analysis.

3.2 Measures of Variables

The survey was based on a questionnaire developed based on the research questions and the literature. The focus areas where the details of the interviewed incubators, their success factors as well as anticipated changes within the incubator, but also in the ecosystem.

3.3 Data Analysis Procedure

A qualitative content analysis of the ten interviews was done, using the software atlas.ti, which facilitated systematic organization and categorization of the extensive interview transcripts. A coding system was developed based on key themes and questions from the interview guide. The coding process consisted of multiple iterative stages, beginning with open coding to identify initial patterns. Through constant comparison and refinement, these codes were then organized into subcategories, allowing for a higher level of abstraction and thematic grouping.

4. Results

Based on the ten interviews, we analysed the services offered, definitions of success, success factors, barriers, and challenges as well as expected changes in the next five years.

The interviews reveal a comprehensive range of services offered by deep tech incubators. These services are designed to address both the technical and business aspects of start-up development.

- Access to technical resources and facilities as well as labs.
- Technical and business mentorship: These are mostly intense programmes tailored to the needs of the start-ups. A few take in cohorts on regular basis.
- Coaching for all legal aspects, specifically about the protection of intellectual property.
- Offering financial support directly to start-ups, including investments and guidance on securing additional funding. Increasing the investor readiness of the start-ups is also an important factor here.
- Assisting start-ups in finding a market for their ideas, transforming ideas into viable products, and identifying the most promising industries for their technologies.
- Help to develop a product that can be delivered to the market, training them in business aspects while they develop their technology.
- Networking and matchmaking with potential partners, investors, and customers.

- After the incubation phase, some incubators offer acceleration programs to further support start-ups in scaling their business, market validation, product marketing, and engaging with real customers.

4.1.1 What is success?

To understand success factors, we first have to look at what the incubators understand as success.

One of the most mentioned factors is the creation of start-ups, which can be measured in different ways. It is mentioned that the number of teams in the incubators, successful financing rounds and the survival rate of start-ups are used as measurement tools, of which the successful financing rounds seem most important as one interviewee said *"our number one metric is the capital raised by the start-ups that we support"* and another *"our success metrics are really the amount and the number of those series A capital raises"*. Also, reaching different stages in technology and market validation are considered, for example the readiness in technology, team, or business model.

A second important factor is job creation and the broader impact in economy and society that the incubator and its ventures have. Not to be neglected are the financial returns. The incubators can get shares in the ventures they support. With successful financing rounds and/or exits the incubators receive a financial reward that will allow them to continue with their operations. These factors show that success goes beyond financial measurements and also look at the impact on society or the number of start-ups that reach technological readiness.

4.1.2 Success factors

There have been many success factors mentioned and most are connected to the offered services.

Firstly, the connection to a collaborative ecosystem. In particular, institutes of higher education are crucial and with it comes access to expertise on the one hand, but also to facilities on the other hand, which can include labs and specialized equipment. This access can significantly reduce the capital required for the teams to develop their technologies. Partnerships to raise capital also come into play here, which can be business angels, venture capitalists or also organisations that provide grants. These two points are also part of a needed collaborative ecosystem, that should also have a strong network of start-ups supporting each other.

Secondly, a strong strategy in regard to intellectual property is also crucial, as it helps to protect the innovations and provides start-ups with a competitive edge in the market.

Thirdly, the selection of start-ups is important, as the start-ups are obviously the basis for the successful incubation. The two main factors are the technology and the team. Most of the incubators have strict selection processes and very low acceptance rate.

Fourthly, a customized approach in supporting the start-ups is essential as the needs of all of them are different. An important factor herewith is a pool of experts that contains subject matter experts on the technological side, but equally important also successful entrepreneurs, who can share their experiences and knowledge. One manager mentioned that *"also a success factor for me would be: are you responsible [as an incubator] and are you delivering what the team needs? Or are you just telling people that you are a good service provider?".* This leads to the success factor of how the incubator itself is organised. It needs a strong methodology with a strong team that accompanies and challenges the start-ups regularly to ensure that they reach their milestones.

4.1.3 What are the challenges and barriers?

The cultural and mindset challenges are a hurdle for the incubators. The teams are traditionally very diverse in terms of background and cultures. This can lead to difficulties in finding a common language. The mindset of the universities can also be a challenge on two sides. They have often slower processes and are less adaptable to the dynamics of a start-up, which can slow everyone down. Also, they sometimes lack the motivation to create spin-offs. This makes it difficult for the incubators to find the technologies and people within the universities. However, this seems to change recently. One manager mentioned that *"I can see that more and more academic people are interested in trying out to spin off a company or start the company. That has changed […] especially during the last five to six years so the newer generation is kind of interested in alternatives to the academic career"*.

Once the technologies have been found, there is the challenge of bridging the gap between the technology, its application by a start-up and the market access. In this factor, also a lack of business awareness of the founders plays a role. One incubator said that *"second, [and] I would even put it as even more important [success factor],*

is that business awareness of these teams is missing, the ability to understand how to generate or to create a company, how to create a business out of their ideas". It is therefore necessary for the incubators to find business-minded people that can join the teams.

The incubators also face operational challenges. One is the lack of space to accommodate the start-ups. Second is the team composition of the start-ups and their ability to keep up with the speed of the incubation programmes. And third is the funding for the incubators themselves, which are often partly dependent on government funding or on funds that are tied to a certain programme. This can be uncertain at times. Lastly, there are also regulatory challenges. The start-ups often face difficulties navigating regulatory environments, and incubators may struggle to provide adequate support in this area, despite having a voice in relevant ministries or governmental bodies. These challenges highlight the complexity of operating deep tech incubators, which have to find a balance between supporting the start-ups, ensuring financial sustainability, fostering a conducive cultural and operational environment, and engaging effectively with broader ecosystems and networks.

4.1.4 What changes are expected?

The interviewees expect several changes in the deep tech landscape in the next few years, highlighting shifts in investment priorities, technological development, and the broader ecosystem. The increasing recognition of deep technologies in addressing societal challenges will likely continue and lead to a shift in start-up-creation and investment towards sustainability. This includes the trend of having more "zebras" rather than "unicorns". Zebras are start-ups that are not solely focused on financial gains but prioritize a positive impact in the world. In regard to the investment, there is an expected shift towards an even longer-term mindset. The development of deep technologies can span over a decade or more and investors need to be ready to have a long breath.

Another expected change is towards even more internationalization and global collaboration of the incubators and their start-ups. A change from a competitive to a more collaborative mindset will happen. This should lead to a pooling of resources and expertise, which bring better and quicker developments. This is also seen as crucial to establish Europe as a global player in the deep tech landscape. These expected changes reflect a broader understanding of the need for innovation that not only offers financial returns but also addresses the pressing challenges facing society today. The emphasis on collaboration, societal impact, and long-term investment strategies indicates a maturing of the deep tech ecosystem towards more sustainable and impactful innovation.

5. Discussion

Firstly, the proposed definition of a deep tech-incubators has been confirmed as effective and useful by the interviews. In deep-tech incubators start-ups work on substantial and unique scientific and engineering advances that disrupt existing markets or create new markets altogether. The offerings can be summarized as proposed with mentoring, office and lab space, networking, funding, and technical support. Training has not been mentioned often but is based on the websites also part of the incubators. And lastly, they are all connected to a university or other research institution. Interestingly, the majority of incubators do not have focus industries, but is rather broad in the areas of deep tech. Therefore, the validated definition is:

> *"Deep tech incubators are an entrepreneurship development tool for start-ups that are based on substantial and unique scientific or engineering advances, either with protected IP or hard-to-reproduce, and address an unmet market need or disrupts an existing market by leveraging on deep technology. They typically offer mentoring, training, office and lab space, access to the incubator's network, access to funding and technical support and are associated with a university or another research institution including corporations."*

For the definition of success, it can be summarized that the number of successfully funded start-ups are the most important metric. This number of start-ups is a used metric in every incubator, including also derived indicators like start-ups reaching market readiness or that are established on the market (Doga-Mirzak & Naval, 2014); however, the strong focus on successfully funded start-ups and start-ups that reach later stage funding seems to be stronger in deep tech-incubators. A second component that becomes more important is the societal impact of the start-ups, which has been part of incubators focusing on sustainability. One metric that is often mentioned in the literature is the economic impact including the creation of jobs (Mubarak AL-Mubaraki & Busler, 2014), which has also been mentioned by the deep tech-incubators. Hence, success is defined very similar to traditional incubators with a stronger focus on later stage financing rounds and the impact on society.

One of the most important success factors for an incubator is the selection of its start-ups. This has also been confirmed in other literature on incubators and accelerators. (Theodorakopoulos et al., 2014; Mann et al., 2020). They build the basis and without them the best mentorship or networking opportunities will not help in supporting successful start-ups. For deep tech-incubators, this factor is even more important, as their start-ups have long research and development times and require large capital investments. Part of this is the importance of looking at the team and ensure that they are capable of developing the respective start-up. Therefore, all of the incubators have rigorous selection processes and low acceptance rates. However, there is no generally agreed way of selecting start-ups, neither in the interviews nor in the literature (Alzaghal & Mukhtar, 2017).

The connection to a research institution or a corporate is also seen as crucial for the incubators, which is less the case in traditional incubators, as they are often independent. This connection is crucial for two reasons. Firstly, it is a way for the incubators to source technologies and talents for their programmes. Secondly, as deep tech-start-ups usually need more than just a shared office space, it gives the start-ups access to research facilities, such as specialised labs, and expertise from the academic staff. These partnerships should then be part of broader ecosystem that the incubators can mobilize to get additional resources in. While the ecosystem is an important part of every start-up, strong connections to research institutions and other ecosystem players seem to be even more important for deep tech-incubators. The partnerships with universities have also been mentioned as a challenge. There is a reluctance to create spin-offs in certain departments or universities; however, it is mentioned that the newer generation of researchers is more open towards these possibilities.

There were other success factors mentioned. A strong strategy in intellectual property is also more needed in deep tech. While all companies have to think about the topic, it is often the technological advancement that have to be protected. Therefore, a traditional incubator with a less tech focus needs less resources in this area. The customized approach and the strong team and methodology are also a success factor for other incubators and do not seem to be specific for the deep tech-landscape. Thus, another important factor is that deep tech-incubators need a strong team to protect the research results of their start-ups.

The expected changes could influence the success factors in the future twofold. It will lead to more start-ups that focus on societal impacts and incubators need to find a way on how to deal with zebras instead of unicorns. Through the focus on impact and less on financial returns, there might be different investors needed or also a shift in the priorities of the investors. Also, a more collaborative approach around the globe means that it will become crucial to develop international networks for exchange of knowledge, resources, and talents. Thus, these two factors might be added to a list of success factors in the future.

6. Conclusion

This paper examines incubators that focus on start-ups in the deep tech space. It shows that the success factors are very similar to those of traditional incubators. They can be summarized as a rigorous selection process, strong ties to a research institution or company, a functioning local ecosystem including investors, a customized approach to incubation, and a working strategy regarding intellectual property. The operational set-up of the incubator, including its methodology and team, is also crucial. In the future, it is expected that incubators increasingly focus on societal impact and international collaboration.

This research has certain limitations. It only looked at 12 incubators, which can lead to certain biases. Also, interviews with managers of traditional incubators can be added to allow a direct comparison and not just a comparison with existing literature. Further studies can investigate the details of the success factors and develop best practices for them. For example, how does a good selection procedure of start-ups look like and how can the relationships with research institutions be implemented in the best way.

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