



VILNIUS UNIVERSITY
BUSINESS SCHOOL

DEEPTech ENTREPRENEURSHIP

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THE FINAL MASTER'S THESIS

<i>TITLE</i>	<i>TITLE</i>
<i>NUO CERN LABORATORIJOS IKI RINKOS: PREKĖS ŽENKLO VAIDMUO KOMERCIALIZUOJANT AUKŠTŲJŲ TECHNOLOGIJŲ INOVACIJAS</i>	<i>FROM CERN LAB TO MARKET: THE ROLE OF BRANDING IN COMMERCIALIZING DEEP-TECH INNOVATIONS</i>

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SUMMARY

VILNIUS UNIVERSITY BUSINESS SCHOOL
DEEPTECH ENTREPRENEURSHIP

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FROM CERN LAB TO MARKET: THE ROLE OF BRANDING IN COMMERCIALIZING
DEEP-TECH INNOVATIONS

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Master's thesis was prepared in Vilnius, in 2025

Scope of Master's thesis – 150 pages.

Number of tables used in the FMTP – 5 pcs.

Number of figures used in the FMTP – 4 pcs.

Number of bibliography and references – 63 pcs.

The FMTP described in brief:

The master's thesis analyzes the role of branding in facilitating the transfer of high-tech innovations that have been developed at CERN. The study aims to address the role of the brand as a means that enables the presentation of scientific achievements in a manner that the public can understand and acknowledge. Emphasis has been placed on the reputation of the brand and its goal-oriented communication in the CERN Knowledge Transfer environment.

Problem, objective and tasks of the FMTP:

Problem: The startups working on deep-tech, which are generated in research-intensive environments like CERN, are expected to overcome some serious issues related to commercialization.

Objectives: To investigate the importance of branding for the process of commercializing deep-tech innovations originating from CERN.

Tasks:

1. To explore the core structural and communication hurdles faced by deep-tech commercialization.

2. Analyze branding as the process of building integrity and simplifying complexity.
3. Empirically studying branding processes within the CERN Knowledge Transfer environment.

Research methods used in the FMTP:

The study employs a qualitative approach, which involves a literature review as well as semi-structured expert interviews. The empirical data is gathered through conducting interviews with CERN Knowledge Transfer experts, deep-tech entrepreneurs, and communication specialists. The data is analyzed through the use of thematic coding.

Research and results obtained:

The results indicate that branding has an important function in terms of decreasing cognitive complexity, indicating credibility, and aligning stakeholder expectations when faced with a lack of initial market indicators. Institutional reputation, framing of missions, and peer-to-peer communication were found to be important drivers that facilitate the commercialization of technologies of CERN origin.

Conclusions of the FMTP:

The conclusion states that branding has become an essential part of the commercialization process for deep-tech, rather than an add-on marketing activity. When incorporated effectively into the processes related to technology transfer, branding can lead to efficient formation and effective communication with different groups of stakeholders, ensuring market entry success.

Information about the publication of FMTP results or adaptation for publication:

This master's thesis provides results that can be applied in a practical manner to technology transfer offices or deep-tech start-ups, and which can be used as a foundation for further research on branding in science-based innovation environments.

SANTRAUKA

VILNIAUS UNIVERSITETO VERSLO MOKYKLA
GILIOSIOS TECHNOLOGIJOS VERSLUMASAMRAH ABBASZADE
NAMIG JAVADLINUO CERN LABORATORIJOS IKI RINKOS: PREKĖS ŽENKLO VAIDMUO
KOMERCIALIZUOJANT AUKŠTŲJŲ TECHNOLOGIJŲ INOVACIJAS

Prof. Saulė Mačiukaitė–Žvinienė

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FMTF panaudotų lentelių skaičius – 5 vnt.

FMTF panaudotų paveikslų skaičius – 4 vnt.

Bibliografijos ir nuorodų skaičius – 63 vnt.

Trumpai aprašytas FMTF:

Magistro darbe analizuojamas prekės ženklo vaidmuo palengvinant CERN sukurtų aukštųjų technologijų inovacijų perdavimą. Tyrimo tikslas – nagrinėti prekės ženklo, kaip priemonės, leidžiančios pristatyti mokslinius pasiekimus visuomenei suprantamu ir pripažintu būdu, vaidmenį. Dėmesys skiriamas prekės ženklo reputacijai ir tikslingai komunikacijai CERN žinių perdavimo aplinkoje.

FMTF problema, tikslas ir uždaviniai:

Problema: Tikimasi, kad giliųjų technologijų startuoliai, kurie kuriami intensyviai moksliniais tyrimais paremtoje aplinkoje, pavyzdžiui, CERN, įveiks kai kuriuos rimtus su komercializavimu susijusius klausimus.

Tikslai: Ištirti prekės ženklo svarbą CERN giliųjų technologijų inovacijų komercializavimo procese.

Uždaviniai:

1. Išnagrinėti pagrindines struktūrines ir komunikacijos kliūtis, su kuriomis susiduria giliųjų technologijų komercializavimas.

2. Išanalizuoti prekės ženklo kūrimą kaip vientisumo kūrimo ir sudėtingumo supaprastinimo procesą.

3. Empiriškai tirti prekės ženklo kūrimo procesus CERN žinių perdavimo aplinkoje.

FMTF naudoti tyrimo metodai:

Tyrime taikomas kokybinis metodas, apimantis literatūros apžvalgą ir pusiau struktūrizuotus ekspertų interviu. Empiriniai duomenys renkami atliekant interviu su CERN žinių perdavimo ekspertais, giliųjų technologijų verslininkais ir komunikacijos specialistais. Duomenys analizuojami naudojant teminį kodavimą.

Tyrimai ir gauti rezultatai:

Rezultatai rodo, kad prekės ženklo kūrimas atlieka svarbią funkciją mažinant kognityvinį sudėtingumą, rodant patikimumą ir derinant suinteresuotųjų šalių lūkesčius, kai trūksta pradinių rinkos rodiklių. Nustatyta, kad institucinė reputacija, misijų apibrėžimas ir tarpusavio bendravimas yra svarbūs veiksniai, skatinantys CERN kilmės technologijų komercializavimą.

FMTF išvados:

Išvadoje teigiama, kad prekės ženklo kūrimas tapo esmine giliųjų technologijų komercializavimo proceso dalimi, o ne papildoma rinkodaros veikla. Veiksmingai integruotas į su technologijų perdavimu susijusius procesus, prekės ženklo kūrimas gali padėti efektyviai formuotis ir efektyviai bendrauti su skirtingomis suinteresuotųjų šalių grupėmis, užtikrinant sėkmę patekime į rinką.

Informacija apie FMTF rezultatų publikavimą arba adaptavimą publikavimui:

Šiame magistro darbe pateikiami rezultatai, kuriuos galima praktiškai pritaikyti technologijų perdavimo biuruose arba giliųjų technologijų startuoliuose ir kurie gali būti naudojami kaip pagrindas tolesniems tyrimams apie prekės ženklo kūrimą mokslu grįstose inovacijų aplinkose.

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INTRODUCTION

Research Relevance and Novelty

Scientific and economic advancements are now being driven by the challenges associated with commercializing high-tech innovation. The world's leading fundamental research institutes, including CERN, have developed revolutionary technologies such as the World Wide Web and Advanced Medical Imaging Systems. While many of the above-mentioned technologies were born out of discoveries made in laboratories, there continues to be an enormous gap between developing new technologies through discovery and making them into commercially viable products. This transition from discovery to commercially viable product development is often both a lengthy and expensive process. Industry reports currently estimate that the global High-Tech Market will reach an approximate value of USD \$714.6 billion by 2031, with a cumulative annual growth rate (CAGR) of 48.2%. (IndustriARC, 2024). Although the estimated growth of the high-tech market appears promising, the actual commercialization successes for high-tech ventures continue to be very low; fewer than 5% of high-tech companies receive Series C funding, and even fewer of those high-tech companies are able to generate ongoing sales of over \$10 million. (Dealroom, 2025).

The relevance of this research arises out of the following paradox: although high-tech innovations continue to contribute to both economic and social development, the vast majority of high-tech companies do not successfully navigate what is referred to as "the valley of death" between discovering new scientific ideas and successfully introducing them into the marketplace. One of the primary causes of this lack of success is that there is inadequate attention to branding and its impact on the commercialization of high-tech ventures. Historically, branding was primarily studied in the context of consumer goods markets, however, as is discussed in this study, branding provides a unique function in the deep-tech market. In particular, branding helps to bridge communications gaps, build trust and legitimize complex technologies for multiple stakeholders (BCG, 2023).

This study differs from prior studies in the area of technology transfer and innovation management because it examines branding as a mechanism of commercialization within the CERN technology transfer ecosystem. As is stated above, prior research has examined technology transfer and innovation management broadly, but little systematic research has been conducted examining how branding strategies facilitate the advancement of science through innovation. Therefore, this study fills a significant gap in both theoretical and practical knowledge regarding the mechanisms of knowledge transfer processes at CERN and similar institutions.

Problem Statement and Research Gap

Although CERN has a strong history of developing innovative disruptive technologies from their particle accelerators to new healthcare and environmental applications for their spin-offs, there are still significant hurdles facing most of these technologies as they move out of the lab or research institution and into the commercial sector. These obstacles include the length of time it takes to develop a technology, the large amounts of capital required to do so, the complexity of regulations, and the uncertainty of the market value (Kumar, 2019; Creswell & Creswell, 2018). Additionally, there is also a less studied barrier which includes the difficulty of transforming complex scientific concepts into narratives that effectively communicate with and resonate with investors, companies, regulators and end-users.

The paper examines the potential offered by branding to counter communication and operational obstacles to the commercialization of technologies from the European particle physics laboratory, known as CERN. The main objectives are to develop recommendations to improve the value and market feasibility of deep technologies.

Research Objective

To discover and study branding methods that enhance the commercialization and market entry process of deep-tech innovations originating from CERN labs.

Research Tasks:

1. The first objective is to review successful and failed cases of CERN technology transfer and to assess whether CERN has been able to use branding strategies to produce good results in terms of the commercialization of its technologies.
2. The second objective is to develop a theoretical framework for branding practices that are adapted to high-tech companies and research institutions.
3. The third objective is to provide operational recommendations to CERN, to research organizations and to start-ups on how to improve their branding strategies to increase the chances of success in the commercialization process.

Research Methods

The research incorporates the mixed methodology that has three aspects:

- Structured literature reviews: Scientific and industry publications from 2019 – 2025 regarding the process of transferring technology, branding, and commercializing high-tech technologies in general.

- Semi-structured quality interviews: CERN knowledge transfer experts; High-Tech entrepreneurs and Investors.
- Comparative case-by-case (Simplified): Detailed cases of two or three of the CERN examples (Medipix, PlanetWatch) that are supplemented by short illustrative mini-cases.

These case analyses are used to ground and add depth to the themes that have emerged from conducting interviews.

Limitations and Challenges

There are several limitations to the research. Due to confidential agreements regarding CERN's commercialization information, access to CERN commercialization information in some areas is limited, and therefore, the ability to use some case examples is limited. Also, the relatively small number of CERN side-projects limits the empirical sample. Additionally, as high technology commercialization often takes a longer period than other types of product or service, it is difficult to measure the long term results of branding, and therefore, this study can only provide a short-term view of branding at CERN. Finally, since CERN has member countries throughout Europe and most of its activities occur in that region, the geographic scope of this study may limit global brand distribution possibilities.

Structure of the Thesis

The dissertation was written according to the recommendations for methodology of Vilnius University Business School (Oželienė, 2024) and consists of three major parts:

- **Theoretical part** - overview of the literature of branding and technology transfer. It illustrates how branding can play a key role in the commercialization of high-technologies.
- **Methodical part** - description of the structure of the research, the methods and ways to collect data.
- **Analytical Part** - empirical data received through the literature analysis, interviews and case studies are the base for the final generalizing discussion and combined conclusion and recommendation.

Scientific Benefits

This research contributes to the theories of innovation management and technology transfer by systematically incorporating branding as a commercialization factor. This work offers a conceptual framework that may be applied to deep-tech ecosystems, thus expanding the field of branding research from traditional consumer markets.

Practical Benefits

From a practical point of view, this research provides best-practice examples of branding for deep-tech startups, CERN Knowledge Transfer offices, or new spin-offs regarding how branding can help with commercialization. The results demonstrate how branding can make complex tech more accessible to non-technical people, enhance legitimacy with investors, partners, and experts, and remedy communication challenges faced by scientists.

Authorship Contribution Statement

This master's thesis was jointly prepared by two authors - Amrah Abbaszade and Namig Javadli. Both authors participated in all stages of the research process but each author was responsible for different stages of preparation:

- **Theoretical part:** Prepared solely by Amrah Abbaszade. Namig Javadli reviewed the structure of the theoretical part to ensure that it is compliant with theory and provided additional conceptual interpretations.
- **Methodology part:** Mainly developed by Amrah Abbaszade. Namig Javadli reviewed the tasks of the study and ensured compliance of the methodology and also reviewed clarity of the research plan.
- **Analytical part:** Mainly developed by Namig Javadli. Amrah Abbaszade reviewed interview questions, coded logic, jointly interpreted empirical results and jointly developed analytical ideas.

Both authors were involved in maintaining consistency, coherence, and academic quality of the final version of the dissertation manuscript.

1. THEORETICAL PART: Deep-Tech and Branding

1.1 Deep-Tech: General Problems and Challenges

Deep-tech innovations occur in an environment characterized by large-scale science and engineering activities, where research and development timeframes can be lengthy, investment is substantial, and a very specific group of specialists is required to develop a product or service (OECD, 2023; WEF, 2023). In this prolonged validation process, little feedback is received from the marketplace on the viability of a product or service (McKinsey & Company, 2024), and many traditional indicators of commercialization, such as sales and customer acquisition, are simply unavailable. The combination of these factors underscores the increased importance of building credibility, establishing legitimacy, and developing clear branding stories when engaging stakeholders at early stages of the development process of CERN-origin technologies.

Structural Characteristics features of Deep-Tech

While there are no limitations, based on the literature, we can discuss some structural constraints that can influence or limit the ability of deep-tech start-ups to develop and grow in terms of both their products and services in the global marketplace.

Firstly, the development cycle for products and services of deep-tech start-ups is typically longer than that of most other types of businesses. This is due to the fact that the development cycle includes not only the development of the products and services themselves, but also the testing and validation of such products and services prior to the commercial release of such products and services (OECD, 2023). In many cases, the first stage of the commercial release process is the identification of potential customers and the validation of the interest of such customers in purchasing the products or services of the deep-tech start-up. Therefore, during the development cycle of a deep-tech start-up, the company may have very little, if any, direct contact with customers. In many cases, the customer base of a deep-tech start-up is typically small at the beginning, and it can take years for a large enough customer base to emerge (Dealroom, 2025; WEF, 2023).

Secondly, deep-tech start-ups are typically very resource-intensive. As such, they require significant investments in order to create the necessary infrastructure, test prototypes, and develop the necessary evidence of the quality of the products and services provided by the start-up in order to attract potential investors, partners, and customers (EIB, 2023). In addition, the development of products and services of deep-tech start-ups requires the involvement of experts who have a thorough understanding of the technology being

developed. For example, when developing advanced biotechnology products and services, experts in microbiology, molecular biology, genetic engineering, cell biology, biochemistry, and biophysics are needed. In addition, when developing advanced materials science products and services, experts in metallurgy, solid-state chemistry, materials physics, mechanical engineering, electrical engineering, and computer science are needed. The need for experts in these fields can make the recruitment and retention of employees a difficult task for many deep-tech start-ups (Fraunhofer, 2023).

Thirdly, the technology behind deep-tech start-ups is complex and difficult to understand for people who do not have extensive knowledge of the field. This difficulty in understanding the technology can lead to a cognitive dissonance between the experts and non-experts involved in the evaluation of the viability and potential of the products and services of a deep-tech start-up. For example, when evaluating the viability of a new medical device, the biomedical engineers responsible for the design and development of the device may believe that the device has great potential because of its improved functionality compared to existing devices. However, the physicians and patients who would use the device may not fully understand how the device works, and therefore, may be skeptical about the potential benefits of the device (Perkmann et al., 2021).

The Role and Limitations of Research Institutions

Science-based institutions are the foundation of deep-tech ecosystems (Audretsch & Link, 2019) - CERN represents an example of a science-based institution, where many technologies that were developed to aid in high-energy physics research have been used in other fields such as medical imaging, aerospace inspection, and environmental monitoring (CERN, 2023). However, in terms of incentives, these institutions focus on scientific discovery (Perkmann et al., 2021; Fraunhofer, 2023). Thus, activities like down-translation (regulatory preparation, industrial design, etc.) receive relatively little attention.

This pattern continues to emerge in this type of configuration. The level of scientific excellence supports prototype development, however, the lack of a translation capability leaves the interpretation of the results largely up to outside parties. This is particularly relevant to the current study. Source technologies at CERN not only face limitations in their ability to deliver technically or financially, but are also challenged by questions of legitimacy and perception, and thus require a well-developed brand and a well-defined frame of reference for the technology's value.

Summary and Link to the Research Question

Deep-tech companies operate in an environment characterized by extended lead times on product development, large amounts of capital required to set up commercial-scale manufacturing lines, a highly regulated environment, and a high level of disparity of information among investors, partners, and entrepreneurs (OECD, 2023; EIB, 2023; WEF, 2023), which causes market validation to be delayed and makes the use of traditional performance metrics less relevant, as they have historically been used to make investment and partnership decisions. Consequently, the initial evaluations of companies in the early stages of their life cycles depend less on observable operational results and more on unobservable signals, such as credibility, institutional reputation, and the internal consistency of the presented narrative.

In particular, for technologies originating from CERN, characterized by a highly specialized scientific environment and with scarce early commercial anchoring, the outlined dynamics are even more pronounced. In this context, stakeholders should be able to make judgments on the long-term viability and value of CERN-origin technologies' products/services in the absence of clear market signals. Under such conditions, the brand functions as a facilitator of legitimacy, reduces interpretative uncertainty, and enables engagement with interested parties.

This section establishes the structural context in which the brand becomes relevant to the marketing of deep tech. It provides the analytical basis for the subsequent examination of Technology Transfer processes in section 1.2 and for the discussion of branding mechanisms in section 1.3.

1.1.1 Long Development Cycles and Capital Intensity

There are two structural issues that influence the way marketing is developed in deep-tech businesses. The initial and middle stages of development are typically capital intensive. Venture capital firms have shorter deadlines for development compared to a deep-tech company's typical extended development deadline.

Extended Development Cycles

Development for deep-tech innovation is done through incremental testing of prototypes and successive validation of product performance. High-tech industries are subject to regulatory oversight that has an impact on the duration of each phase of testing. This results in a longer period of time where a company cannot use reliable data to gauge its growth. The venture capital community is generally focused on short-term financial returns. Therefore, the

first investment in a deep-tech business will frequently occur when there is still incomplete information available about the product's potential (EASA, 2022-2024; EMA, 2023; IEA, 2022). It is common for venture capital to invest in businesses with incomplete evidence and also accept a greater degree of uncertainty as part of the deal (McKinsey & Company, 2024).

The literature suggests that a low rate of technological advancements creates uncertainty and therefore shifts validation from the present to the future. When a business delays its evaluation, it relies on a variety of non-technical credibility measures to establish a level of confidence with stakeholders. The implications of this model are clear for this thesis. Technologies developed from CERN sources will need to demonstrate their legitimacy to maintain stakeholder confidence over a long period of time.

Capital Intensity and Mid-Stage Funding Constraints

High upfront costs for special-purpose equipment and personnel make it difficult for deep-tech companies to generate meaningful revenue before they have spent significant resources (EIB, 2023). As a result, these high costs create persistent finance gap issues during the later stages of development. In many cases, deep-tech companies will be able to demonstrate the technological progress they have made. There is still an excessive level of investment risk associated with attracting private funding, as investors will not be able to evaluate their level of investment risk and appear to have distant horizons for their potential exits (OECD, 2023).

According to OECD (2023), EIB (2023), and McKinsey (2024), there appears to be a similar process for the commercialization of deep-tech. While high investment costs represent an important barrier to entry, the limited availability of funds during the middle phase of development further increases investor conservatism and creates a dependency on signals of legitimacy and a valid value framework for investors. For CERN-sourced technologies, a credible value framework serves to signal feasibility, relevance, and continued development and growth in ways that are understandable to external stakeholders.

Partial Mitigating and Remaining Gaps

There are hybrid financial products and specific programs available that may help mitigate some of the uncertainty that exists in the early development stage of a business. This could allow the shared use of facilities and production capabilities and the knowledge base of corporate partners in the design and regulatory compliance processes to support the credibility assessment of external stakeholders (FEM, 2023; EC, 2023). However, these solutions do not resolve the fundamental issue since the development process is characterized as being both slow and resource-intensive and therefore difficult to evaluate by outside parties.

1.1.2 Regulatory Complexity and Talent Shortages

The time it takes for new technologies to receive regulatory approval is lengthy, mainly because they are tested so extensively prior to approval. Additionally, the approval process also hinders early-stage market validation data and thereby delays the overall validation process (OECD, 2023).

During the initial stages of a product or system's development, very little actual evidence exists to show that the product or system will be both viable and compliant with regulations. In addition, decision-making by external stakeholders has not yet taken place. Therefore, when assessing the amount of progress made during this phase, the assessments are generally done through indirect indicators rather than examining the product's performance directly.

Regulatory Heterogeneity and the Time for Approval

There is a great deal of variation among the regulatory paths found within each sector and jurisdiction. Therefore, the regulatory paths are fragmented, and there are many uncertainties associated with the path, such as what constitutes acceptable evidence, what are the approval timelines, and what criteria will be used to evaluate the applicant. Regulatory paths delay the time it takes for systems to achieve an approved status, slow the amount of time to confirm viability, and increase the time it takes to validate the market.

Two practical consequences follow from this situation. First, unclear regulatory expectations increase perceived risk for investors and industrial partners. Second, inconsistent documentation and testing requirements often lead to repeated verification efforts and additional administrative burden. Together, these effects extend development timelines and reduce the availability of concrete performance signals during early commercialization stages.

Shortages of Hybrid Talent

Commercializing new technologies requires a combination of scientific knowledge and a range of other skills including regulatory, engineering, and business. Globally, this hybrid talent is in short supply (McKinsey, 2024; OECD, 2023). Consequently, when this combined expertise is absent, the transition from laboratory prototypes to certified and commercially viable systems is slowed.

However, ecosystems where universities work closely with industry and regulatory bodies develop stronger talent pipelines and reduce the length of time it takes to get from

prototype to product (Rasmussen and Wright, 2015; OECD, 2021). Since CERN is located within an ecosystem where the level of coordination between these various entities is lower and where the number of observable milestones that are available to external observers is smaller, this means that the amount of time it takes to get from prototype to product is longer.

Institutional Responses and Remaining Gaps

Engaging early with regulatory bodies, establishing a system of transferring technology that is integrated into the development of the technology, and providing specialized support services to address the uncertainty of commercializing a new technology reduces the uncertainty associated with the pathway to commercialization and provides greater clarity on the procedure and coordinates interactions between science teams and external stakeholders.

While institutional responses to this problem can address some of the issues associated with the uncertainty of commercialization and provide greater clarity to the process, they cannot eliminate the uncertainty associated with developing new science or the structural issue of talent shortages. Therefore, even after these institutions have been established and during the extended period of development, the major uncertainties continue and external stakeholders need to make interpretations of the progress made using very limited tangible evidence. Under these circumstances, the development of a new technology continues to be difficult to measure by standard market-based indicators.

1.1.3 Communication, Perception, and Investor Gaps

Many parties struggle with determining whether a company is viable because there are still large communication and perception barriers between the party with expertise and the ability to understand the science behind the technology and the party that cannot. Deep-tech companies have a combination of very complex sciences and long-term development timelines. Non-experts find it challenging to read and follow the trajectory of technological advancement within deep-tech companies (W.E.F., 2023; OECD, 2023), while validation is typically done through much slower feedback loops than those experienced by digital technology companies. Additionally, validation methods used by deep-tech companies to evaluate their potential are generally more difficult to decipher due to the longer timeframes involved, compared to digital technology companies where validation can occur through rapid feedback mechanisms (WEF, 2023).

Scientific Opacity and Cognitive Barriers

Highly specialized knowledge makes up a significant portion of innovation in high-tech. Examples of this include the use of quantum mechanics, particle detection systems, and electronics designed to be resistant to radiation. These types of innovations create a barrier to interpreting these types of technologies for non-expert stakeholders. Investor behavior illustrates this, as over 60% of European investors identified that they do not fully comprehend the technology sufficiently enough to adequately assess its value (Dealroom, 2025). All of the previously cited reports (Dealroom, 2025) (OECD, 2023) (World Economic Forum, 2023) express the same issue, lack of scientific transparency increases the difficulty in reading and assessing technological trajectories and subsequently creates an increased sense of risk for various stakeholders.

The above-mentioned issue is especially prevalent with technologies originating from CERN. The principles and performance standards of many technologies were originally developed for extremely scientific conditions and therefore make it difficult for external users to translate the technical merit of the technology into practical application. As such, early-stage evaluations are often performed by providing interpretive signals that enable external users to develop expectations rather than evaluating the technology itself.

Investor Perceptions and Risk Framing

The application of branding as a tool to change the direction of technological progress by using social and mission-based stories to shape CERN's development will allow the organization to review and assess the impact of developing and implementing new technologies without relying solely on the immediate financial results associated with the implementation of those technologies. The importance of narrative positionality is crucial here, because, as stated by the World Economic Forum (2023), organizations that have defined and communicated their social missions are more likely to attract and secure patient capital. Branding has been identified as one of the mechanisms used to communicate an organization's commitment to long-term value creation, and therefore to build institutional credibility (Engez, Klyver & Nielsen, 2023).

There are many potential high-risk applications for CERN-derived applications, including medical imaging and environmental sensing, and both users and institutional adopters need to understand the scope of the technology's goals, the security implications of its use, and the possible ramifications of its use. In terms of the logic developed within our work, the brand acts as a source of security and legitimacy that assists in the formation of public perception and facilitates the acceleration of adoption. As a result, there are a number

of risks and barriers to acceptance that arise from how institutions communicate technology in pedagogical spaces.

Public Acceptance and Social Perceptions

Acceptance of new technologies is influenced by more than just empirical evidence. Public acceptance of new technologies also depends on the way technologies are positioned in public debates and political discourses (Davies and Horst, 2016). Research has shown that interpretation plays a greater role in the identification of perceived benefits and risks than the maturity of the technology itself. When concerns about new technologies remain unaddressed, uncertainty is created, which slows the rate of adoption and creates a need for visible signals of legitimacy.

Societal trust plays a critical role for CERN-derived applications in fields such as medical imaging or environmental monitoring. Users and institutional adopters require a clear understanding of purpose, safety considerations, and long-term consequences. Within the logic of this research, branding is understood as a source of reassurance and legitimacy cues that help stabilize public perceptions and facilitate adoption.

Institutional Communication Gaps

There are institutional tendencies around communication, particularly in the academic organization, to round out results in scientific publications or "conferences", which tend not to yield clear narratives that can serve marketing purposes (Germain, Vaara & Patriotta, 2023). The Fraunhofer Institutes provide an example of an 'institutional' approach, where capabilities on communication are integrated into transfer processes for technology. Their experience bears out how communication challenges shape and thereby closes perception gaps and stimulates the genesis of acceptance (Fraunhofer, 2023).

Similar things are noted in the CERN domain. Many industry partners and public actors do not necessarily hear about their capabilities around translation or may have figured that CERN-origin technologies are domain-specific only, and not applicable to other realms. This is particularly acute for engagement with SMEs, hospitals, and industrial users, those who require reliable tapping from obvious verbal sources of relevance, where misunderstandings discourage. In circumstances of information gaps, the brand helps close perceptual boundaries, mapping 'misunderstanding' and helps work through how to read things at all in the early stages.

Measuring Perception, Legitimacy, and Stakeholder Confidence

Ecosystems in deep tech rarely use a set of indicators to measure legitimacy or perception by stakeholders. Studies in B2B branding focus on the need for congruence within an organization, in addition to sending a positive, consistent, and stable signal in the external domain in order to generate trust (Leek & Christodoulides, 2011; Santos-Vijande, et al., 2013).

In light of the absence of metrics for perception within deep-tech situations, the literature at hand emphasizes the significance of communication practices and indicators within the area of legitimacy. This can very much apply to the processes of knowledge transfer within the CERN laboratory, where the potential for commercialization cannot easily be judged. Within the premises of this thesis, branding can actually be observed with respect to such processes.

1.1.4. Summary of Deep-Tech Challenges

The absence of stable signals when investors cannot rely on their usual heuristics creates an environment where stakeholders use surrogates as a means of creating expectations at the earliest stage. In addition, public and mission-oriented programmers absorb some of the technological and financial risks associated with the project, the funding models continue to be fragmented and have only partially adapted to the extended time frames of the development process for deep-tech companies (European Commission, 2023). For technologies originating from CERN, where there are no initial commercial anchors and cover multiple application areas, this environment increases the demand for framing mechanisms that will allow stakeholders to evaluate the feasibility of these technologies prior to visible traction in the marketplace.

This continues to create an environment of ongoing uncertainty, which requires stakeholders to rely on interpretive and signaling mechanisms to develop expectations and make investment decisions before there is commercial validation of the innovation. The framing acts as a temporary structural mechanism that allows stakeholders to fill the void created by the lack of market-based evidence, thereby enabling them to determine if a long-term commitment of resources to the innovation is warranted.

In this context, the mechanisms related to the brand reduce informational asymmetry and provide clarity regarding the level of technological maturity and application potential of the innovations developed at CERN, thereby providing additional support for the interpretative and legitimacy creation pathways depicted in Figure 1, and preparing the way for the next section on Technology Transfer and branding.

1.2 Technology Transfer from Research Institutions

Technology transfer (TT) refers to the institutional and organizational procedures that enable public research organizations to use scientific knowledge, early-stage technology, and intellectual property to develop an innovation that a third party may use, adapt, and commercialize (Bozeman, 2000; Perkmann et al., 2021). Within the realm of deep tech industries, technology transfer serves as a pivotal means of overcoming the structural divide that emerges between scientific discoveries and their applications within the market, which are characterized by a long development timeline and high scientific and technological uncertainty (OECD, 2023).

Prior to the current shift in thinking, the majority of the literature on TT was based on the Linear Innovation Model and portrayed innovation as a series of stages that flowed from the basic research stage to the applied research stage and then to commercialization (Bush, 1945). While the linear innovation model provided a useful framework for understanding innovation in the past, it has been seen recently as being overly restrictive in that it did not capture the iterative, interconnected, and reciprocal nature of relationships among science, industry, and communities as exist during modern innovation processes (Markman et al., 2005; Godin, 2006). As such, TT research has shifted toward models that highlight the importance of collaboration, networks, and the systemic connections and linkages among stakeholders involved in innovation.

According to the Triple Helix model, TT represents an ongoing interactive relationship between the public research community, the private sector, and governments, and are facilitated by hybrid structures that include Technology Transfer Offices (TTOs), incubators, and joint labs (Etzkowitz and Leydesdorff, 2000; Ranga and Etzkowitz, 2013). The Theory of Open Innovation takes this idea further by highlighting how knowledge flows across firm and market boundaries.

The mission-oriented innovation system creates a TT context through broader social and technological mission definitions by government agencies. In order to achieve their long-term objectives, these agencies will direct funds towards objectives with public value (OECD, 2023) (Mazzucato, 2018). The ecosystem perspective adds to the previous views that the success of TT as an output of the combination of capabilities such as translational infrastructure, industrial absorption capacity, patient capital, and regulatory compatibility among the university, company, investor, and intermediary components in networks of the same (Perkmann et al., 2021) (Autio & Thomas, 2014). The ecosystem view is especially

useful in understanding how TT at CERN is dependent on coordination across many different contexts of science, industry, and politics.

Regardless of the model, all deep-tech transfer is hampered by similar barriers due to its underlying structure. For many early-stage TRLs, there will be an enormous amount of development that has to take place in terms of design validation, testing, and productization (EIB, 2023) before a TRL can be considered investible or manufacturable. Additionally, research prototypes are typically missing important features that are required to deploy them, including but not limited to robustness, regulatory-compliant documentation, and certifications (OECD, 2023). Furthermore, there are differing incentive structures between the two parties involved, universities seek to disseminate knowledge, while companies focus on creating market-fit products with reasonable timetables and manageable risk (Siegel & Wright, 2015), which creates friction when collaborating, raises transaction costs, and makes it difficult to make joint decisions.

The more friction occurs among parties, the more difficult it will be for external stakeholders to understand the degree of technological capability each partner has. The less visible the technological capabilities and responsibilities are, the more uncertain the environment becomes. These conditions lead to a greater need for mechanisms, such as branding, to enable the interpretation of progress at an early stage. Branding is one mechanism to assist with framing stakeholder expectations, signaling institutional trustworthiness, and enhancing the level of coordination between partners.

In this context, CERN represents an example of TT environments. The technology it has created to support its research activities in high-energy physics also demonstrates relevance and application in other fields, such as medical imaging, aerospace, environmental monitoring, and security (CERN, 2023). It is responsible for acting as an intermediary and facilitating the connection between the internal knowledge production at CERN and potential users outside the laboratory by identifying possible use cases, managing licenses, coordinating collaboration, supporting the establishment of spin-offs, and facilitating connections between science output and external actors' requirements.

There are many features of the CERN TT Environment that are structural in nature. Governance is transnational with respect to countries, and intellectual property agreements are associated with very large scientific collaborations. There are also many technologies created for extreme research conditions, which would need significant re-engineering before they can be commercially implemented. The industrial capacity for manufacturing throughout Europe varies greatly, which limits the options for expanding production for hardware-intensive innovations. Additionally, there is a relatively low level of translational funding in research-

focused institutions. Furthermore, due to the high degree of scientific sophistication involved, it is common for communication and perception problems to occur between parties that do not have advanced technical knowledge (Vykydal, Turecek and Jakubek, 2021).

The limitations associated with the TT at CERN constitute a technological task as well as a communication task. Many outside parties lack an appreciation of the applications and related technology development at CERN or are uncertain how technologies developed from particle physics can be appropriately modified to meet the requirements of their own specific environment. Therefore, it is necessary for CERN to establish credibility (legitimacy), articulate compelling value propositions, and sustain commitment over time for the purposes of successfully transferring technology.

Within the thesis, TT provides the overarching structure for the analysis of the movement towards commercialization for deep-tech innovation and the subsequent relevance of branding as an enabling factor. Within a scenario where the absence of scientific transparency, the early scarcity of evidence, or the timescale of innovation is most prevalent, TT encompasses much more than the management of intellectual property or the optimization of the technology itself as an innovation artifact. Branding engages with TT to address the asymmetry of information as an innovation facilitator for the positioning of CERN within the ecosystem of innovation.

1.2.1 Models of Technology Transfer

The concept of Technology Transfer has matured from a simple linear concept of knowledge transfer into a complex system involving scientists, industry, and government. In the literature, a number of approaches/models exist, which contemplate the process by which research institutions develop scientific outputs for use by businesses. Each of these models is founded upon a set of differing assumptions regarding innovation processes.

Linear Model of Innovation

The linear model portrays the process of Technology Transfer as a sequential process that advances directly from basic research, through applied research, development, and finally into commercialization. The linear model is based on the notion that scientific findings will necessarily advance into industrial innovations (Bush, 1945; Godin, 2006). The linear model dominated how technology transfer occurred between the university and industry before being generally discredited for not accounting for feedback, participation, or institutional considerations (Markman et al., 2005).

Triple Helix Model

The Triple Helix approach reinterprets the concept of Technology Transfer into a three-part model that includes universities or research facilities, industry, and government. Here, where the three circles intersect, new forms of hybrid organizations emerge in the form of technology transfer offices, incubators, and shared laboratories (Etzkowitz and Leydesdorff, 2000). These organizations function to facilitate collaboration and the flow of knowledge. In research facilities, such as the CERN collaboration with national agencies and industry, the role of the Triple Helix approach is highlighted in emphasizing that technology transfer occurs at points of leverage that are not dependent on agency.

Open Innovation

Open innovation focuses on how knowledge and ideas can be transferred outside of an organization. Chesbrough (2003) notes that organizations, including universities and research labs, have both internal and external sources that they can draw upon to shape their technological trajectory. For example, applied to the technology transfer process, openness will allow external partners, such as start-ups, large corporations, and small and medium-sized enterprises (SMEs), to be involved in the commercialization stage, as well as early-stage scientific development. Von Krogh and Haefliger (2020) note that openness within scientific work can create a greater sense of transparency and facilitate collaboration through shared experimentation and distributed problem-solving, which ultimately lowers the development risk associated with developing a complex deep-tech project.

Mission-Oriented Innovation

In mission-oriented innovation systems, Technology Transfer is positioned by governments in the context of publicly defined long-term societal missions and strategies (OECD, 2023; Mazzucato, 2018). In this system, Technology Transfer is framed as an activity creating "public value" and involves coordination between research activities, industrial capabilities, and policy instruments to achieve common social challenges. This approach to the mission orientation of science and technology, for organizations like CERN that identify commercialization of their scientific output as a means of providing benefits to society, rather than just for profit, highlights the importance of ensuring that the scientific output is aligned with broader societal goals.

Ecosystem Models

Technology transfer from an ecosystem perspective involves multiple stakeholders within a network, including universities, startups, investors, corporations, regulators, and intermediaries (Thomas & Autio, 2014; Perkmann et al., 2021). The outcomes of technology

transfer depend on the complementary capacities of the stakeholders in the network, such as absorption capacity, infrastructure, finance, and legitimacy, which are distributed among the stakeholders rather than solely depending on the quality of the technology. Therefore, CERN's successful knowledge transfer is a function of its ability to align itself with both industrial and financial partners across Europe, in addition to having a strong scientific foundation.

Cross-Author Comparison

This comparison also demonstrates an evolution in how the concept of technology transfer has been viewed. Initially, linear models show a simple flow from basic science to the market. Subsequently, the Triple Helix model introduces institutional interactions. Then, open innovation expands this by highlighting the porous nature of organizational boundaries as well as the degree of collaboration between organizations and outside stakeholders. Then, mission-oriented models highlight the importance of public value creation over time. Finally, ecosystem models have integrated many of these factors into a system of multiple actors working together to achieve technology transfer.

In addition to technological advances, through these models, the Technology Transfer process in deep-tech environments also depends on additional factors for an assessment of suitability (readiness), relevance, and risks of a new product or service. In particular, when the development time is very long and early market evidence is limited, players can use interpretative mechanisms in order to estimate how ready the market is for a product or service.

Therefore, the Technology Transfer in the context of this thesis represents a condition in which the mechanisms connected with branding become increasingly important. Stakeholder interpretation occurs during periods of framing, legitimacy signaling, and mission articulation, when formal validation and business indicator data do not yet exist. The dynamics are especially relevant in research-intensive environments, such as CERN, where the quality of science is very high, but market signals develop relatively slowly.

1.2.2 Barriers and Success Factors in Technology Transfer

In deep-tech environments, there are multiple structural, organizational, and relational barriers that complicate the process of transitioning from scientific discovery to commercial application for Technology Transfer. Some of these obstacles occur because of the characteristics of the deep-tech itself, for example, technological uncertainty, lengthy development processes, regulatory requirements, and the need for unique capabilities. Other obstacles occur due to conflicting or unaligned incentives and expectations between research

institutions, industries, investors, and regulators. In addition to the above barriers, there are several key success factors that may improve the outcomes of Technology Transfer if consistently applied.

Technological Immaturity and TRL Gaps

The main obstacle to commercializing deep-tech innovation is its technological inexperience. In general, most deep-tech innovations are developed using relatively untested and immature technologies in terms of Technological Readiness Levels (OECD, 2023), with respect to their need for significant engineering, testing, validation, and transformation before they will be viable commercially. Scientific prototype developments seldom address the industrial expectations related to product durability, strength, manufacturing feasibility, or cost-effectiveness. The literature suggests that the degree of success of a technology transfer will be based on the degree of fit between the technical characteristics of the technology being transferred and the preparedness of the adopting entity (Bozeman, 2000). In general, at intermediate levels of technological maturity, the degree of fit is typically very poor, therefore, the time to develop and field test the technology is extended, the costs of developing the technology are increased, and there is less of an incentive to engage in the adoption process. Similarly, CERN source technologies face analogous issues, since most of these technologies will have to undergo significant re-engineering before certification and implementation can occur.

Regulatory Complexity

Another major hindrance to technology transfer is the regulatory complexity involved. In Section 1.1.2, it was highlighted that high-tech technologies are subject to stringent regulations and therefore require an extensive body of data regarding both safety and efficacy in order to be approved by regulatory authorities (EMA, 2023; EASA, 2022-2024), these are areas where research organizations typically place their primary focus on generating scientific results as opposed to preparing for regulatory compliance (Siegel and Wright, 2015). Consequently, the lack of internal knowledge and experience with regulatory compliance, quality assurance, and certification in Technology Transfer Teams will extend the time-to-market and hinder industrial planning.

Organizational Barriers and Incentive Misalignment

Technology Transfer results from a variety of factors, including organizational structure and the incentives that researchers have available to them. While academic environments reward the publication of research and its associated "scientific impact", a commercial environment rewards the rapid, iterative development of products, aligning them to markets

and sustaining relationships with industry (Perkmann et al., 2021). This can create a disincentive for researchers to participate in Technology Transfer or to continue developing products for long-term, industrial use. Additionally, many Technology Transfer Offices are under-resourced and often lack the specialized knowledge and skills needed to conduct a comprehensive market assessment, product development, intellectual property strategy, or engineering translation, particularly in deep-tech environments (Markman et al., 2005).

Relational and Ecosystem Conditions

Relational and ecosystem-related factors also play a significant role in determining Technology Transfer. Absorptive capacity has a key role to play, as it includes the ability to assimilate or apply what is learned from outside sources into an organization's existing stock of knowledge (Cohen & Levinthal, 1990), and as such, effective technology transfer relies on an adequate absorptive capacity within the industry partner. However, in many European economies, particularly those with small-sized and medium-sized enterprises (SMEs), there are limitations in terms of resources, technical personnel, and lack of cohesive industrial infrastructure that limit this absorptive capacity (OECD, 2023).

Success Factors in Technology Transfer

Although many obstacles are present in this area of research, many authors have pointed out a number of factors that can contribute to an improved outcome for collaborative research. For example, collaborative or co-created research by both industry and science-based partners is one such factor that helps to eliminate uncertainty, establish common goals, and speed up development processes with applications-oriented (von Krogh & Haefliger, 2020; Chesbrough, 2003). Including regulatory, engineering, and quality control aspects at an early stage of the development process will enable teams to predict requirements for compliance and address risks prior to the point where they reach commercialization (Fraunhofer, 2023).

A mission-oriented innovation program helps bridge the financial gap in long-cycle technology by offering "patient" funding, coordinating funding, and developing a structural relationship between innovators and industry (Mazzucato, 2018; European Commission, 2023). When funding flows and common goals are aligned, TRL mid-gaps narrow, and as long as there is an expectation that the innovation will mature, there is less volatility as the innovation matures. Communication best practices also contribute to Technology Transfer success by reducing information asymmetry between parties and reinforcing stakeholder confidence regarding the social benefit of technologically complex innovations (Leek & Christodoulides, 2011).

A combined analysis of the research literature by Bozeman (2000), Perkmann et al. (2021), Chesbrough (2003), Von Krogh & Haefliger (2020), Germain et al. (2023), and Fraunhofer (2023) identifies that technology transfer has numerous barriers. In addition to structural discontinuities between the scientific characteristics of a technology and the industry requirements for that technology, there are also organizational incentives and relational capability barriers, as well as an openness and co-creation barrier to reduce uncertainty. Furthermore, the legitimacy barrier refers to how stakeholders perceive the value of technological advancements. Finally, the operational competency barrier is related to the ability to meet regulatory and engineering requirements. The results of this research clearly indicate that successful technology transfer is dependent upon technological strength, institutional coordination, adequate financing, and sufficient communicative capacity.

1.2.3 CERN's Knowledge Transfer Framework

CERN's Knowledge Transfer framework is a unique approach to translating technology from within a large, supranational research entity. CERN operates as an international entity with an international mandate based on scientific excellence, open science principles, and governed by its member states (CERN, 2023). As such, CERN's Knowledge Transfer will reflect a blending of collaborative R&D, mission-oriented innovation, and ecosystem-oriented models of knowledge transfer. These models reflect the nature of deep-tech innovation as well as CERN's unique institutional environment.

Mandate and Strategic Objectives

Four objectives are part of CERN's Knowledge Transfer mission: generating societal value through the application of scientific and technological research outputs, increasing innovation in its Member States, enhancing the competitive position of industry, and developing cross-sectorial applications of the technology created for Particle Physics. This demonstrates that CERN has a social-impact perspective on Technology Transfer, as opposed to treating it as an income-generating operation (CERN, 2023; Mazzucato, 2018).

To achieve cohesiveness within this mission, CERN has divided its Knowledge Transfer work into several thematic areas, which include medical applications, aerospace/aviation, cultural heritage, environmental monitoring, and advanced manufacturing. All of these thematic areas function independently as ecosystems, combining internal experts with their external collaborators and industry partners.

Operational Mechanisms of CERN's Knowledge Transfer

Knowledge Transfer at CERN utilizes multiple operational systems to convert technological outputs from scientific research to other areas of society or business:

- **Collaborative R&D Consortia.** The Medipix Collaboration is an example of how CERN works with the hospital sector, academic institutions, and private enterprises to jointly develop Hybrid Pixel Detectors and iteratively test, optimize, and engineer them (Vykydal, Turecek & Jakubek, 2021).
- **Flexible Licensing and IP Models.** Low-barrier licenses for small and medium-sized enterprises (SMEs) are one such model. Other types of flexible models exist, such as exploratory licenses, and open hardware models (CERN, 2023).
- **Public-Private Partnerships.** CERN collaborates with hospitals, national research institutions, aerospace industries, and so on, to validate prototypes and develop applications.
- **Capacity-Building and Training.** Fellowships, entrepreneurial programs, knowledge exchange opportunities, and so on, enhance the absorptive capacity of member states.

These two mechanisms illustrate how an open science approach, selective intellectual property protection, collaborative engineering, and mission-driven impact are combined together.

Table 1

Operational Definitions of Key Concepts in the CERN Context

Concept	Theoretical definition	CERN practice	Source(s)	Interview indicators
Participatory governance	Decision-making shared among multiple actors, ensuring inclusion of stakeholders (Ansell & Gash, 2008).	Collaboration agreements, spin-off policy rules, and governance of KT licensing processes.	OECD (2023); CERN KT policy docs	References to shared decisions, multi-party agreements, or governance rules.

Co-creation	Joint development of products or services by users and producers (Prahalad & Ramaswamy, 2004).	Medipix collaboration (joint R&D with universities, hospitals, & industry).	Vykydal et al. (2021); CERN KT docs	Examples of co-designed pilots, demonstrators, or technology adaptations.
Stakeholder engagement	Active involvement of external partners in shaping outcomes (Freeman, 2010).	Hospitals, corporates, agencies, and investors engaged in KT projects.	CERN KT Highlights reports	Mentions of external validation, regulatory involvement, industrial partnerships.
Autonomy	Degree of independence granted to spin-offs or partners (Deci & Ryan, 1985).	Spin-offs operate with independent branding while negotiating CERN brand-use rules.	CERN KT brand guidelines	Narratives about balancing CERN reputation with independent identity.
Commercialization	Process of translating research into marketable products or services (Markman et al., 2008).	Licensing portfolio, spin-off creation, joint pilots.	Guest et al. (2006); CERN KT docs	Descriptions of licensing, formation of new companies, or collaboration for market entry.

Source: Completed by authors

The data in Table 1 provides an overview of the most important operative concepts that guide CERN's Knowledge Transfer activities. The purpose of this table is to serve as an operative reference for empirical research, linking abstract theoretical concepts with specific CERN operative practices and interview indicators. This table does not provide new empirical information, rather, it offers a systematic linkage between the theoretical framework developed in Chapter 1 and the coding scheme used in Chapter 3.

Scientific-Industrial Misalignment

Technologies developed with extreme scientific applications, for example, radiation hardness, precision of micrometers, or nanoseconds, may already be more advanced than what the industry demands. This may pose challenges in adapting towards the development of product-grade systems (CERN, 2023).

Multi-Country Governance

Due to its multi-country governance, decisions regarding licensing, collaborations, and commercialization of products must be made within the context of multiple different laws and policies. Therefore, CERN's ability to make decisions is typically both more time-consuming and less adaptable compared to other laboratories governed by the laws of one country (OECD, 2021).

Limited Mid-TRL Funding

Although CERN is particularly successful at conducting research in the early stages of development, it has significant limitations when it comes to obtaining funding for technology readiness levels four through seven, such funding usually comes from Horizon Europe, EIC transition programs, or private industries. This creates delays during the demonstrations of technology, which require large sums of money to successfully complete (European Commission, 2023).

Cross-Author Perspective

The general literature emphasizes that the importance of Technology Transfer goes beyond the management of Intellectual Properties, and relationship-based, communication-driven, and institutional dimensions have important parts to play in this regard (Bozeman, 2000; Perkmann et al., 2021; Germain, Vaara & Patriotta, 2023). The aforementioned complexity is also observed at CERN. Scientific excellence helps in establishing credibility. Consortia provide engineering capabilities. Multi-national governance features institutional constraints. Cross-sector agendas provide for societal importance. All the above elements put

together situate CERN at the nexus of the aforementioned paradigms as described in Section 1.2.1.

1.2.4 Summary of Technology Transfer Insights

Technology Transfer in the deep-tech environment represents a complex and relational process that is affected by the maturity of the technology, the capabilities of the involved parties, and the institutional framework, as well as the shape of stakeholder networks. The existing literature portrays a transition from linear and transactional concepts to more collaborative, ecological, and mission-driven innovation paradigms (Etzkowitz & Leydesdorff, 2000; Chesbrough, 2003; Mazzucato, 2018). All these paradigms imply that the efficiency of Technology Transfer increases with a higher degree of coordination among various actors. This phenomenon assumes greater significance for technologies derived from CERN in various national environments. Within this thesis, the rise of ecosystem-based and mission-oriented Technology Transfer requires research institutions to increasingly be required to develop their branding responsibilities. CERN is required to clearly articulate the value of its technologies in environments characterized by scientific opacity and institutional diversity.

In this thesis, the emergence of ecosystem-driven and mission-driven Technology Transfer accentuates the need for branding on the part of research institutions. CERN needs to define the benefits of technology in contexts that are generally opaque in science and institutionally diverse.

The results of the analysis for Technology Transfer Barriers indicate that research organizations systematically experience technological immaturity, regulation complexity, funding gaps at a mid-TRL level, incentive misalignment, a lack of capability in technology transfer offices, and information gaps that limit stakeholder understanding of the technology (Bozeman, 2000; Perkmann et al., 2021). This leads to environments for evaluation in which stakeholders rely on non-technical information as a basis for forming assessments of feasibility. In the case of CERN, the presence of multi-country systems and the lack of early commercialization exacerbate this uncertainty. Therefore, third-party stakeholders rely more on a range of mechanisms associated with reputation and branding for envisioning the technology.

The Knowledge Transfer framework of CERN illustrates the above dynamics. It would be more appropriate to perceive the overall approach of CERN, rather than its individual instruments, as a hybrid approach that combines excellence with science-related collaboration and mission-oriented activities. Such an architecture gives rise to interpretive gaps. High levels

of technical expertise, high requirements for re-engineering, and complexities in governance heightened uncertainties among non-expert parties. A mismatch in science and industry, mid-TRL funding sources, as well as disparate capacities for absorption contribute to heightened dependence levels among parties to be assisted.

For this thesis, what this means is that the totality of the structural advantages and limitations of CERN contributes to an enhanced need for branding in terms of the clarity of technology's purpose, viability, and relevance. The process of Technology Transfer is apparent within complex socio-technical systems as more than just an administrative process. When evidence accumulation is slow, ambiguity is associated with evaluation through framing, justice signals, and institutional markers.

In the case of CERN, this phenomenon appears as the need to provide a clear and credible story about the relevance and viability of technology that may not be immediately apparent to third-party collaborators. The lack of scientific clarity creates interpretive gaps that increase the need for non-technical information. As a result, branding appears as the main tool for managing expectations.

As emphasized in the relevant literature on Technology Transfer, in deep-tech environments, commercialization can be influenced not only by technology readiness levels but also by institutional coordination, regulatory frameworks, capabilities, and communication. In environments that present high uncertainty in science, long development periods, as well as fragmented ecosystems, it can be expected that technology readiness levels can interact in complex ways.

In the context of CERN, given that Knowledge Transfer activities extend across various countries, sectors, and different types of governance, these issues are especially relevant. The lack of commercial validation at the initial stage, as well as the complexities involved in understanding the scientific origins, trigger increased dependence on the interpretive mechanism on the part of stakeholders regarding the validation of the technological potential itself. In this background, branding acts as an impetus to Technology Transfer because branding helps create expectations, demonstrates credibility, and induces alignment among the various stakeholders.

1.3 Branding in Innovation and Deep-Tech Commercialization

Brands have traditionally been identified with consumer markets or fast-moving consumer goods industries. There, the key to competition lies in the principles of differentiation, emotions, or customer experience. Nevertheless, the current literature

indicates the significance of branding in innovation-driven or science-based industries. In such sectors, it becomes imperative to communicate intricate value propositions, reduce uncertainty, or enhance efficacy with targeted stakeholders (Beverland, 2018; Leek & Christodoulides, 2011).

In the deep-tech ecosystem, the scientific obscurity and the lack of early evidence make the brand not a means of promotion. However, as a means of institution-building, it serves as a basis for establishing credibility and trust. It helps in building trust when the uncertainty level is high, as discussed in the literature. It becomes applicable in the case of CERN technology, because it involves high levels of information asymmetry in the early stages of Technology Readiness Levels.

Deep-tech innovation creates a disconnect between scientists developing deep-tech innovations, investors, industrial partners, and end-users. The gap is created due to the technological difficulty, the time it takes before knowing whether an innovation will perform as expected, and the limited validation possible (WEF, 2023; OECD, 2023). In such a context, stakeholders are highly reliant on relational and symbolic information related to an organization's reputation, the framing of its mission and purpose, the clarity of the organization's mission, and the identity of the organization (Santos-Vijande et al., 2013; Zimmerman & Zeitz, 2002) in order to evaluate an organization's future potential. As illustrated in Figure 1, this corresponds to the legitimacy signaling pathway. In cases where there is little or no empirical data available, organizations' reliance on these types of institutional cues increases significantly, particularly with respect to innovations developed at CERN, as they generally have few, if any, commercial anchor points.

Branding has become a strategic function of innovation management by providing support for both the technological and organizational strengths of an organization, Urde (1999), and Balmer (2012) suggest that developing a strong corporate brand provides a sense of coherence and consistency which enables organizations to communicate their purpose, values and direction, this can be particularly important in science-based organizations where it may help facilitate the transformation of complex research based outcomes into a coherent narrative that is understandable through a technological lens. In contrast to advertising and marketing, which focus on short-term persuasive goals, Leek and Christodoulides (2011) point out that branding in B2B and technologically demanding markets often seeks to build long-term relational trust with customers rather than achieve short-term sales.

Longer product development cycles of deep-tech firms are both limiting the opportunity to receive market feedback and limiting stakeholders' ability to understand the complexities of the technology and regulatory environment. Therefore, effective branding will require a

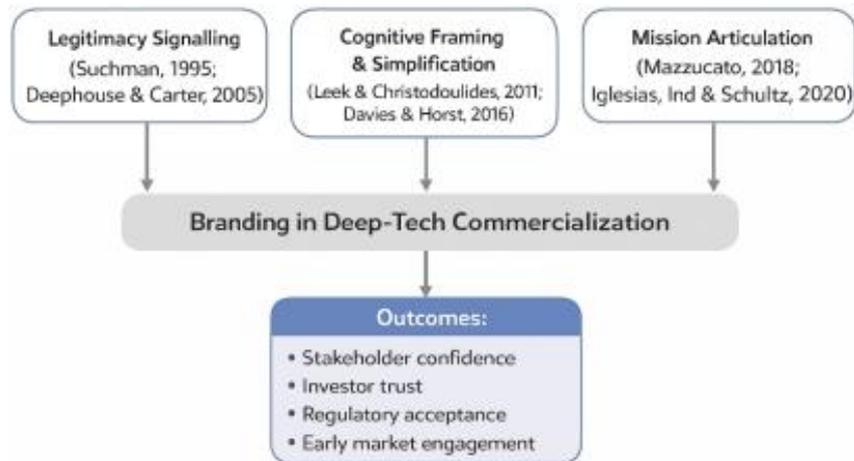
combination of mission orientation, stakeholder engagement, and credibility signaling, which are beyond the scope of traditional marketing logic (Germain, Vaara & Patriotta, 2023; Mazzucato, 2018). The three elements combined provide the mechanisms shown in Figure 1, and are why branding in deep-tech is an interpretive and legitimacy-building infrastructure, and not simply a marketing promotion layer.

Mechanisms to promote public awareness of new products also have special implications for institutions like CERN that are involved in basic research, because many of the technologies developed at CERN originate from a high degree of specialization in scientific areas of study, require collaborative efforts among multiple institutions, and have an extended path through both the engineering and regulatory processes before reaching the marketplace. A major source of perception gaps regarding the technological maturity of products developed at CERN is the fact that external stakeholders generally equate CERN primarily with basic physics research, rather than with applied innovation (CERN, 2023).

When there is no empirical market signal for the organization to draw upon, they will utilize branding cues as an alternative mechanism to determine the feasibility of a project, understand the maturity of that project, and establish the relevance of that project to society. The way in which this occurs illustrates the processes described in Figure 1. Cognitive framing allows for clarity about the possible pathways that could be used to apply technology, legitimacy signaling reduces the risk associated with using technology, and mission articulation enables connections between the technology and broader societal impacts.

This section examines the role of branding in deep-tech commercialization through three areas of discussion:

1. Challenges faced by science-based ventures with respect to building a brand identity (Section 1.3.1).
2. Strategies employed by organizations to enhance their credibility, legitimacy, and align stakeholders (Section 1.3.2).
3. Case evidence from spin-offs of CERN and other deep-tech ventures (Section 1.3.3).

Figure 1*Core Branding Mechanisms in Deep-Tech Commercialization*

Source: Completed by authors

1.3.1 Branding Challenges in Science-Based and Deep-Tech Ventures

Branding for science-based and deep-tech ventures differs from branding for many traditional industries. Consumer-facing firms have options to differentiate their brand through experience, emotional connections, and through familiarity with customer journeys. In a way, they are able to build credibility and communicate the value of their products and services directly to consumers. Organizations working within deep-tech operating environments are subject to the structural realities described in Section 1.1, which include limited transparency into the development process and an extended time frame before being able to validate early stages of product or service development. The structural nature of these environments also shapes the ways in which organizations communicate the value of their technology to stakeholders, and build credibility as trusted sources of information to those stakeholders over extended periods of time.

The convergence of these factors will turn branding into an issue of legitimation as well as interpretation. The process of this is summarized in Figure 1. This dynamic is directly applicable to CERN-origin technologies.

Cognitive Complexity and Information Asymmetry

One major challenge is to provide clarity on cognitive complexity. Most deep-tech technologies involve complex science-based principles that both investors, policymakers, industrial partners, and even technically educated B2B buyers find difficult to comprehend

(OECD, 2023). Therefore, evaluators have to make a decision with significant informational restrictions.

According to Leek and Christodoulides (2011), under business-to-business and technology-driven contexts, branding serves to compensate for low technological understanding by emphasizing organizational credibility, which signifies a strong identity and provides continuity in relationships. In the above thesis, the OECD provides the empirical foundation for complexity, while Leek and Christodoulides describe how this complexity is alleviated by the process of branding. This fits well with the cognitive mechanism of framing illustrated above in Figure 1.

Lack of Early Market Signals

Another challenge that deep-tech ventures face is the lack of early market signals. As these ventures can be pre-revenue for extended periods of time, they will typically have no basis upon which to evaluate customer traction, adoption metrics, or even short-term performance metrics. WEF (2023) noted that delayed validation creates uncertainty regarding the venture from the perspective of external stakeholders.

As illustrated in the works by Zimmerman and Zeitz (2002), in a situation where there is dominant intensity, startups compensate for the lack of commercial signals by using symbolic cues, such as institutional ties, endorsement by authorities, and a narrative. In the current analysis, the World Economic Forum (WEF) provides an example of delayed validation, and Zimmerman and Zeitz explain the need for a legal substitute in these circumstances. Brands take a crucial role in combining these symbolic cues, which corresponds to the authoritative signaling process depicted in Figure 1.

Regulatory Intensity and Risk Perception

Another factor that causes additional complexity to the situation is regulatory intensity. Technological domains such as healthcare or energy and aerospace technology involve capabilities for regulatory compliance, an orientation to safety, and a readiness for regulatory inspection. None of these are core considerations under typical branding discourse, but are extremely important within a deep-tech domain. Beverland (2018) illustrates how, within a risk-sensitive technology setting, instead of being attached to emotional meanings, the meanings of brands are anchored within competence, transparency, and reliability. This applies squarely to the mechanisms within credibility, as mentioned in Figure 1.

Organizational Characteristics of Science-Based Ventures

Science-based ventures have their own internal issues as well. Research-driven teams will typically put science first and focus on both the nuances of science and precision in technology, in order to build an effective brand message, science-based ventures need to communicate clearly and effectively with their stakeholders. Perkmann et al. (2021) identify that academic organizations tend to underinvest in developing a communication strategy and creating visibility externally, and thus develop fragmented narratives. Additionally, scientists are often hesitant to promote new and emerging technologies confidently, due to the uncertainty associated with these early-stage technologies. This hesitation by scientists to present these emerging technologies creates messages that are overly cautious, and limits the opportunity for scientists to engage with all stakeholders. The limitations of the internal challenges create barriers for science-based ventures to develop a consistent and coherent technological identity, and therefore limit their ability to implement an integrated branding strategy.

Ecosystem-Level Perception Barriers

At the ecosystem level, it is difficult for stakeholders to distinguish research prototypes from new commercial developments. This creates challenges with respect to scalability, manufacturability, and feasibility expectations. This scenario is characterized by low absorptive capacity, as defined by Cohen and Levinthal (1990), and evidence of its impact on technology adoption, as reported by OECD (2023). These two works demonstrate that a low level of absorptive capacity creates a greater need for branding, which acts as interpretive infrastructure.

As a result, the role of branding goes beyond being a source of information to spanning boundaries for understanding the relevance and maturity of technology within various settings.

CERN-Specific Challenges

These challenges collectively demonstrate why the task of branding has become so crucial to the commercialization of deep-tech. Ideally, branding at this level has evolved into more than a mere creative process and has become a fully-fledged strategy that influences legitimacy. Regarding CERN and research institutions in general, branding acts as a facilitator that ensures the technological readiness and sociological appropriateness of innovations, which implies that Technology Transfer and the subsequent commercialization of innovations become successful. Regarding the research question at hand, these challenges demonstrate that CERN innovations require branded processes that define complexity into compelling narratives during early commercialization.

Analytical Implications

Overall, these challenges also explain why branding is critical for deep-tech commercialization as a strategic tool to build stakeholder credibility, reduce uncertainty, and support stakeholders' alignment throughout the extended time frames required by development processes. Branding can assist in conveying the technical maturity, social relevance, and credibility of CERN and other research institutions, thereby strengthening Technology Transfer and innovation enabling progress toward market adoption. These challenges also provide additional insight to answer the research question. The scientific complexity of the technologies originated at CERN demonstrates the need for structured branding that can translate the scientific complexities into credible, application-oriented narrative forms as early as possible in the commercialization process.

1.3.2 Branding Strategies for Deep-Tech Commercialization

Branding strategies for deep-tech companies deviate from traditional consumer or B2B markets. Where scientific and disruptive environments define sectors, branding should provide supportive roles in legitimacy-building and credibility signaling for stakeholder alignment that will be required across long and difficult commercialization cycles. While emotional differentiation and the positioning of the brand in the marketplace will be less important than they typically would be, the focus of branding in the deep-tech industry is on providing clarity regarding the company's mission, demonstrating expertise, establishing institutional trustworthiness, and reducing technological ambiguity (Leek & Christodoulides, 2011; Beverland, 2018) and therefore, these factors will create a logical framework for strategic branding which will respond to the framing and legitimacy issues presented in Figure 1.

Strategic Identity Foundations of Deep-Tech Branding

Brand orientation serves as the groundwork of deep-tech branding by establishing brand values within the organizational decision-making framework. This demonstrates that brand-oriented companies consider their identities as a strategic, long-term platform and not an add-on in the marketing aspect, as explained by Urde (1999) and Balmer (2012). This consistency within deep-tech companies plays an integral role because identities are usually considered within the reliability framework relative to the companies' credibility for stakeholders who are mostly unfamiliar with the technologies themselves.

The identity models put forward by Kapferer (2008) and Balmer can be extended to deep-tech startups through engineering excellence and technical know-how, a stated technological mission that has relevance to society, scientific credentials rooted in heritage,

and sharing development processes and underlying uncertainties. These identity models not only provide stability and authenticity to an organization when direct market validation is not possible, and that applies to CERN-origin technologies, where the identity and credentials of the institutions are evaluated even before commercial success.

Signaling Theory and Legitimacy Building

In the presence of a high degree of uncertainty, it has been found that assessors hardly use direct evidence, and the interpretation of the available signal prevails. As proposed by the signaling theory, when the signal is visible, credible, and difficult to imitate, it helps mitigate the information asymmetry issue, and deep-tech startups employ branding as it emphasizes the partnerships with proven scientific or industrial partners, advancements in the authorization process, engagement with publicly or mission-driven research initiatives, and validation by experts, government agencies, hospitals, and early adopters. The process involves the facilitation of legitimacy creation, as proposed by Zimmerman and Zeitz (2002), making the technology cognitively comprehensible, normative, and consistent with official standards, as depicted by the legitimacy signaling mechanism represented by Figure 1.

Mission-Driven Branding and Narrative Framing

Mission-driven branding in relation to many societal issues being addressed through deep-tech innovation, including medical diagnostics, environmental monitoring, and aerospace safety, supports this argument. By clearly defining a mission, as argued by Mazzucato (2018), it increases credibility by linking technological development to societal objectives rather than just commercial interests. The framing of deep-tech solutions using these missions provides an opportunity to position technologies as platform solutions with long-term developmental potential and large-scale impacts, they can also translate the complexities of science into understandable and actionable narrative statements. These statements are most valuable in situations where the commercial success or failure of a deep-tech solution has not yet been determined, and where they can create interpretative frameworks to enable understanding and evaluation of the potential of a solution by patient investors, long-term business partners, and regulatory actors, all of whom prioritize long-term value creation over short-term financial returns.

Stakeholder Alignment and Communication

The various stakeholders of deep-tech ventures (scientists, engineers, investors, industrial partners, authorities, and users) have different cognitive bases and evaluation criteria when they are involved with deep-tech ventures as stated by Santos-Vijande et al. (2013), an internal brand orientation is essential for the organization's actors to send coherent

and trustworthy information to all their points of contact, because this fragmentation of communication increases the perception of risk and weakens legitimacy. In order to align effectively with the needs of the various stakeholders, it is necessary to adjust the technological intensity of the venture to the absorptive capacity of the stakeholders, to build development plans connecting scientific progress to the phases of implementation, to translate the complexity of the technology using visualizations and analogies, to coordinate the R&D, Knowledge Transfer, regulatory, and business development functions, etc. These practices will contribute to framing and managing expectations by integrating scientific, regulatory, and social narratives into a unique communication structure.

Foundational Pillars of Deep-Tech Branding

Within the literature, deep-tech branding approaches typically consist of at least four interrelated pillars: the first one is related to gaining credibility through scientific reputation, progress in regulations, partnership-building, and scientific endorsement, highlighting the second pillar, which is gaining sustainability by positioning applications and technologies through missions, value narratives, and compliance, and then there is the third pillar that is related to managing expectations through communication, which encompasses uncertainties, TRL, development time, and adoption, and lastly, alignment through messaging across audiences. All these pillars identify significant challenges introduced in Section 1.3.1 and relate well to the discussion found in Chapter 1.2 regarding the Technology Transfer requirements.

CERN Spin-Offs and Knowledge Transfer Branding

In case of CERN, branding practices need to incorporate both aspects of being a global hub of scientific research and a producer of innovative technologies applicable in practice. CERN spin-offs and licensed technologies generally rely on the reputation of CERN as an indication of their credibility, couch their technologies in mission-based stories like biomedical imaging and ecological monitoring, and stress the reliability derived from engineering applications informed by the demanding needs of high-energy physics. Moreover, they convey stories of long-term research and development phases associated with government approval and industrial acceptance. The above practices generally are sufficient to deal with the branding issues discussed in Section 1.3.1 and offer a foundation for investigation into how these above-mentioned mechanisms are at work in deep-tech cases discussed in Section 1.3.3.

1.3.3 Case Evidence: Branding in CERN Spin-Offs and Other Deep-Tech Ventures

Empirical research on deep-tech ventures have clearly shown the significant impact of branding on the perceptions of stakeholders and on the mitigation of uncertainty in technologically complex settings. Findings gathered from CERN spin-offs, licensed CERN technology, and other deep-tech ventures illustrate the role of branding in bridging the complexity of science and communicating effective value statements, and the use of branding in the positioning of new technology within the context of its applications.

Evidence from CERN-Originated Ventures

Medipix and MARS Bioimaging

The Medipix collaborations are an established channel for the commercialization of deep-tech that has its roots in CERN. The initial application of the collaborative effort was the development of a hybrid pixel detector for particle physics applications. The detector was later repurposed for other sectors, including medical imaging, materials science, and industrial inspections. This shift in application also meant a transition from the initial scientific identity to an application-based value.

MARS Bioimaging illustrates this trend particularly well. Instead of emphasizing the scientific heritage of CERN, the company positioned spectral CT as a highly innovative technology with the potential to produce color three-dimensional images that can differentiate tissues (Vykydal, Tureček, & Jakubek, 2021). The emphasis here was clearly on clinical insight, patient outcomes, and alignment with clinical practice, none of which were part of the scientific discourse. This illustrates the necessity of focusing scientific innovations on practical applications to communicate with non-scientific communities.

ADVACAM and Industrial Imaging

In the case of ADVACAM, the company has refined the technology developed from Medipix for non-destructive testing, aerospace, and semiconductor inspection. In the presentation of these technologies, the company does not take a branding approach with a single, distinctive focus. Instead, the company establishes a connection between the scientific background of the technology and its relevance to the business world. By pointing to the accuracy of the detector, the ability to resist radiation, and the scientific robustness of the technology, the company demonstrates scientific credibility. However, the same attributes also pertain to reliable functionality, viability, and relevance to current business processes. In this way, the company translates scientific superiority into a domain that the business world can easily relate to.

PlanetWatch and Environmental Monitoring

PlanetWatch converted gas-sensing technologies that originated in the context of CERN projects to facilitate environmental monitoring. Their branding strategy conveys the idea of ease of access, decentralization, and impact, and the communications strategy in the context of the organization retains a direct focus on its environmental goals. Relevance to society emerges as the prime mover, indicating the use of mission articulation as the primary branding story, when the underlying technological challenges are high and recognition is pending.

Comparative Evidence from Non-CERN Deep-Tech Ventures

Nanox Imaging

Nanox positioned its innovation in the area of the X-ray source with a mission to improve the accessibility of healthcare globally, although the actual technological innovation was still in the early stages of its development. Such a mission-based approach to positioning its innovation led to a significant amount of investor interest before full regulatory approvals were obtained. The case thus illustrates the use of value stories for improving early-stage validation, which is a challenge that faces many technologies that come out of CERN.

Quantum Motion

Quantum Motion promotes itself as a commercially driven initiative related to quantum computing, highlighting engineering viability, scalability, and collaboration. This branding approach fosters greater ease of interpretation for a highly complex research area. Analogous challenges can be noted for technologies that originate at CERN, which may feature scientific ideas that impede assessment by people not familiar with this realm.

Cross-Case Patterns

In both CERN and non-CERN cases, three categories of branding can be identified.

Firstly, venture projects actively interpret scientific complexity into value statements targeted at specific applications. MARS seeks outcomes related to patient health, while both ADVACAM and PlanetWatch focus on applications within industry or the environment, respectively. Technologies that address specific domain-related needs always develop faster among stakeholders.

Second, scientific pedigree is a strong signal of credibility. Being associated with CERN is a strong signal of credibility, and this pattern is evidenced in the quantum and AI

initiatives associated with prestigious research institutions. This pattern is consistent with the theory of signaling (Spence, 1973).

Third, reframing narratives serve the role of uncertainty management and legitimacy affirmation. Mission, application, and result narratives function as a replacement for unavailable market cues. This is in line with legitimacy theory as well as research studies on institutional branding (Zimmerman & Zeitz, 2002; Germain, Vaara, & Patriotta, 2023).

Implications for Branding within CERN's Technology Ecosystem

The evidence from this case suggests that CERN spin-offs are more effective when branding communicates a focus from scientific competence to application-driven, mission-focused, and stakeholder-aligned narratives. The branding task is, therefore, to express technological value in a manner that is pertinent to specific stakeholders. The objective of deep-tech branding is seen to be focused on achieving legitimacy, rather than merely seeking visibility. The importance of narratives differentiates investors, regulators, users, and partners, even when Technology Readiness Levels are low. This indicates that branding offsets the consequences of delayed validation, which is common among CERN-origin technologies. The findings from this case further strengthen the major mechanisms explored in this thesis, which consist of cognitive framing, legitimacy signaling, and mission articulation.

Analytical Link to the Research Question

The cases demonstrate that branding plays a crucial role in both the interpretation and assessment of innovations in the field of deep-tech, particularly in a context of uncertainty. The branding process in start-ups within the CERN community and similar projects converts the complexity of science into a benefit-oriented idea, enabling the achievement of legitimacy and creating a framework for interpretation in the context of market validation.

In the context of CERN-origin technologies, it is not sufficient to depend solely on scientific lineage to guarantee their commercialization in an environment characterized by regulatory uncertainties, unfamiliar technology spaces, and development time scales. Cognitive framing, signaling, and articulation are aided by branding, which helps to overcome risks. The results empirically validate the conceptual framework proposed in Figure 1 and specifically respond to the research question of how branding can facilitate the commercialization of CERN-origin deep-tech innovations.

1.3.4 Branding as a Mechanism in Deep-Tech Commercialization

Branding serves as an enabling mechanism for the commercialization of deep-tech innovations from CERN in a state of prolonged uncertainty. The proposed conceptual framework in Figure 1 integrates the literature concepts of deep-tech innovation commercialization, Technology Transfer, the theory of legitimacy, signaling, and framing to answer how, in the absence of traditional market information, branding influences the interpretation of innovations by various stakeholders.

Context Conditions

The emergence of deep-tech innovations from the CERN-origin occurs under a specific set of structural conditions. Such conditions include a high level of scientific complexity, long development times, high capital requirements, uncertainties in the regulatory environment, and a low level of validation in the early stages. Finally, the Technology Transfer environment of the specific case of CERN adds a set of specific conditions, which include the governance structure of a supranational organization, the culture of open science, collaborative development, and specific rules concerning intellectual property rights, as well as the use of brands.

Branding Mechanisms

Under this paradigm, the role of branding in mediating technological progress and resultant commercial performance is accomplished through four distinct mechanisms.

First, the lack of commercial evidence becomes less of an issue as CERN affiliation, compliance with public mission statements, and references to scientific and regulatory standards become sources that provide cognitive, symbolic, and regulative legitimacy, respectively. The affiliation with CERN, compatibility with public mission statements, and references to scientific and regulatory standards help stakeholders make sense of CERN-affiliated technologies as legitimate, trustworthy, and acceptable, even when there is limited commercial evidence.

Second, the problem of information asymmetry is reduced by the presence of signaling, as there are visible and expensive signals about quality and intentions. Being in partnerships with credible industrial partners, engaging in joint consortia, reaching regulatory milestones, implementing pilot projects, acquiring certifications, and affiliations from experts act as signals to indicate advancement and intention. In the deep-tech space, signals mitigate the lack of measurable revenues or adoption.

Third, cognitive framing helps in the translation of complexity in scientific knowledge into value statements that are easier to understand. In this process, technology is framed within fields of application, benefit, improvement, and development, as opposed to being expressed in scientifically complex terms. This makes it possible for non-experts to develop well-informed expectations.

Fourth, mission articulation ties the advancement of technology back to larger, often society- or policy-driven, goals like better healthcare, environmental stewardship, and industrial safety. Mission stories can offer an overarching, guiding interpretation for many years that will appeal to patient capital, governments, and institutional stakeholders. In answering why a technology matters, mission articulation again builds on legitimacy.

Expected Outcomes

These mechanisms work cumulatively to shape the perceptions of stakeholders with regards to technologies that come out of CERN, thus shaping the course of commercialization. Branding mechanisms are used to build credibility, reduce uncertainty, and shape views on market readiness. Therefore, these mechanisms induce involvement in collective innovation, investment, participation in pilot projects, or the formation of licensing or spin-offs, despite a lack of full market verification.

Operationalization for Empirical Analysis

The mechanisms mentioned in the literature were applied in the empirical analysis by using interview-based indicators for legitimacy, signaling, framing, and mission articulation. Legitimacy is represented by references to trust, reputation, affiliation with institutions, and compliance with regulations. Signaling was indicated by mentions of partnerships, certifications, pilot projects, milestones, and endorsements. Framing represents the translation of complex technology into a narrative that can be utilized by applications. Mission articulation includes statements describing the social impacts of the technologies being described.

By connecting structural aspects, branding mechanisms, and anticipated results, this conceptual framework provides a tool for analysis for the study of how branding assists in the commercialization of CERN-based deep innovations of a technological nature. It clearly informs the coding frame and thematic analysis in Chapter 3 and assists in answering the research question of how branding mechanisms influence the interpretation and engagement of stakeholders in uncertain situations.

2. METHODOLOGICAL PART: Research Design

2.1 Research Approach

The study applied a qualitative and exploratory approach to gain insights into the role played by the branding process itself in achieving the commercialization of deep-tech innovations produced within large scientific institutions, such as CERN. A qualitative approach was suitable for this study because the studied phenomena rely on relationships and processes that are developed. Factors like the construction of legitimacy or the building of credibility cannot be translated into quantitative values, and the early stages of the branding process only become apparent when considering how actors interact within a particular context.

Abductive reasoning is adopted. The existing research on deep-tech, technology transfer, and branding constitutes an initial frame of analysis, but it is not considered a closed frame. In an iterative process, theoretical notions and empirical data build on and inform each other: notions such as signaling through legitimacy or institutional support inform data gathering, and unexpected findings revert to theoretical notions about these constructs. This strategy of reasoning is highly relevant for this CERN context, since branding devices remain only partly conceptualized.

The methodological structure is composed of three interconnected elements

1. A Systematic Literature Review (SLR) to provide the underlying theory and suggest candidate mechanisms.
2. Semi-structured interviews that explore the experiential understanding of the workings of these mechanisms during the commercialization of CERN-origin deep-tech.
3. Examples of cases illustrating mechanisms in the context of commercialization processes.

The empirical data generated through these building blocks informs the analytical phases discussed in Section 2.4. The advantage of the overall design, which allows for the integration of all the building blocks, is facilitating the linkage of constructs such as legitimacy or signaling, or institutional support to existing literature, investigating their presence within the primary data source, as well as their compatibility among the assorted data sources.

2.2 Data Collection Methods

Three methods of data collection have been employed to support triangulation to help identify mechanisms. The aim of the current study is not a statistically driven aim of generalization, but rather to gain a better understanding of the mechanisms in the observed processes.

Systematic Literature Review (SLR)

The SLR has provided the conceptual framework on which this research is based. The search took place on both Scopus and Web of Science, using predefined criteria concerning deep-tech research organizations, technology transfer, legitimacy, signaling, communication, or relevant grey literature. The role of Google Scholar remained limited to tracing citations for the purpose of grey literature searching.

The search strings used combined terms such as "deep-tech," "technology transfer," "legitimacy," "signaling," "branding," and "research institutions." The articles must have: (1) studied science-based or deep-tech firms, (2) explored commercialization, technology transfer, or stakeholder assessment, and (3) investigated methods associated with legitimacy or reduced certainty. The SLR had three purposes:

- to identify the deep-tech structural barriers to commercialization.
- to map theoretical mechanisms related to branding.
- to formulate what should or should not be traced in qualitative data.

This provides the abductive "theoretical anchor" against which the interview and case data are evaluated.

Semi-Structured Interviews

Semi-structured interviews were preferred as they provide a middle-of-the-road approach between comparability and the ability to search for novel findings. A more structured method would confine the respondent to pre-set categories, and finding mechanisms that have yet to be identified might become more difficult and less noticeable to the researcher. On the other hand, unstructured interviews would enable the development of rich descriptions but might pose difficulties when making cross-case observations. Semi-structured interviews enable the researcher to delve into the mechanisms and retain enough uniformity for the identification of expert descriptions about legitimacy mechanisms, signaling, and branding.

The interview guide was developed from the SLR and structured around some mechanism areas: legitimacy, credibility, endorsement signaling through institutional backing,

partnership framing through narrative mechanisms, and uncertainty reduction. These areas contained open questions referring to specific instances such as funding phases, conversations, or brand decisions. Both researchers pre-tested the guide and refined it to avoid leading questions and definitions of specific terms.

This approach aligns well with the CERN environment, where the process of commercialization is only comprehended by a small community of experts and where mechanisms are at work within the project histories that demand follow-up questions.

Case Illustrations

Cases provide additional illustrations to complement the interview data, where mechanisms associated with branding manifest themselves in real-world settings of commercialization. These are not ethnographic cases. They are more empirical illustrations that observe mechanisms, such as credence in CERN affiliation or the application of mission framing while communicating with investors, among others.

Cases were chosen based on three criteria:

1. Relevance to technologies of CERN origins.
2. Availability of any documentation related to branding or communication methods (e.g. websites, presentation slides, media articles, CERN reports).
3. Sectors and intensity of regulation (e.g., medical imaging, environment monitoring) with differing levels of risk and requirements for evidence to monitor how mechanisms are functioning.

To avoid institutional self-presentation bias and to verify that the identified mechanism is not related to a specific type of information source, publicly available information has been compared to the interview results.

2.3 Interview Design and Procedure

Sampling Logic and Choice of Experts

The sampling strategy followed was purposive, reflecting an "expert-oriented logic", suited to small, specialized populations. The relevant population comprises individuals (1) engaged or actively involved in CERN technologies or their applications, or commercially related, and (2) those who make or help shape evaluative judgments concerning credibility, legitimacy, or risk.

Three criteria were used:

- **Relevance** – participants must have first-hand experience with CERN KT processes, CERN-related ventures or investments made in deep-tech.
- **Expertise** – roles involve analytical or decision-making functions (KT officers, founders, investors, TT experts) as opposed to tangential knowledge.
- **Heterogeneity of evaluative perspective** – incorporating institutional participants (CERN) and external stakeholders (industry, hospitals, or investors) to reflect the varied interpretation of the same signals by diverse groups.

Specialists, rather than “average” entrepreneurs and users, were chosen for the study, since the paper is about evaluation mechanisms, and these are more known to individuals who regularly assess new technology. This approach was also necessary, since the study was not limited to entrepreneurs, so the opinions of institutions should also be included, and vice versa.

Sample Size Justification

The final sample of five interviewees has a sufficiently large number to achieve thematic saturation, since the pool of experts with direct experience in commercializing CERN-origin deep-tech is very limited. As such, the methodological quality is much more dependent on achieving depth in the information collected, as well as achieving positional diversity, rather than the quantity of interviews. Guest, Namey, and Chen (2020) have identified that for homogeneous expert populations, thematic saturation will generally occur after no new insights are reported in an additional two to three interviews, or with approximately 4-6 interviews in total.

In this study, the fifth interview participant did not identify mechanisms beyond those previously identified, such as institutional endorsement, mission framing, or legitimacy signaling. It is probable that additional interviews would have produced additional illustrations of these same mechanisms, rather than new ones. For this reason, along with the mechanism-focused abductive design of the study, and the limited number of experts available, an interview sample size of five was acceptable and consistent with qualitative research practices. Additionally, the FMTP provides acceptable guidelines for using small numbers of expert participants when the purpose of the study is to find out how mechanisms work, rather than to provide statistically representative results.

Interview Procedure

All of the interviews were conducted using a similar format to ensure consistency across all participants. Authors A and B both assisted in developing the interview guide and determining the strategy that would be used to probe for information prior to conducting the interviews. Author A completed three interviews, while Author B completed two interviews. In addition to being able to conduct interviews in the same format based on the preferences of the participants, interviews were also conducted through multiple formats, including online video conferencing, face-to-face, and written responses. All participants who completed oral interviews signed an informed consent form before completing the interviews, had their interviews recorded using audio recorders, and had their interviews transcribed verbatim. The written responses were accepted as is from the participant and were utilized as equivalent sources during the analysis of the data. After each interview, a brief memo was written documenting initial thoughts regarding potential links to theory and emerging mechanisms identified in the interviews. All transcripts and written materials were anonymized and formatted in preparation for coding.

Ensuring Reliability and Minimizing Bias

Several procedures were employed to ensure reliability and minimize bias:

- **Neutral interviewer position** – an understanding that there are no "right" answers, and a lack of evaluative reaction during interviewing.
- **Cross-interviewer agreement** – the authors reviewed each other's early transcripts and agreed upon the type of questions asked and their depth.
- **Iterative probing** – asking for specific episodes, examples, and documents to decrease dependence on general statements or post-event recollections.
- **Terminology checks** – the authors clarified any definitions of terms used, such as "branding", "legitimacy", or "endorsement from CERN", in a way that could be easily understood to prevent misinterpretations.
- **Selective member checks** – follow-up with short emails to clarify unclear interpretations of factual information.

The division of labor for conducting the interviews, in accordance with the FMTP, was distributed as follows. Author A was primarily responsible for developing the interview guide and conducting three interviews. Author B organized the recruitment for the interviews and conducted two interviews, and transcribed all the interviews. Both authors collaborated on transcribing the interviews for analysis.

2.4 Data Analysis and Validation

The data analysis employed a structured abductive approach to uncover how branding-oriented mechanisms interact within the commercialization process of deep-tech solutions originating from CERN. The process was designed and developed with the research question in mind. It is evident that themes developed empirically from the data, yet remained aligned with prevailing studies.

Five-Step Analytical Procedure

The analysis proceeded in five sequential but iterative steps.

Step 1 - Familiarization

Authors both reviewed all documentary evidence and transcript interviews multiple times. They also produced analytical memos during this process. The authors noted their early impressions, common themes that were found throughout the data and how participants may have used mechanisms such as CERN affiliation, credibility, legitimacy, etc., to reduce their uncertainty. Authors used these findings from the initial review to create a baseline for later formal coding and analysis.

Step 2 - Open Coding

Open line-by-line coding was conducted on all of the interview transcripts. The coding identified both explicit and implicit references to legitimacy, credibility, signaling, institutional endorsements, uncertainty, trust, and value framing. These codes at this point were intended to be as broad and descriptive as possible, so as to prevent premature closure of categories, and allow for potential patterns not originally anticipated.

Step 3 - Axial Coding

In axial coding, open codes that were relevant to one another were combined into larger conceptual clusters based on their function. For instance, open codes “use of CERN name,” “mention of CERN reputation,” and “link to CERN standards” were all combined into a node that was linked to institutional endorsement. At this particular stage, it was essential to focus on the relationships between the codes, rather than identifying themes.

Step 4 - Thematic Grouping

The conceptual clusters were further developed into wider themes for the mechanisms, such as institutional support, mission-based framing, or using transparency to reduce uncertainty. The themes were also tested against the interview data to ensure that they were

not based on single instances, but were also held by other participants. Only those themes that were consistent across a few interviews were retained.

Step 5 - Mechanism Validation through Triangulation

Finally, the themes were validated through the findings of the systematic literature review, as well as the cases. A theme was retained only if at least two different sources were supporting the theme, for example, interviews and documents, or interviews and cases. An effort was made to ensure that the findings revealed known mechanisms, rather than personal opinions.

Abductive Coding Logic

The analytical process employed abductive logic. The existing knowledge on deep-tech commercialization, technology transfer, and branding provided sensitizing concepts, and the data was employed to refine or adjust these expectations. The analytical process did not employ deductive theory application. There was also no inductive generation of themes. The process oscillated between theory and data.

This is relevant in the context of CERN, in as much as branding in research-intensive deep-tech institutions is a field in its infancy within the current literature.

Mechanism Operationalization

Mechanisms were grouped based on the involvement of each in the assessment of stakeholder value as follows:

- Legitimacy implies ideas about appropriateness and acceptability related to formal institutional and marketplace norms held by stakeholders.
- Credibility signaling, which embodies the idea of intentional communication with respect to competency or readiness, including but not limited to scientific qualifications or milestones of development.
- Evidence-based credibility is associated with external verification of proof related to approval or performance certification.
- Uncertainty Reduction involves actions aimed at enhancing the certainty and clarity of risks, time scales, and development paths.
- Institutional endorsement includes the explicit and implicit use of the name, reputation, and authority of CERN.

Table 2*Theory–Codes–Empirical Categories Mapping*

Theoretical Lens	Deductive Codes	Empirical Examples
Deep-Tech	TRL gaps; uncertainty; scientific complexity	Validation challenges; risk perception; long development timelines
Technology Transfer (TT)	Stakeholder alignment; governance structures; TTO roles; commercialization pathways	Coordination within CERN KT; decision-making; partnership patterns
Branding	Legitimacy-building; scientific narrative; mission framing; credibility mechanisms	Communication practices; stakeholder trust; value translation

Function of Table 2

Table 2 illustrates the abductive analytical logic by connecting the theoretical lenses derived from the literature review with the deductive codes and the empirical categories. This shows how the initial coding framework was guided by theory and how the empirical information was consolidated into themes. It provides an account of how abstract ideas were operationalized in the analysis by being mapped into the framework of the analytical chapter.

Triangulation and Validation

Three forms of complementary evidence were sought:

1. Interviews that provide experiential insights into the evaluation of branding and legitimacy.
2. Documents such as CERN Knowledge Transfer documentation and public venture communication pieces that tell formal stories.
3. Examples of cases, illustrating the visible branding practices on the respective commercialization routes.

Saturation was explored in the analysis and was achieved by the fifth interview, as there were no further mechanisms emerging from the interviews beyond those already identified. Cross-coding was used to improve reliability, with the authors independently coding elements of the transcripts and discrepancies being resolved through discussion.

Table 3

Interviewee-Theme-Expected Insight Matrix

Interviewee	Theme	Expected Insight
P1	Branding role in deep-tech commercialization	Clarification of how branding functions within CERN KT processes and influences external stakeholder perception.
P1	Communication challenges of science-based technologies	Identification of internal/external communication gaps specific to CERN-originating technologies
P1	Legitimacy and trust-building mechanisms	Understanding how branding enhances credibility, trust, and legitimacy in CERN's technology transfer ecosystem
P1	Stakeholder engagement & value proposition clarity	Insights into which branding elements help align technology narratives with investor and partner expectations.
P1	Organizational constraints and institutional context	Observations about structural or cultural constraints within CERN that affect branding strategies.
P2	Branding role in deep-tech commercialization	Practical perspective on how branding accelerates or slows commercialization for CERN-related ventures
P2	Communication challenges of science-based technologies	Real-world examples of how technical complexity blocks communication with customers or investors
P2	Legitimacy and trust-building mechanisms	Evidence of how trust and legitimacy influence funding decisions and partnerships.

P2	Stakeholder engagement & value proposition clarity	Evaluation of branding tools (storytelling, positioning, design) used by startups to reach markets.
P2	Organizational constraints and institutional context	Founder's view on how institutional setups support or hinder branding efforts.
P3	Branding role in deep-tech commercialization	Investor's criteria for evaluating branded vs. unbranded deep-tech ventures.
P3	Communication challenges of science-based technologies	Identification of communication red flags that impede investor understanding.
P3	Legitimacy and trust-building mechanisms	How perceived legitimacy affects willingness to invest in high-risk technologies.
P3	Stakeholder engagement & value proposition clarity	Insights into the branding signals investors find credible and persuasive
P3	Organizational constraints and institutional context	Investor perspective on institutional readiness and ecosystem maturity
P4	Branding role in deep-tech commercialization	Institutional view on how branding integrates with KT strategy
P4	Communication challenges of science-based technologies	Main communication bottlenecks observed in technology transfer processes.
P4	Legitimacy and trust-building mechanisms	Mechanisms through which institutional branding supports trust-building.
P4	Stakeholder engagement & value proposition clarity	How stakeholder alignment is achieved through clearer branding narratives.
P4	Organizational constraints and institutional context	System-level constraints and enablers affecting branding implementation.
P5	Branding role in deep-tech commercialization	Perspective on branding's role in overcoming market-entry barriers for spin-offs.
P5	Communication challenges of science-based technologies	Examples of failure points in translating scientific value to user-facing language.

P5	Legitimacy and trust-building mechanisms	Insights on how recognition, endorsements, and affiliations contribute to legitimacy.
P5	Stakeholder engagement & value proposition clarity	Evaluation of effective vs. ineffective stakeholder communication strategies.
P5	Organizational constraints and institutional context	Founder's insights into structural obstacles (bureaucracy, IP, governance).

Table 3 illustrates the role of each interview in making a contribution to the analysis with a mapping of participants to thematic areas and expectations regarding analysis outcomes. The table provides transparency regarding analysis contribution expectations for each interview and its relevance to the objectives.

Division of Analytical Roles (FMTP Requirement)

Author A conducted open and axial coding on three interviews. Author B did the coding on two interviews and supervised the coding of the documentation. The two authors then went through the coding framework together to ensure agreement on the themes.

Research quality was evaluated using Lincoln and Guba's (1985) criteria of credibility, transferability, dependability and confirmability. These criteria were adapted to fit the mechanism-oriented abductive design used in this study.

2.5 Research Quality, Ethical Considerations, and Limitations

Research quality was evaluated using Lincoln and Guba's (1985) criteria of credibility, transferability, dependability and confirmability. These criteria were adapted to fit the mechanism-oriented abductive design used in this study.

Credibility

The extent to which the findings appear convincing to actors familiar with CERN's technology transfer environment was supported through several procedures embedded in the analytical process described in Section 2.4. Triangulation of data was implemented by verifying mechanisms only when they emerged consistently across at least two forms of evidence, either through interviews, texts, or exemplars, to avoid the risk that particular trends might merely represent the sentiments of one interviewee or source. Triangulation on theory

was implemented through ongoing comparison of empirical findings concerning themes, as they related to antecedent literature on deep-tech, technological transfer, or branding. Whenever inconsistencies emerged, coding was investigated, and when necessary, a refinement of mechanism definition was conducted.

The saturation tests revealed that no significantly new mechanisms appeared after completing the fifth interview, and it could thus be determined that a good representation of basic patterns related to legitimacy, signaling, and institutionally sponsored acknowledgment had been obtained. The selective member checks included instances where there was a question surrounding a factual interpretation concerning the chronologies of knowledge transfer initiatives.

Together, these methods increase confidence that the observed mechanisms are indicative of branding functioning within the commercialization of CERN-origin deep-tech, but are not simply a reflection of personal views.

Transferability

The applicability of the results is considered through the provision of a thick description rather than statistical generalization. The study describes CERN's knowledge transfer structures, governance, and typical routes of technology commercialization, as well as key actor roles and viewpoints, including knowledge transfer officers, founders, financiers, and technology transfer professionals.

In addition, the regulatory and technological environments in the focal cases, including sectors such as medical imaging and environmental monitoring, are discussed. These factors help the reader determine whether the mechanisms are potentially applicable in other research-intensive organizations.

Dependability

To ensure the stability and transparency of the research process, a concrete analytical procedure in the form of a five-step process, described in Section 2.4, was strictly adhered to for all interviews and documentary analysis. A common semi-structured interview guide was employed, with some minor variations based on the roles of the interviewees. Crucial steps of the research process were recorded in analytic memos, such as merging versus splitting procedures and mechanism definition.

Additionally, a subset of the coded and transcribed texts was independently verified against the transcripts by both researchers. Such procedures contribute to creating an audit trail, which could theoretically allow the replication of the analyses undertaken.

Confirmability

The basis of the findings in the data, rather than in the preference of the researchers, was supported by the linking of each identified mechanism to several examples from the interviews. A codebook was kept to record the progression from initial open-coding to final themes.

Reflexive memos were used to document and reflect on previous assumptions about the topic of branding and the commercialization of deep-tech that were disproven by the data. The analytical chapter of the study distinguishes between descriptive and interpretive claims to clarify how the interpretive logic works.

Ethical Considerations

The research adhered to GDPR rules and other institutional considerations regarding qualitative research on human participants. The study participants were given an information sheet regarding the nature of the study, the proposed use of the study data, the voluntary nature of their participation, and their right to withdraw from the study without any repercussions. Informed consent was obtained either in writing or through voice recordings prior to each interview.

Personal identifiers were removed from the transcripts, in addition to referring to the individuals solely through pseudonymous roles (e.g., knowledge transfer officer, founder, investor). Audio files, as well as transcripts, were stored in password-protected devices available solely to this particular researcher. Storage of data was kept for the shortest time period feasible for the completion of thesis assessment, afterward, all data were properly erased. Because the population examined contained individuals with rather specialized knowledge, there was particular attention to protect against the revelation of sensitive organizational information capable of indirect identification.

Limitations

Some constraints need to be considered when reflecting on the results. The community of experts involved in the commercialization of CERN-origin deep-tech is necessarily limited, and while the five interviews provide important insights, they do not cover the whole spectrum of opinions within CERN or its wider community. Some mechanisms found are likely to be highly context-dependent, deriving from the unique blend within CERN of supranational regimes, high scientific sophistication, and its funding mechanisms, which are clearly not replicated anywhere else. Some mechanisms could be applicable to other organizations, while others may be CERN-origin.

While a reliance on self-reporting from interview responses presents a possible risk of either hindsight rationalization or selective reporting, the use of triangulation can mitigate that risk, but it cannot totally prevent it.

Interview case studies were developed from public data and information, as well as insights from interviews, as opposed to having complete ethnographic access to each venture. Therefore, the case studies illustrate how ventures operate, but provide no comprehensive history of the venture.

Similar to other qualitative research, although the researcher used systematic coding, cross-checks, and triangulation, the results of this research will still be influenced by the researcher's interpretive perspective. In addition, one of the interviews was completed using written responses, as opposed to an oral response, limiting the opportunity to probe and ask follow-up questions, and therefore potentially reducing the depth of the interview compared to an oral interview. While these restrictions limit the generalizability of this research, they do not limit the methodology used to determine if the objective of the study is valid.

Summary

In this chapter, a mechanism-oriented abductive approach has been described, and a combination of a systematic literature review, semi-structured expert interviews, a case illustration, and a multi-stage analysis protocol has been introduced. Observations regarding research rigor, ethics, and boundaries provide a clear basis for the empirical analysis regarding the impact of branding on the commercialization of CERN-origin deep-tech innovations.

3. ANALYTICAL PART: Empirical Research on Branding and Commercialization

3.1 Introduction to the Analytical Chapter

This chapter will report on an empirical study of how far branding can help with the transition from the lab to the market for deep-tech innovation produced by CERN researchers. To conduct this study, we relied on the comments of two CERN-based knowledge transfer specialists (Participants 3 and 4), two spin-off founders or technical managers (Participants 1 and 5) and one deep-tech marketing specialist (Participant 2). Each of the three groups has a distinct viewpoint and experience, all provide insight into the role of branding and legitimacy in the transfer of technologies developed at CERN to the private sector.

The data collected were analyzed via the thematic approach outlined in Section 3.5. This approach follows Braun and Clarke's (2006) guidelines and includes the following steps:

- Open coding the participant's answers to identify the major concepts and ideas in the participant's responses to the research questions related to uncertainty, legitimacy, institutional reputation, communication methods and commercialization obstacles.
- During axial coding, grouping the codes into categories.
- Identifying selective themes that represent commonalities in the participant's comments across the interviews.

By employing this coding process, we can move beyond merely identifying the key points made by the participants to illustrate how the participants viewed branding as a mechanism to assist in moving the CERN-developed deep-tech from the laboratory to the commercial marketplace.

The chapter is organized around five interrelated themes that emerged from the coding:

1. Branding under the influence of deep-tech uncertainty, show how participants see branding, and their experience with it as a mechanism for long term development cycles, technical opacity, and limited early information.
2. The "CERN halo": institutional reputation as a legitimacy asset and constraint, examining how CERN's brand simultaneously opens doors and sometimes signals bureaucratic risk.

3. Translation of the scientific complexity, analyzing communications practices, channels, and formats (e.g., video, expert-to-expert interaction) helps make CERN-related technologies understandable to non-scientific stakeholders.
4. Mission framing, societal value, and trust, exploring how health, space, or environmental narratives are used to justify patient capital and long-term engagement.
5. Internal issues (Communications Problems) and alignment around branding in a deep-tech environment between scientists, KT specialists, and marketing professionals, and their point of view about the role and legitimacy of branding inside the organization

The themes of the study are supported with quotes from the interviews instead of just quotes from the summary of data. As participant 3 says, “Nowadays, without digital presence, you basically don’t exist. Marketing is mandatory. It’s the only way to let people know what we do,” and participant 5 adds, “We wouldn’t have got through the door of a hospital like that if we didn’t have the appropriate marketing and branding.” Quotes like those directly support the empirical evidence of the mechanisms that we found within the theoretical framework.

The chapter also links all of the observations found throughout the other chapters to the problems associated with the deep tech challenges in sections 1.1 – 1.1.4, the perspectives on technology transfer in sections 1.2 – 1.2.4, and the branding mechanisms in sections 1.3 – 1.3.3.

In addition to identifying and reporting on the current literature, the analysis allowed for the identification of nuance and at times challenged existing literature by looking at direct quotes from the experiences of experts. For example, prior studies have discussed the importance of branding in creating uncertainty, but participant 1 critiqued branding, saying “branding is even exaggerated. It’s overestimated, overused, abused,” and therefore refocused the conversation to the quality of products and communication between experts. These contradictions help to refine the conceptual model presented in Figure 1 and provide an empirically grounded answer to the research question: How does branding enable the commercialization of CERN-origin deep-tech technologies?

3.2 Participant Profile and Interview Process

This study uses in-depth, semi-structured interviews of five people who are involved in the commercialization of CERN-origin deep-tech technologies. The five participants selected through purposive sampling were diverse: engineering, marketing, science communication, entrepreneurship and innovation policy. Since branding in the commercialization of deep-tech

technologies is multi-dimensional and requires technical knowledge, institutional legitimacy and mission-based communication, diversity was necessary for this study.

Semi-structured interviews allow the researcher to explore and address the complexities of legitimate building, framing narratives, branding, etc., and give the participants the opportunity to verbally express their thoughts and describe their experiences in their own words. Semi-structured interviews also allow researchers to develop and inquire about follow-up questions based on the participants' responses. This was advantageous for this researcher, as she was examining a new area of research with structured interviews.

Participant Overview

The views of the participants are represented as follows:

P1 / Senior Engineer / Engineering and Commercialization. P1 has worked with Medipix/Timepix detectors for over fifteen years. P1's senior engineer view of branding at a deep-tech level is related to engineering and commercialization.

P2 / Marketing and Communications Lead / Deep-Tech Marketing. P2 has experience with B2B communications and describing visually complex things as simply as possible, and how these types of descriptions create a first impression of what stakeholders can expect from a company or product according to P2.

P3 / Communications and Branding Specialist, CERN KT / Institutional Branding. P3 is responsible for developing the digital strategy for CERN KT, as well as for the management of the CERN KT presence on LinkedIn and the creation of institutional positions for CERN KT. P3 provides information related to institutional branding including the political environment in which institutional branding decisions are made, the process by which institutional branding decisions are made and approved and the challenges in applying the overall brand of CERN to B2B marketing.

P4 / CTO / Scientific Entrepreneurship. P4 is the founder of Spectral Photon-Counting CT technology and developed it in collaboration with CERN. P4 has an entrepreneurial/scientific perspective on legitimacy, clinical adoption and the "halo" effect of being associated with CERN and the practical benefit of this association.

P5 / Science and Innovation Policy Specialist, CERN KT / Policy and Governance. P5 develops policy and innovation related to science. P5 will provide insight into how branding and framing the mission functionally operate within governance structures and how the institutional reputation of CERN influences the pathways to commercialization.

Methods of Data Collection and Interview Style

All of the interviews were completed with a ten-question semi-structured interview guide that included the topics of:

- Branding in deep-tech commercialization.
- Communicating scientific complexity.
- Institutional reputation (CERN) and its influence.
- Mission framing and trust.
- Organizational structures influencing the communication and technology transfer of the organization.

Each interview took approximately thirty to sixty minutes and was designed to establish familiarity between the two parties prior to beginning the interview (either online or at the CERN site). One participant (P4) sent a written response following completion of the interview in the same interview format. Each of the interviews was taped and transcribed verbatim with minimal errors corrected while retaining the original intent of the participants.

To ensure consistent analysis of the data collected for all participants, each participant has been given a code (P1, P2, P3, P4, P5). These codes have been utilized in the coding table and analysis. These data serve as the empirical base for both the coding scheme presented in Section 3.4 and the thematic results. This study uses in-depth, semi-structured interviews of five people who are involved in the commercialization of CERN-origin deep-tech technologies. The five participants selected through purposive sampling were diverse: engineering, marketing, science communication, entrepreneurship, and innovation policy. Since branding in the commercialization of deep-tech technologies is multi-dimensional and requires technical knowledge, institutional legitimacy, and mission-based communication, diversity was necessary for this study.

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3.3 Data Collection and Processing

This research is based on five semi-structured interviews, which were done in several forms (face-to-face and others(online)). Interviews were done with the first two participants, P3 and P5, as researchers were present at the CERN site. Interviews with P1 and P2 took place via online session with MS Teams. Participant P4 provided answers via e-mail.

Each participant completed the same ten open-ended questions about branding, communication barriers, legitimacy, structural barriers, and potential commercialization methods in the same sequence of questions. Since each participant was asked the same set of questions using a single guide, it enabled comparison of the responses of participants from different institutional backgrounds. A single guide also ensured methodologically equivalent responses despite differences in format. In addition, the use of a single guide regardless of the format ensured methodological equivalence in each area examined.

Each transcript was provided to the participants after they gave their permission for it to be used for the analytical purposes of the paper. Each transcript was lightly cleaned to help the analysis of the content. Non-substantive parts were removed, and redundant words were deleted, but the original wording and reasoning were preserved. The written response was also formatted to match the organization and style of the verbal responses. The method for preparing the papers was chosen to allow for readability, suitability for coding, and richness for analysis.

Participants were assigned identifiers to each - P1, P2, P3, P4, and P5 - so that all references could be made consistently throughout the thematic analysis. Before starting the coding process, the transcripts were read multiple times to familiarize with the content, and to recognize early trends, ideas, and narrative styles. Familiarity with the data is essential before beginning the coding process, which is discussed in detail in Section 3.4.

3.4 Coding Framework and Code Development

This study utilizes Braun and Clark's (2006) framework for thematic analysis to develop an analytical coding system that moves transparently from unanalyzed interview data to thematically robust answers to the research question regarding how branding facilitates the commercialization of deep-tech innovations originating from CERN. The purpose of this section is to describe the development of the coding framework used for this study and how the coding framework was applied to develop themes from the coded data.

3.4.1 Basis for Choice of Coding Framework

This method allows the research question to benefit from a theoretical basis as well as CERN-specific knowledge, yet neither of these can be predicted in advance. Deductive codes will be used to analyze the theoretical framework described in Chapter 1 of the dissertation to interpret the application of the power of branding, legitimacy, communication structures, and the framing of the mission in the promotion of the commercialization of deep technologies. An initial review of the transcripts before coding identified a number of aspects, including the communication skills of engineers, the alignment of the organization inside CERN, and the prestige of the CERN name, that were not initially contained within the predetermined themes. To enable the consideration of data-driven themes in the results, inductive coding was used.

A hybrid coding framework is required since the branding and legitimacy in CERN's environment arise from both established theoretical constructs and the emergent empirical patterns. As Braun and Clarke suggest in their recommendations for conducting studies of complex organizational processes, the hybrid coding framework represents a combination of theoretical guidance with openness to new insights.

3.4.2 Data Familiarization

Before commencing coding, each of the five transcripts was read at least three times in order to get a sense of the major concepts and recurring themes among participants and the various ways that participants from differing roles (engineering, marketing, communications, entrepreneurial, and policy) described branding and commercialization.

In addition to identifying major concepts and recurring themes, the participant's descriptions of branding and commercialization also provided an opportunity for early identification of signals and/or markers that would potentially appear again. For example, after reading the transcript of P3, it became apparent that "having 'CERN' on their website opens

doors" indicated that institutional reputation could have an impact on multiple participants and, therefore, may be an element that would be included in the analysis.

Reading the same transcripts multiple times facilitated a clear, initial understanding of the data and served as preparation for the subsequent stage of open coding.

3.4.3 Open Coding

The first stage of analyzing the data involved examining the transcripts, line-by-line, to find meaning units. Each time a participant identified a problem, perspective, or experience regarding branding or commercialization, a brief, descriptive tag or label was assigned. It was essential that the tags or labels remain as close as possible to the participant's language to ensure that the analysis reflected the actual meaning of the statements made by the participants.

When P1 explained detector technology, he stated, "the important channel of communication should be expert-to-expert. Not through marketing, not through salespeople." This statement was tagged as "technical communication need." When P2 explained that complex technologies are easier to communicate using visual and digital media, it was stated, "You can explain much more content in 10 seconds of video than in two pages of text. And no one will read the text nowadays," which was tagged as "visual and digital communication." P3 explained that many people view CERN as primarily a science organization and public outreach organization, stating "most industry people don't understand particle physics," which was tagged as "perception gap."

At this point, there were over one hundred initial codes developed. These codes captured ideas regarding complexity, legitimacy, communication barriers, the importance of the CERN name, storytelling practices, investor perspectives, the way mission framing occurs, and the way internally coordinated activities occur. Focus was not on organizing or interpreting the codes, but rather on identifying and labeling every meaningful concept expressed by the participants.

The open coding phase produced the raw materials that allowed the next phase of coding (axial coding) to develop related concepts into higher-level categories.

3.4.4 Axial Coding

Following the completion of the first stage of analysis (open coding), the open codes were reviewed and categorized based on similarity in thinking across participants and

commonality in the types of challenges or mechanisms described by different participants. The objective of axial coding was to organize the numerous open codes developed in the previous stage of analysis into fewer, yet more cohesive categories that represented shared patterns in the data.

Several open codes that were related to communication difficulties were grouped together to form one category. P1 described the need for engineers to explain the technology, P2 explained that the limitations of text-only communication make it difficult to effectively communicate, and P3 stated that many people misinterpret CERN's applied capabilities. All three of these codes were grouped together to form the category "communication and perception gaps".

Another category was derived from repeated references to the power of the CERN name. P3 described how CERN builds trust, P5 stated that being affiliated with CERN enhances credibility during investor meetings, and P1 stated that many industry partners feel confident due to CERN's scientific foundation. These codes were categorized together as "institutional legitimacy signals".

A third category was developed from comments made regarding the challenges associated with coordinating internally within organizations. P3 described the organization's internal process as slow, P2 stated that it is challenging to coordinate marketing teams and engineers, and P5 stated that communicating has political implications. These codes were organized to form the category "internal barriers and coordination".

Through this process, the initial large number of open codes were reduced to a smaller number of categories that demonstrated how different elements of the data relate to each other. These categories would serve as the foundation upon which the final themes would be built.

3.4.5 Selective Coding

The last step of the coding process was the selective coding. At this stage, categories that been created during the previous stage (Axial Coding) were compared with each other to recognize the main themes that best represented the full dataset. The main idea was to identify and select main themes that explain how branding supports deep-tech commercialization in the CERN context, moving from the many connected categories.

During this stage, the categories were checked against the research question. For example, the category "institutional legitimacy signals", supported by comments from P3, P5,

and P1, connected directly to the theoretical idea of legitimacy and clearly described how participants use CERN's reputation to reduce uncertainty. Because this category appeared across several interviews and matched the theoretical framework, it became part of a core theme.

The category "communication and perception gaps", which included P1's description of the technical complexity, P2's comments on the need for visual explanations, and P3's comments about external misunderstandings, also appeared consistently. This category became part of a theme about communication and cognitive barriers.

Another category, "internal barriers and coordination", came from repeated comments about slow processes, political sensitivity, and differences between engineers and marketing specialists. These insights were strong enough to form a supporting theme that explains organizational constraints on branding.

By comparing these categories with each other and with the research question, three main themes were identified. These themes capture the most important mechanisms described by the participants and form the foundation of the thematic analysis in Section 3.5.

3.4.6 Operationalisation of Legitimacy

Legitimacy was identified as being a core element to the research question and, as such, was operationalized clearly and practically before the coding process. As per Suchman's model of legitimacy as acceptance based on credibility, trust, and perceived appropriateness, indicators for legitimacy were produced to enable identification of legitimacy-related information within the transcripts, regardless of whether participants specifically referred to legitimacy.

As legitimacy was explicitly connected to the research question and simultaneously represented one of the primary aspects of the analysis, it was defined in a clear and practical manner prior to coding. Furthermore, operationalization of legitimacy in terms of indicators was conducted according to Suchman's model of legitimacy as acceptance based on credibility, trust, and perceived appropriateness. The indicators produced enabled the operationalization of the concept of legitimacy throughout the analysis process and assisted in establishing the point at which participants were discussing legitimacy, irrespective of whether the term was used directly.

Four indicators were generated to assist in the operationalization of legitimacy.

Trusting Signals - For example, P3 stated that having "CERN" on a website opens doors, which indicates that institutional trust represents a key component in how partners assess early-stage technologies.

Risk Reduction - P5 explained that CERN affiliation provides advantages as follows: "CERN is well-known for its high-technology and cutting-edge capabilities... That has some huge advantages". This illustrates how legitimacy can assist in reducing perceived uncertainty.

Access and Openness - P1 asserts that it allows CERN to raise awareness and physical access to networks that are normally out of reach for enterprises, for this reason, the legitimization of the enterprises by the activities conducted at CERN enables collaboration.

Reputational Signals - Multiple participants referred to the symbolic value of CERN's scientific excellence and how this reputation assists with investor meetings or initial partner engagement.

These four indicators were utilized throughout the coding process to determine which segments of the transcripts pertained to legitimacy and were used consistently across all interviews. Through their application, legitimacy was transformed from a theoretical concept to an observable pattern in the data. This permitted direct linkage between the interview materials and the research question regarding how branding impacts commercialization.

3.4.7 Development of the Code Book

Following the development of the indicators, a concise code book was created to guarantee consistency and transparency in the analysis of all transcripts. Any established patterns observed in more than one interview that reflect both theoretical concepts and real empirical observation were then translated into code based upon the repeated patterns of those established patterns. The code book was not created before the analysis process began, it was developed step-by-step as the open and axial codes were reviewed, and it reflected the material accurately.

An example of developing codes includes "Complexity Explanation" which was added to the code book as P1 and P2 both repeatedly discussed the difficulties in simplifying detector technology for non-expert individuals. An additional example includes "CERN Reputation (Positive)" which was added as P3, P5 and P1 all referenced how the CERN name assists in building trust among investors. An additional example includes "Internal Misalignment" which was added as P2 and P3 both described internal challenges in cooperating between engineering groups, communications departments and decision-makers. Similarly, the code

"Mission Framing" was added as P5 described how linking technology to health outcomes assists with clinical involvement.

Twelve codes were ultimately included in the final code book with a brief definition provided for each code explaining the criteria necessary for applying the code. The objective of the code book was to establish a consistent structure for subsequent analysis, minimize subjective interpretation and facilitate comparative analysis between interviews. Additionally, maintaining the quality of the analysis was achieved by ensuring that similar statements from various participants were assigned the same code.

The structural code book served as a foundation for determining the final themes presented in Section 3.5.

Table 4

Coding Table

Code	Definition
Complexity Explanation	Challenges in simplifying deep-tech concepts for non-experts.
Technical Communication Need	Necessity of involving engineers or technical experts in communication processes.
Branding Value	Branding as a tool to build trust, visibility, and legitimacy.
Branding Limits	Instances where branding alone is insufficient for commercialization.
Visual & Digital Branding	Use of visuals, videos, websites, and digital platforms (e.g., LinkedIn).
Storytelling / Use-Cases	Communicating value through narratives and real-world applications.
CERN Reputation (Positive)	CERN's name increasing credibility and reducing perceived risk.

CERN Constraints	Bureaucratic or slow processes that limit communication agility.
Investor Perception Issues	Difficulties investors face in understanding and assessing deep-tech projects.
Mission Framing	Positioning technology through societal missions (health, climate, etc.).
Internal Misalignment	Divergent views between scientists, engineers, and marketing/business teams.
Market Customization Need	The need to tailor communication and branding to specific market segments.

3.4.8 Coding Tree Diagram

The Coding Tree shows how the final themes evolved from the initial coding of the interviews to finally identifying the major patterns in the data set. There are three layers in the Coding Tree. The first layer includes the open codes developed during the line-by-line reading of the data. The second layer includes the categories developed during the axial coding of the data. The third layer includes the five main themes representing the major patterns in the data.

The Coding Tree represents the transition from numerous small codes to a few large themes that define branding at CERN. For instance, the codes "Complexity Explanation", "Technical Communication Need", "Branding Value" and "Visual and Digital Branding" were included in the same category because they describe both how complex CERN technologies are and how branding helps explain them. P1 exemplified this when he said, "The important channel of communication should be expert-to-expert. Not through marketing, not through salespeople". Thus, these codes combined to create Theme 1.

Codes "CERN Reputation (Positive)" and "Investor Perception Issues" were categorized as part of a category describing institutional credibility. P3 described this when she said, Having 'CERN' on a website helps them open doors. P5 also provided evidence for this pattern by stating, "CERN is known as high-tech and cutting-edge... that has some huge advantages." These codes together formed Theme 2, which focused on legitimacy.

Theme 3 was developed using codes describing the gap between technical and non-technical stakeholders. P2 exemplified this gap by stating, "So this is everyday struggle: to

explain what it does, how it works. But then at the end of the day, the customer wants results and wants reliability". In addition to comments about internal misalignment and market customization, this demonstrates why the codes belonged to one theme.

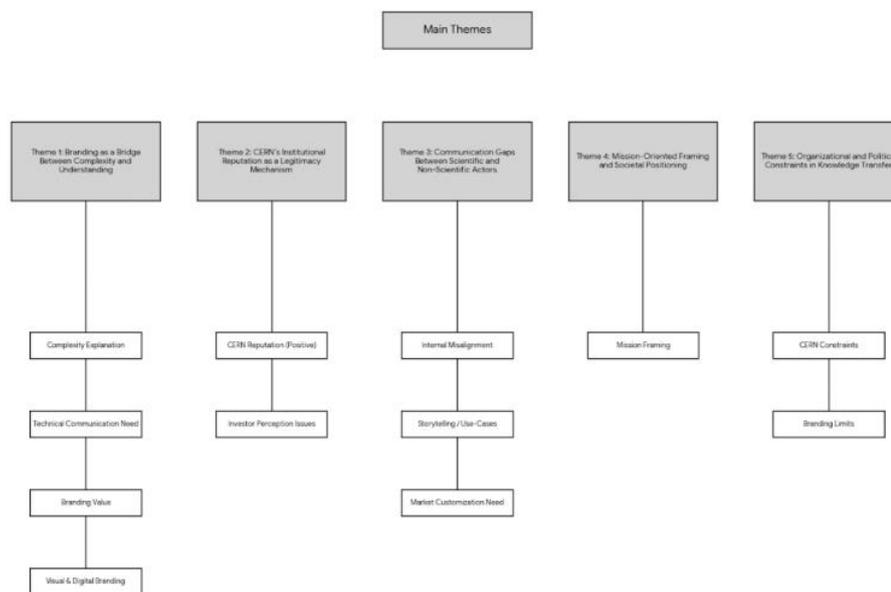
Theme 4 was based upon repeated reference to mission-oriented communication. P4 stated that, "Using healthcare as an example made it easier to explain the technology", supporting the concept of mission framing being its own theme.

Finally, Theme 5 combined comments about the organizational constraints, political sensitivity, and limitations of branding within CERN. P3 illustrated this when she said, "Everything must be checked and approved... I cannot publish anything without approval".

Therefore, the coding tree illustrates how each theme was derived from a multitude of open codes and actual participant statements. It provides transparency to the analytic process and links the final themes to the original interviews.

Figure 2

Coding Tree Diagram



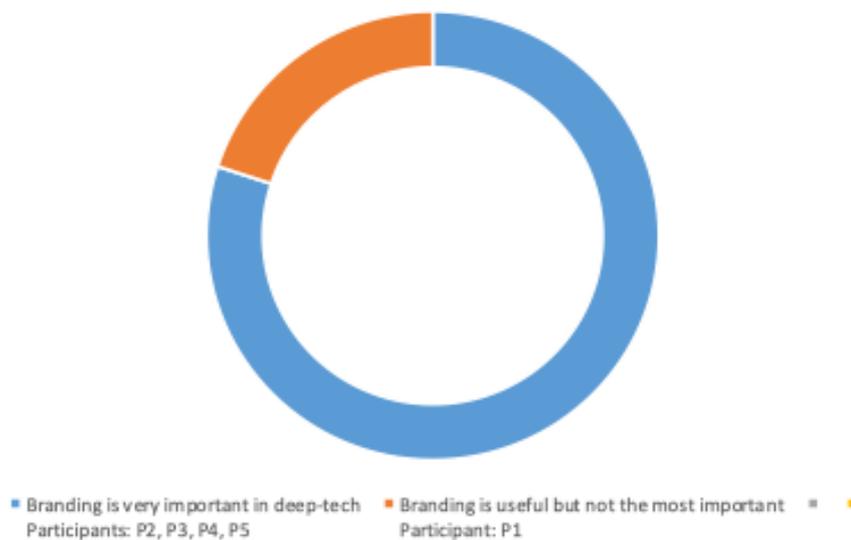
3.5. Thematic Findings

From the five expert interviews, five overarching themes emerged which guide how experts involved in CERN related deep-tech commercialization, construct brand identity, communicate with customers, create legitimacy and frame the mission, as well as recognize

organizational limitations. This framework integrates both inductive findings from the data collected in this study and deductive categories presented in the theoretical chapters. Together, they help us understand how technologies emerging from research institutions can be both communicated to the public, legitimized in the marketplace, and made available for sale.

Figure 3

Perceived Importance of Branding Among Interview Participants



Qualitative representation of how participants assessed the value of branding in deep-tech commercialization. Four participants (P3, P2, P5, P4), perceived branding as a primary tool for generating trust and understanding of products/technologies by customers where technologies are complex and there is little preliminary evidence. Participant P1 believed that branding was useful, however it did not hold as much importance as demonstrating the technology itself. The donut chart illustrates the qualitative frequency of the themes identified from the transcripts and not the quantitative results from the study.

3.5.1 Theme 1. Branding as a Bridge Between Complexity and Stakeholder Understanding

Theme Emerged through Methodological Coding

Through coding on all 5 interviews, branding appeared to be a way to create an understandable (for stakeholders) method of describing, evaluating, and interpreting Deep-

Tech (complex) technologies. The repeated open code that represented this area were: "Complexity Explanation", "Technical Communication Need", "Visual and Digital Branding", and "Branding Value". As all of the 5 participants described this as a function of branding, this led to axial coding of the above open codes to form a single category that reflected the cognitive complexity of Leek and Christodoulides (2011), who describe how stakeholders lacking special skills and expertise have difficulties understanding what CERN-origin technologies do, and why they matter.

Cognitive Framing: The Core Mechanism

The consistent pattern among the five interviewees was the challenge of explaining technologies such as detectors to non-expert stakeholders. Participant 1 explained this using the following statement: " I think the company should also – on communicating directly with experts, you know? Not through marketing, not through salespeople. They are necessary, they do the paperwork, some communication, but the important channel of communication, information and meetings should be expert-to-expert." The cognitive framing mechanism has been observed during three interviews conducted with participants 1, 2, and 4 and represents a recurring mechanism grounded in the theoretical framework of Section 1.1.3, which describes "scientific opacity" and "cognitive barriers" as structural characteristics of deep-tech. "You can explain much more content in 10 seconds of video than in two pages of text. And no one will read the text nowadays," Participant 2 did not argue that the video is visually superior, but that it is functionally required due to the excessive complexity of the technology. This relates to Suchman (1995) and his descriptions of how stakeholders judge legitimacy when they are unable to directly confirm the technical quality of a technology.

Participant 3 stated: "Most industry people don't understand particle physics." This perception gap inhibits stakeholders from even realizing that commercialized technologies exist. This corresponds with Cohen and Levinthal's (1990) conceptualizations of absorptive capacity, where audiences fail to recognize technologies outside of their prior knowledge structures.

The Substitution Mechanism: Branding When Direct Proof is Unavailable

"We wouldn't have got through the door of a hospital like that without the appropriate marketing and branding. And I don't mean just marketing collateral. I mean the logo and, more importantly, the perception of us and our technology", stated Participant 5. The hospitals could not fully comprehend the imaging systems. At this stage, the substitution mechanism becomes apparent. Organizations employ this substitution mechanism to substitute missing technical evaluations with logos and other signals, perceptions, and institutional affiliations. As well,

Participant 5 also specified: "Marketing in the broader sense is absolutely essential, particularly for deep tech. For what we're doing, we need high-profile customers and partners".

Bridging vs. Replacing: The Analytical Distinction

Participants 3, 2, 5, and 4 referred to branding as a means of facilitating engagement with uncertainty. Participant 1 emphasized that branding does not and should not replace the actual quality of a particular technology. "Branding is just marketing. It's on labels. I'm not saying it's useless, but it's necessary to put a good product and get good feedback to have results". Participant 1 further specified: "The most important thing would be to have good customer service, to build the brand actually from the bottom, from the experts in our case, because we are not selling bread or potatoes".

In addition, Participant 1 discussed the limitations of branding: "Branding is even exaggerated. It is overused, over-represented, and abused." He used a comparison: " You go to the supermarket and buy a very beautiful apple – red, bright. Actually it's not delicious. Very often, the most delicious apples are the ugly ones, or the standard ones". Therefore, while branding allows you to sell and gain more clients than if you didn't utilize it in the short term, it explains the point at which branding loses its purpose and exceeds the potential of the product itself in terms of legitimate performance by Suchman (1995).

The Theoretical Integration: Cognitive Framing and Legitimacy Signaling

Section 1.3.1 defines "cognitive framing" as a major process in branding the commercialization of deep-tech products. Leek & Christodoulides (2011) explain that "when B2B or technology-intensive businesses are involved, the issue with which brand managers need to deal is making up for a lack of technical knowledge using the credibility of the organization." This data pattern confirms this definition, with the respondents identifying the role of branding in providing stakeholders with interpretative frameworks and facilitating an understanding of complex technologies.

Cross-Participant Validation

Each of the 5 participants mentioned complexity as a barrier to stakeholders' ability to understand. Each of four participants (P3, P2, P5, P4) identified branding as the primary mechanism for overcoming this barrier. Only one participant (P1) identified the necessity of branding, however indicated that it is insufficient without supporting technical excellence. Thus, this pattern satisfied the criteria that themes should appear in multiple interviews and represent stable mechanisms.

The Mechanism in Action

Participant 3 produced empirical evidence: "Knowledge Transfer existed for 35 years, and only the last two years, with proper marketing, brought almost the same level of visibility as the previous decades". For 33 years, the same technologies existed with the same quality. However, stakeholders were unable to perceive that they existed. Branding made this perception feasible and created substitution, not replacement.

3.5.2 Theme 2. CERN's Institutional Reputation as a Legitimacy Mechanism

Establishing Thematization Using Coding Methodology

Institutional reputation of CERN was established using axial coding from the repeated use of the open codes: "CERN Reputation Positive", Institutional Legitimacy Signals", and Risk Reduction". Using selective coding, these open codes were combined into one category due to all five participants (P1, P2, P3, P5, and P4) discussing how the name of CERN and institutional reputation serve as a way of reducing uncertainty in the early stages of commercializing their technology. This illustrates the concept of legitimacy defined by Suchman (1995) as a function of stakeholder acceptance, which is based upon credibility, trustworthiness, and appropriateness. In other words, in legitimacy demanding environments where there is delayed proof of commercial viability, the lack of commercial information is equilibrated by symbolic representations like institutional ties, expert endorsements, or narrative explanations with significant detail, consistent with the conclusions drawn by Zimmerman and Zeitz (2002).

The CERN Brand as a Credibility Enhancer

P3 indicated that "Having CERN on a website helps them open doors, get into networks, get new opportunities", which she indicated was the direct mechanism. It was clarified by P3: "The CERN branding built over the years gives a strong base - people know CERN," and continued, "The CERN name helps tremendously". All three interviews referenced by (P3, P5, and P1) showed a pattern of thinking versus just a single, unconnected view. It was described how being associated with an institution sends a "costly, credible signal", (Spence, 1973), and since it is well-established that partners find institutions they associate with CERN to be credible, based on the weight of CERN's reputation.

P5 supported this mechanism from a spin-off viewpoint: "The CERN reputation is obviously very critical for the reputation of our products". This is obviously indicative of how the substitution mechanism is applicable. P5 mentioned that CERN is known as high-tech and

cutting-edge that has some huge advantages. The advantage here is that CERN is widely recognized for its cutting-edge technology. However, all this takes place on the premise of beginning with an intuitive cognitive lead to create an initial assessment. The trust mechanism here creates an expectation with stakeholders to begin with.

P2 described the same process from a marketing viewpoint, saying, "If you look at our website, for example, you can find the CERN logo right on the website, and it's actually on every subpage as a partner. CERN is very important, and we have to do it – but even if we didn't have to, we would, because CERN is an institution of respect and authority". This implies that the institutional brand serves as a signal for absorptive capacity, as shown by Cohen & Levinthal (1990), where audiences see CERN as a sophisticated institution, therefore perceiving a lower risk of becoming involved in its technologies.

Legitimacy and Constraint: Two perspectives

While acknowledging the advantage, P5 pointed out a problem with the role of institutional reputation: "It has a huge amount of value in terms of quality and novelty. Because CERN is essentially an academic institute, that does have some hindrances too". However, P5 noted that "But in terms of novelty, quality, and being a world leader, it's absolutely out there – almost unbeatable", referencing the fact that the scientific stature of CERN produces expectations, which in itself could be burdensome for the placement of such organizations in markets where cost and usability must be weighed against perfection.

P4 made a point that "CERN's reputation is overwhelmingly beneficial. If there are disadvantages, they are minimal in comparison", thereby pointing out that institutional reputation plays a role at both a policy and organizational level. This mechanism extends beyond market stakeholders to include governmental and regulatory counterparts.

Signaling Theory & Legitimacy: Theoretical Integration

As outlined in Section 1.3.2, legitimacy-building is an integral component of branding during the commercialization of deep technologies. Empirical evidence demonstrates this assertion because CERN's institutional reputation decreased uncertainty where no technical proof existed. Thus, it creates "cognitive legitimacy" (Suchman, 1995) - does this organization make sense as a provider of quality innovation? Being affiliated with CERN immediately answers this question based on institutional reputation rather than performance.

Interviews also demonstrated that "normative legitimacy" (Zimmerman & Zeitz, 2002) - is this the right activity for this institution? The basic research mandate and world leader status of CERN clearly illustrate that the technologies developed at CERN are for science and society, and that profit maximization is not the objective. This type of legitimacy is necessary

in highly regulated sectors (such as healthcare and space exploration), because all parties must know that technological development is legitimate and responsible.

Cross-Participant Validation and Consistency

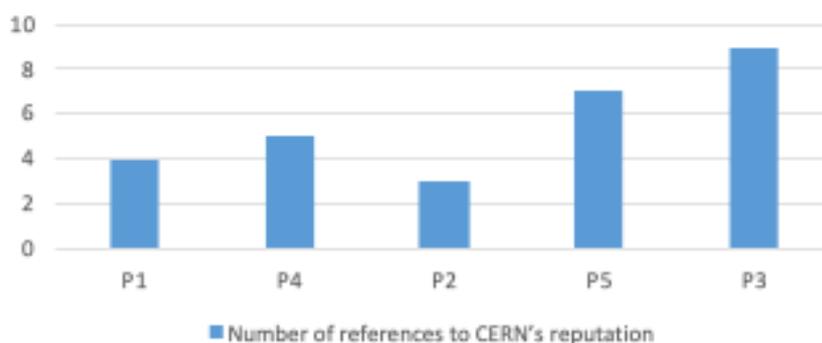
An extremely similar trend is found amongst the 5 interviewees: P3 emphasized trust and visibility, P2 emphasized the symbolic representation of a CERN Branding, P5 discussed direct market access, P1 mentioned the benefits and complex requirements, and P4 stated that trust develops in governance level. A 5-for-5 result demonstrates an exceptional saturation of identified themes, therefore, the findings do not show any degree of specificity regarding institutional trust toward either role or technology related to CERN. The overall trends are relevant to stakeholders in interpreting all CERN related technologies within the entire CERN Ecosystem.

The Mechanism in Action

P5 demonstrated the type of process described above through a very specific example of how this process worked to provide evidence of their process from CERN: "When we first began speaking with the innovation unit at the Hospital for Special Surgery, they said, 'We've seen your information on the CERN website. We believe you immediately validated our position'". The example provided by P5 illustrates that the process of institutionally validating was used to both add credibility to their work and for actual application.

Figure 4

Number of References to CERN's Reputation



The figure displays the different levels to which the positive reputation of CERN was referenced throughout the interviews. Although the levels differ, each of the 5 interviewees

referenced the CERN name with a positive reputation to mitigate uncertainty between the external organizations to which it is well-known. The results of the thematic coding support this conclusion, as "CERN Reputation (Positive)" was referenced in all of the transcripts.

P3 was referenced the most times. The strength of the CERN brand was continually expressed by P3 during the interview, for example, stating, "The CERN name helps significantly", and later, "Having "CERN" on a website helps open doors". As such, P3 illustrated the role of institutional brands in developing trust in knowledge transfer environments.

P5 frequently referenced the reputation of CERN in terms of commercializing in regulated areas. During the interview, P5 explained the benefits of association with CERN, stating that "CERN is known – and it's not just branding, it's their perception in the market. They're known as being very high-tech and very cutting-edge." On the other hand, P5 also emphasized the role of identity in clinical engagement, explaining that it would not have been permitted to enter hospitals in the same manner as it did if it had not had appropriate marketing and branding.

P4 concentrated on CERN's standing in governance and policy, emphasizing its global stature and power. According to the impact study, this reputation has few significant drawbacks and significantly promotes technology transfer by boosting market trust, visibility, and access to talent, funding, and sales. "CERN improved credibility for their long-term vision and even helped sell existing products".

P1 and P2 referenced CERN's name regarding industrial communication. P1 expressed that due to CERN's excellence in sciences, engineers expect nothing less than perfection in terms of standards. P2 stated that the communicative powers of the CERN logo build trust before presenting any material. Both perspectives illustrate how institutions affect communication when those with a niche of knowledge communicate with others who possess a higher level of knowledge. Ultimately, they interpret them based on reputation when the complexities are beyond their practical experience. Therefore, it can be concluded that the institutional reputation of CERN plays a central role in facilitating communication, technology, entrepreneurship, and policy settings. The communication-related participants (P3, P2) created a perception of trust and visibility, whereas the technology and entrepreneurial participants (P1, P5) created an increased rate of acceptance and reduced uncertainty regarding access to partners. Therefore, this supports Theme 2: Institutional Legitimacy, showing that institutional legitimacy acts as a fundamental branding enabling mechanism for CERN deep-tech technologies in the evaluation and adoption phases of start-up companies.

3.5.3 Theme 3. Communication Gaps Between Scientific and Non-Scientific Actors

Emergence of the Theme Through Methodological Coding

A major challenge for organizations in collaboration with deep technologies in the CERN Ecosystem is the formation of communication gaps between scientists and non-scientists. The coding methodology used at the axial level of analysis identified five open codes to describe this gap: Internal Misalignment, Complexity Explanation, Technical Communication Need, CERN Constraints, and Market Customization Need. Selective coding showed that the five codes were consistently grouped throughout the first four participant interviews (P1, P2, P3, P4), forming an axial category that describes the organizational and communicative friction in the CERN Ecosystem. The axial category described the friction in the CERN Ecosystem that results from the institutional and cognitive barriers to communication, including understanding, time to develop products, and institutional barriers (Section 1.1).

The primary tension in this theme is the Expert-to-Expert vs. Market Communication. For example, P1 stated, "The most important channel of communication should be expert-to-expert. Not through marketing, not through salespeople. They are necessary, they take care of the paperwork, they communicate to some extent, but the main channel of communication, the flow of information, and meetings should be expert-to-expert". This statement is representative of the "Technical Communication Need" and is supported by the theoretical background found in Section 1.1.1. The theoretical background identifies that the cognitive gap created by obscured expertise produces a barrier to successful communication between experts and non-experts.

This was reinforced by P2's comments from a marketing standpoint who stated, " it's very different. There's a sort of internal battle running all day, because everyone is underlining something else". As shown in Section 1.1.3, the communication and perception gaps produce a disadvantageous situation for the stakeholder in terms of absorptive capacity (Cohen & Levinthal, 1990; OECD, 2023). As P2's comments illustrate, the scientist faces an overwhelming scientific basis to explain the simple concept of technology and the communicator has no concrete evidence in the early market to build upon in order to tell the story.

In total, both participants represent the complementary mirror mismatch: engineering professionals view communication professionals as being uninformed of technical aspects and communication professionals view engineering professionals as failing to realize the degree of difficulty in translating complex technology into communications related to markets. This is clearly evident in the challenges described in Section 1.2 concerning Technology Transfer.

The organization of this entity is solely based on scientific precision and therefore limits the ability to communicate application stories to facilitate commercialization (Perkmann et al., 2021).

Additional institutional constraints and governance friction were identified by P3. She stated, "CERN is also very political. We deal with countries. Everything must be checked, approved, and politically correct. I cannot publish anything without approval." This represents the "CERN Constraints" code and is an additional example of institutional rigidity in scientific entities that hinder clear communication and clarity (Fraunhofer, 2023). Additionally, P3 identified another misconception in expressing that some people still believe that CERN is only about science and public outreach. This is an additional representation of the perception gap described in Section 1.1.3 and further emphasizes that all public institutions experience challenges in effectively communicating the relevance of technology through institutional identity constraints.

P4 identified this process by stating, "CERN's communications and marketing teams do not aim to attract investors for technologies. Instead, they aim to attract industry partners who want to bring the technology to society, not necessarily through commercialisation". His comments are aligned with the complexities of Section 1.2 and Section 1.1.2.

Market customization is an additional issue that was addressed in all interviews. P2 stated, "You have to do 10 years of evangelization – travelling across the world, showcasing all the time again and again – and then maybe after 10 years the market will understand the advantages". This is in alignment with the theoretical discussion in Section 1.3.1. Deep Tech branding needs to change the way it communicates for different absorptive capacities of its stakeholders and aligns with the mission of society (Mazzucato, 2018) and the expectations (Leek and Christodoulides, 2011).

Common Thread Among Participants

Each of the participants identified structural misalignments between technical experts, marketers, and institutional communicators. A general template was developed for the three roles. Technical experts emphasized the technical accuracy and communication of the technical expert. Marketers emphasized the difficulty in translating or providing simplified explanation hooks for the technical expert. Institutional communicators emphasized the bureaucratic constraints and perceptions of the institution.

3.5.4 Theme 4. Mission-Oriented Framing and Marketing

Emergence of the theme through Methodological Coding

Mission-Oriented Framing & in Marketing. The theme arose after Axial coding of four repeated codes: "Mission Framing", "Societal Value", "Patient Benefit", and "Branding Value". During Selective coding, these codes were found to be repeatedly linked together across all five interviews (P1, P2, P3, P5, P4), thus forming a category where interviewees talked about specific technologies not merely as technical or business solutions, but as services to larger missions surrounding Cancer Care, Safe Space Travel, Earth Observation, etc., as part of a larger social good. This is due to it correlating to the Theory introduced in sections 1.1 and 1.3, where Mazzucato (2018) states that the credibility of such technological development narratives increases when they are aligned with broader societal agendas.

Customer Benefit as Primary Motivation

P5 articulated the mechanism most clearly when they said, "I want to deliver a product that helps patients and doctors and makes healthcare more efficient. If you're doing that, you've got a product and you should be making money". Soon thereafter, it was made clear that this interconnection between mission and profit exists since making money is a by-product of success. This excerpt was coded under both "Mission Framing" and "Patient Benefit", showing that mission-driven objectives play an integral role in the development of technology rather than being simply additional marketing goals.

Mission Framing in Regard to Clinical Uses of Technology

P2 reinforced the same mechanism from the marketing perspective with descriptions of how mission-driven stories facilitate the engagement with specific applications of clinical use. P2 said: "We are helping doctors to reduce side effects of radiotherapy. Nowadays, if someone is under radiotherapy of their brain, there could be side effects such as memory loss or vision loss. With our device, you can aim the therapeutic beam more precisely to the tumor and not damage the healthy tissue of the brain". He then pointed out another area: "We are using it in space, because our detectors are quite widely used in space. We have several of them on the ISS. Because we are looking at the cosmic radiation up there. It's quite important to know the composition of radiation".

These assertions were categorized under "Storytelling Use Cases" and "Mission Framing", highlighting how the same type of technology (Hybrid Pixel Detectors) develops meaning and interest from stakeholders when situated in specific social missions, such as protecting patients from radiation damage, providing safe travel to space, and establishing safe dose levels for space travelers during missions such as the Lunar Gateway Station.

Versatility and Adaptability

P3 highlighted that the orientation of the institutional mission was the core of the Knowledge Transfer identity at CERN: “Knowledge Transfer’s mission is to make an impact on society, not on money. And we collaborate with industry for the benefit of society”. This was coded under “Mission Framing”, demonstrating that a mission orientation may be thought of at the organizational level, as opposed to merely being superficial. P3 as well stated, “For example, many cancer-related technologies at CERN were originally developed purely for particle physics, not healthcare. Later, we realized they could be used to treat patients. So we partner with hospitals and transfer these technologies”. This quotation demonstrates how mission framing can change the institutional environment from primarily focused on research to primarily focused on healthcare.

Mechanisms: Using Mission Frames to Explain Complexities

P4 provided a theory relating to the mechanisms of mission framing in his answer. He stated that a mission framing is associated with the deep-tech problem referenced in section 1.1.3, where the absence of available data disadvantages a stakeholder in terms of interpretation. Based on the example from the healthcare sector, mission-narratives allow complex technological issues to be described in ways that relate to the cognitive frameworks of stakeholders, allowing those without technical knowledge to understand the complexities using relevant domains.

This addresses the situation in which empirical market information is unavailable. As indicated in section 1.3.2, as some data metrics are absent, narrative framing is employed to illustrate connections between technology and societal value. Thus, mission framing replaces missing commercial proof with evidence of societal relevance.

Qualitative Limitation: There are Limitations to Mission Framing

P1 presented a necessary condition for the affirmative effect generated by the mission framing. Although P1 supported the affirmation that “yes, it helps when a project is framed around solving health problems”, he immediately followed with an adequate explanation: “You go to the supermarket and buy a very beautiful red apple, bright. It’s not delicious. Very often, the most delicious apples are the ugly ones, or the standard ones. So, what happens is that in the short term, you sell, you get your customers, maybe more than if you don’t do it. But in the long term, you disappoint people”.

He also expanded this concern to the high-tech field: “But I know in the short term, people prefer to dream, to think they are buying something perfect – like with electric cars. If

you tell the customers of electric cars that the battery is bad and the range is not 500 but only 200, they will not buy”.

This criticism was called "Branding Limits", and represents Suchman's (1995) notion of pragmatic legitimacy: Stakeholders assess technologies based on performance over time rather than on the existing cognitive legitimacy of the mission framing narrative. P1's viewpoint reflects a limitation with mission branding in general in the deep-tech area: The mission here has over-promised and will ultimately undermine the very basis of trust on which the mechanism is intended to function.

High Consensus Among Interviewees Across Roles

All interviewees agreed that mission framing was applicable. The degree of agreement was: All interviewees believed that mission framing was relevant to the development of deep-tech innovation. Four interviewees (P2, P3, P5, P4) articulated the positive relevance of mission framing in attracting stakeholders. One interviewee (P1) indicated that the mechanism was relevant, but expressed concerns that the potential for mission framing to be overemphasized would undermine the foundation of trust on which the mechanism relied.

Theoretical Integration: Mission-Driven Innovation and Legitimacy

Section 1.3.2 describes mission-driven branding as a critical component of branding strategies involved in the commercialization of deep-tech. This pattern was also confirmed in this study and relates to how the utilization of technologies in societal missions enhance the perception of value and institutional motivations through legitimacy-framing as opposed to visibility. This occurs when conventional commercial visibility does not exist.

This corresponds with the views of Mazzucato (2018), who indicates in Section 1.3.2 that “mission orientation targets patient investors, long-term partners, and regulators who prioritize value in the long term over short-term returns.” The technologies that arise from CERN, characterized by prolonged periods of R&D prior to validation, would correspond well to the mission-oriented narrative.

3.5.5. Theme 5. Organizational and Political Constraints in Knowledge Transfer

Development of the Theme through the Methodological Coding Process

Theme 5 emerged from the axial category entitled “Internal Barriers” and “Coordination”. The codes contained within the category of Internal Barriers and Coordination

were: CERN Constraints, Internal Misalignment, Technical Communication Need, and Market Customization Need. Due to the repeated appearance of these codes within interviews with P3, P1, P2, P5, and P4, it became evident that organizational and political constraints within CERN are not random events but have developed into a part of the organizational culture of CERN, thus affecting the function of its brand. The codes were kept consistent throughout the selective coding process relative to the research question, and all five researchers explained how the approval process and the governance process affect both the functionality of the brand and its commercialization.

The Bureaucratic Nature of Communication in CERN

The way P3 expresses the Code CERN Constraints by stating, “CERN is also very political. We deal with countries. Everything must be checked, approved, politically correct. I cannot publish anything without approval. If something is slightly wrong, it can have political implications. So yes, the process is slow. Much slower than in private companies”. The bureaucratic nature of the scientific institution where he works was noted by Fraunhofer (2023) within Section 1.1 as the cause of delay in the communication of ideas and uncertainty. As such, the knowledge transfer process in the case of CERN is also constrained by the difference between the types of knowledge that are deemed acceptable for diplomatic purposes in the communication of scientific knowledge, vs. knowledge transfer in a commercial setting.

P3 went on to describe the challenges he encountered during his tenure: “Marketing is not very well understood in scientific environments. Scientists usually do communication themselves through papers, so having a marketing professional is new. Some people still don’t understand what we do or why we do social media”.

The above quote illustrates an example of the "Internal Misalignment" code and is a representative example of the finding described in Section 1.3.1 by Perkmann et al. (2021) that the research-based environment inherently focuses on scientific detail and publication over other aspects of branding, causing a potential conflict between the two. It was illustrated that the opportunity costs associated with the limitations of those constraints: “Knowledge Transfer exists for 35 years. There are other communications and marketing teams at CERN, but we are the only people who do marketing more than communications. The other teams really only do communications, and their target audience is the general public, students, parents, teachers with the objective to create awareness about CERN”.

Misalignment of Technical Expertise and Marketing

P1, from the perspective of the engineers, articulated the underlying issue of how we place value on expertise and how this impacts the method of communication. According to P1, the most critical channel, "I focus my priority – and I think the company should also – on communicating directly with experts, you know? Not through marketing, not through salespeople". This illustrates one of the themes previously described titled "Technical Communication Need" and illustrates the contradiction between being at the forefront of technology and positioning while the organizations have to pass along the communication to non-technical personnel.

P1 got to the heart of the issue, explaining the organizational coordination problem cited in Section 1.2.2, where the incentives have conflicting objectives. Experts desire scientific dissemination, whereas companies desire market relevance and speed. P1 stated, "The most important thing would be to have good customer service, to build the brand actually from the bottom, from the experts in our case, because we are not selling bread or potatoes. We are selling complicated things". This illustrates that, beyond a certain point of complexity, you cannot communicate the technology to anyone who is not technical without sounding dishonest.

The Challenges of Market Customization under Institutional Constraints

P2 continued to describe the effects of organizational fragmentation on market customization: Every day it's a struggle to explain what it does and how it works... the field is too broad. You must customize it for every market. The same detector means completely different things for material science, for security, for medicine. This corresponds to the code "Market Customization Need". This demonstrates the conflict presented by Theme 5: While CERN technologies require a great amount of market-specific adjustment, the structure of CERN itself hinders and slows the pace required to satisfy the demands of multiple markets simultaneously. This is also in agreement with Section 1.3.2. Santos-Vijande et al. (2013) state that there must be a proper fit between CERN and markets and that "aligning involves adapting technical depth to each audience's absorptive capacity" and "coordinating R&D, Knowledge Transfer teams, regulatory units, and business development". Because approvals take time and decision-structuring occurs, it is impossible to coordinate.

Entrepreneurial Agility and Organizational Slowness

As an entrepreneur, P5 has identified the differences between institutional timescales and market demand: "In any academic institute, commercialization is a long way down their priority list." He further stated, slow timelines, too complex technology, and the perception that

academic motivations are very different from business motivations. It is obvious how the limitations of Theme 5 create a ripple effect on the confidence and investments.

Politics and Governance

P4 stated: "CERN perspective, trust usually comes from the strength of the product. But if I were an individual inventor building a new technology outside CERN, I might have a stronger need to build a brand early". The technology and research carried out at CERN involve supranational governance, where agreements have to be reached amongst 23 member countries, and communication plans are also scrutinized politically. This connects Theme 5 to Section 1.2 Technology Transfer, where Technology Transfer is affected by multi-country governance, and the ability to adapt is reduced as opposed to single country laboratories (CERN, 2023).

Legitimacy vs. Agility: Achieving the Right Balance

Through the interviews, the following paradox is illustrated that must be solved by Theme 5. The institutional processes that limit agility are the same processes that provide a safeguard for the credibility necessary for effective branding. P3 stated that the political neutrality and scientific integrity at the CERN institution are essential to guarantee political acceptance, where the painstaking approval procedures, which slow the pace of rapid market agility, provide a safeguard for the institutional trust recognized in Theme 2. Knowledge Transfer's communication processes are careful and slow because of political sensitivities for the 23 member states, where PlanetWatch may have to rely on faster, more agile communication channels than the ones the CERN can necessarily agree to". This illustrates that some times spin-offs may need to proceed at a faster rate than the hosting institutions.

This paradox answers the question of how start-ups and ventures spawned from CERN achieve success by gaining independence while utilizing their association with CERN's reputation. The implications of the institutional structures that maintain the credibility of CERN do not enable the feedback loops needed for market-based communication. Therefore, Theme 5 illustrates how constraints in organizations are far from being marginal and are in fact fundamental to shaping the commercialization of deep-tech within the CERN ecosystem.

Consistency Across Participants Relative to the Description of Organizational Obstacles

Each of the five interviewees described the organizational and political obstacles as structural properties that influence the level of success in branding. It is noteworthy that all five interviewees (P3, P1, P2, P5, and P4) referred to the same characteristics of organizational and political obstacles, even though they did so based on their individual roles in the

organization. As a member of internal communications, P3 referred to the aspect of delay, political sensitivity, and the lack of comprehension of marketing within their department. As an engineer, P1 referred to the necessity of obtaining opinions from experts and the reservations he had regarding entrusting communicators with technical knowledge. As a marketer, P2 referred to the difficulties associated with performing her routine communication duties regardless of the delays in making decisions and the lack of market responsiveness. As an entrepreneur, P5 referred to the observation he made of the institutional slowness of CERN and the difference between the rapidity of entrepreneurial ventures and that of CERN, leading to timing and positioning challenges. Finally, as a member of the policy formulation segment of the organization, P4 referred to structural aspects of world leader institution (CERN), indicating that it is not an operational concern.

Thematic Findings Implications for the Research Question

Themes 5 demonstrates that the performance of the branding mechanisms, cognitive framing (Theme 1), institutional legitimacy (Theme 2), communication bridging (Theme 3), and mission articulation (Theme 4) are limited by both organizational and political constraints. Therefore, branding cannot function independently in the CERN context. Rather, it must operate with the limitations imposed upon it by organizational constraints (approval chains, coordinating technical and non-technical teams) and political constraints (diplomatic and political acceptability). The results of these constraints can be illustrated by the fact that some branding initiatives are successful in spite of the organization constraints (PlanetWatch; MARS Bioimaging) while other branding initiatives may experience prolonged delays or inconsistent messaging. Thus, the results of Theme 5 indicate that to answer the research question, it is necessary to understand the relationship between how branding performs theoretically and how it performs within the actual organizational context of a supranational scientific institution whose legitimacy, credibility, and governance all impact what communication is possible and effective.

3.6 Mini-Case Examples: Demonstrating How Identified Mechanisms are Used Across Real CERN Technology Pathways

This part shows how the findings from the thematic analysis are related to the documented pathways of commercializing CERN-derived technologies through three mini-case studies. These case studies were used to demonstrate how branding, communication, legitimacy, and organizational barriers interact in practice when commercializing CERN-derived technologies.

Mini-Case 1: ADVACAM / TimePix Detector Family | Branding as a Cognitive Frame and Legitimacy Signal

ADVACAM is a Czech-based company that is commercializing the Medipix TimePix detector family, which was originally developed at CERN's Large Hadron Collider for CERN's physics experiments. ADVACAM exemplifies how deep-tech companies take highly complex scientific innovations and transform them into market-understandable formats.

Relationship to Theme 1: Branding as an Intellectual and Cognitive Bridge

Participant 1 stated that "expert-to-expert is the best channel of communication", thus emphasizing the importance of technical depth to communicate detectors to different types of audiences. Participant 2 stated that you can tell a lot more information in 10 seconds of video than you can tell in two pages of text...nobody reads the text anymore, illustrating the significant role of visual communications. ADVACAM has created marketing videos and named its product lines in simpler terms to enable commercial audiences to understand them, demonstrating Theme 1: branding is a cognitive bridge that reduces the cognitive burden associated with communicating particle physics-based imaging to non-experts.

Relationship to Theme 2: CERN's Institutional Reputation as a Legitimacy Signal

Participant 1 also said that "CERN is a great brand name" and that the connection to CERN has "put us in a better position than we would have been otherwise in terms of positioning our brand in the marketplace". Participant 2 said that "when we add the CERN logo, it gives us credibility right away", demonstrating how CERN's institutional branding as a signal of legitimacy impacts stakeholder perceptions of risk (financial or technology) prior to the existence of technical information. Therefore, this illustrates Theme 2: CERN's reputation as an institutional legitimacy signal influences the assessments of stakeholders prior to the assessment of technical data.

Relationship to Theme 5: Organizational Constraints

Participant 2 stated that every day it's a battle to describe what it does and how it works....the field is too big, which illustrates the code "Internal Misalignment". Participant 1 explained that because of the institutional approval processes at CERN (Theme 5) that the internal communications process may slow down the dissemination of information, sometimes we have to wait weeks to share something that needs to be shared right away. The practical issues Participant 1 raised demonstrate how the organizational and technical obstacles in an academic research institution setting impede even robust technology.

Summary

The ADVACAM case illustrates how a Deep Tech firm uses branding (Theme 1), leverages the legitimacy of CERN as an institution (Theme 2), and addresses internal organizational challenges (Theme 5) at the same time to effectively communicate complex technology to clinicians.

Mini-Case 2: PlanetWatch | Mission-Oriented Framing for Environmental Relevance and Public Engagement

PlanetWatch shows us how CERN-based environmental monitoring technologies can achieve social relevance and public engagement with stakeholders by framing their mission rather than by detailing their technological specifications.

Relationship to Theme 4: Mission Framing, Societal Impact and Trust

Participant 4 stated that “using healthcare as an example made it easier to explain the technology”. Participant 3 stated that Knowledge Transfer’s mission is to create an impact on society, not make money, and therefore frames the technology in the context of society’s narratives that will justify long-term engagement and patient capital. This illustrates Theme 4: mission framing translates abstract technology into socially relevant narratives.

Relationship to Theme 2: Institutional Legitimacy and Political Acceptance

Participant 3 during interview mentioned that CERN’s neutral position and scientific credibility are key to political and regulatory acceptance across PlanetWatch’s diverse membership countries. This illustrates how Theme 2 operates at the macro-level: CERN’s global stature and scientific reputation enable technologies to gain legitimacy in politically sensitive areas, like environmental monitoring.

Relationship to Theme 5: Organizational Constraints and Communication Flexibility

PlanetWatch often needs to operate with faster, more flexible communication than CERN allows." This illustrates Theme 5: the institutional structures protecting CERN’s legitimacy restrict the organization’s ability to be responsive to the rapid pace of environmental monitoring markets.

Summary

PlanetWatch illustrates that mission framing (Theme 4) and institutional legitimacy (Theme 2) can increase the visibility of a company’s communication in the public sphere. However, PlanetWatch also illustrates the trade-off in Theme 5: institutional protection of

legitimacy constrains the ability of organizations to be responsive to environmental monitoring markets promptly.

Mini-Case 3: MARS Bioimaging | The Integration of All Five Themes in Clinical Deep Tech Commercialization

MARS Bioimaging is a company that is commercially developing the Spectral Photon Counting X-ray Imaging that was developed via collaborative work between CERN and academia. MARS Bioimaging is a holistic example of how all five themes were integrated during the commercialization of a clinical deep-tech.

Relationship to Theme 1: Branding as a Cognitive Bridge

Participant 5 stated that we wouldn't have gotten through the door of a hospital like that if we didn't have the appropriate marketing and branding. It was further stated that the company created a name and a logo to "look medical and futuristic," similar to other successful medical devices. This illustrates Theme 1: branding is used to decrease the cognitive gap between complex detector technology and clinical applications.

Relationship to Theme 2: Legitimacy Signals and CERN Affiliation

Participant 5 stated that when first met with the Innovation Unit at the Hospital for Special Surgery, "they mentioned that they had seen us on the CERN Website." P5 as well stated that this validation occurred "due to the CERN affiliation," and that it reinforced the hospital's decision to engage with MARS. This illustrates Theme 2: institutional linkage provides credibility amplifiers in regulated, risk-sensitive markets.

Relationship to Theme 3: Gaps in Communication Between Technical and Non-Technical Actors

Participant 4 agreed that "there are always different opinions" between scientists, engineers, and businessmen about how to describe the technology, however, that internal disagreement has been limited because the branding is largely the responsibility of the commercial, sales and marketing team. This illustrates Theme 3: structural gaps in communication exist can be bridged by dividing responsibilities.

Relationship to Theme 4: Mission Framing and Clinical Benefits

Participant 5 stated that mission is "to improve the care of patients and linked the advancements in imaging to specific clinical benefits: "radiotherapy of brain tumors becomes gentler" and "reduces side effects by focusing the therapeutic beam more precisely on the tumor". Participant 5 gave comment Someone once told me – that was my father, who's a

scientist here at CERN – “good science affects people’s lives. And if it affects people’s lives, it’s commercial”. This illustrates Theme 4: mission articulation is not promotional, but rather structural to how value is perceived in deep-tech.

Relationship to Theme 5: Organizational and Political Constraints

Participant 5 recognized that collaborating with universities necessitates compromise. Investors tend to perceive CERN collaborations as liabilities due to "slow timelines," "the technology is too complicated", and the belief that "academic motivations are much different than business motivations". Participant 5 indicated that "commercialization is always at the bottom of the list" for any university. Therefore, it can be concluded that the same institutional systems that create legitimacy and credibility for an organization can also produce disconnections and delays.

Summary

MARS Bioimaging presents an example of how all five themes come together. Legitimacy from CERN (Theme 2) and a clearly defined mission (Theme 4) allow the company to make a transition to the clinic, branding as a cognitive bridge (Theme 1) helps to turn physics into patient benefit. However, organizational barriers (Theme 5) persist including investor skepticism and timeline challenges.

Synthetic Interpretation

Together the three mini-case studies illustrate:

- Branding can reduce the complexity of scientific concepts (Theme 1) primarily by using visual and clinical narratives as opposed to scientific ones.
- Institutional legitimacy from CERN (Theme 2) plays a major role in building trust with stakeholders, it has been evident throughout the three case studies, but was especially apparent in regulated environments like hospitals.
- Gaps in communication occur due to the structural separation of technical and non-technical actor types (Theme 3) and will have to be continually addressed by both co-presence and intentional translation, rather than relying on individual translators.
- Framing a mission allows for technology to be translated into social narratives that support long term commitment to patients across health, climate, and space sectors (Theme 4).

- Both organizational and political obstacles hinder the commercialization pathway (Theme 5) of the organization, through protection of CERN's legitimacy and through limiting the organization's ability to respond to the rapidly changing market environment.

These examples provide a basis to ground the theme-based findings in documented commercialization pathways and will serve as a base for participant synthesis and implication in subsequent sections.

3.7 Interviewee-Theme-Insight Overview

This section provides a concise mapping of how each participant contributed to the five themes, demonstrating the empirical grounding of findings across diverse roles and perspectives.

Table 5

Cross-Participant Theme-Insight Overview

P1	Senior Engineer, ADVACAM	Theme 1: Expert-to-expert communication necessity; Theme 2: CERN reputation as trade name but creates high expectations; Theme 3: Communication gaps between technical and market languages
P2	Marketing Lead, ADVACAM	Theme 1: Visual communication effectiveness over text; Theme 3: Daily struggle to translate across markets; Theme 4: Mission-oriented messaging generates engagement
P3	Communication Specialist, CERN KT	Theme 1: CERN brand opens doors; Theme 2: Reputation reduces risk; Theme 4: Mission is societal impact, not profit; Theme 5: Approval bottlenecks slow communication
P4	Policy Specialist, CERN KT	Theme 2: CERN simultaneously prestigious and non-commercial; Theme 3: Structural epistemic culture differences; Theme 4: Healthcare examples aid explanation; Theme 5: Constraints reflect governance necessity, not failure
P5	CTO, Bioimaging MARS	Theme 1: Branding essential for hospital access; Theme 2: CERN affiliation validates commercially; Theme 4: Health framing improves acceptance; Theme 5: Academic priorities misaligned with commercial speed

To identify common cross-participant findings, five participants' responses were compared to determine four primary cross-participant findings:

Cross-Participant Finding 1: The process of developing an image of your company (branding) reduces the number of ways a complex product can be perceived by users (decreases cognitive complexity), particularly for products in the deep-tech industry (Themed 1 and 3).

Engineers tend to focus on being technically correct and marketers focus on developing an image of their brand that is clearly understood, all agree that communication between engineers and marketers is critical for successful branding.

Cross-Participant Finding 2: The reputation of CERN (the name of CERN creates perceptions of prestige and credibility) contributes to the credibility (legitimacy) of companies and products in this industry (Theme 2). All of the participants felt that CERN's reputation contributed to the credibility of companies or products utilizing CERN, it also creates high expectations and a non-commercial viewpoint that would be challenging to commercialize.

Cross-Participant Finding 3: Framing an organization's mission, significantly improves stakeholders' understanding of organizations and their products (Theme 4).

All participants agreed that framing organizations' missions in terms of social contexts (health, environment, space-related) improves the likelihood of engagement with an organization.

Cross-Participant Finding 4: While structural barriers (approval procedures) hinder commercialization; operational failures do not hinder commercialization (Theme 5).

Participants 3 and 4 noted that the approval procedures at CERN are in place to preserve the institutional credibility of CERN across the 23 countries that collaborate with CERN.

Participants 5 and 1 both stated that there is a conflict between preserving institutional credibility through slow decision-making processes and the need for rapid decision-making to successfully launch a product into the marketplace.

How Roles Create Different Views:

- **Engineers (Participant 1):** They tend to focus on accuracy and attention to the technology; engineers in general feel a healthy dose of skepticism about the likelihood of simplifying information about technology in marketing.

- **Marketers (Participant 2, Participant 3):** They tend to emphasize clarity and accessibility to information regarding products and services to a broad audience.
- **Policy Specialists (Participant 4):** They emphasize the preservation of the institutional legitimacy of CERN, as well as the integrity of the organizational governance structure.
- **Entrepreneurs (Participant 5):** They emphasize how products and services are perceived by stakeholders in the "real world" and the timeframe within which products and services must be launched into the marketplace.

These differing perspectives offer complementary, not conflicting, evidence regarding the layered branding mechanisms utilized during the commercialization of deep-tech products.

3.8 Cross-Participant Comparison

Overview and Structure

The cross participant section will provide an overview of all five interviews as to what similarities were found among participants on the five major topics and where they differed. A comparison of the perspectives provided from each participant for the five major topics, will demonstrate how each participant has different layers to branding, communication and legitimacy in CERN origin deep-tech commercialization. The findings are grounded in relevant research literature.

All Participants Agree: Branding Reduces Complexity of Technologies

All five participants agree that branding provides a value to consumers, that is to say, branding reduces the complexity of explaining new or complex technologies. However, they did so from different viewpoints based upon their role(s). Participant 1, Senior Engineer, stated that when communicating about this type of technology there must be a direct line of communication between two experts. He stated: "The important channel of communication should be expert-to-expert. Not through marketing, not through salespeople."

Point is that the complexities associated with high level specialized detector technology cannot be communicated to non-experts using general marketing materials. Therefore, direct communication with other experts is required. This is consistent with research conducted by Leek and Christodoulides (2011) which states that in the case of deep-tech, branding needs to build trust and support long term relationships and therefore can never simply be used to promote products.

Participant 2 identified another benefit to branding. Participant 2 stated: You can explain much more content in 10 seconds of video than in two pages of text... no one will read the text nowadays." This statement from Participant 2 illustrates how visual communications such as video, images, and graphics are better able to communicate complex technology-based information than text-based communications. The OECD (2023) states this too. In B2B communications involving technical products, credibility for the organization through multiple communications channels, not just text, is necessary to effectively brand the product.

Participant 5 demonstrated how branding functions in a business environment. They also stated, "We wouldn't have got through the door of hospitals like that without the appropriate marketing and branding." which indicates that for Participant 5 branding isn't useful but rather a necessity. If Participant 5 had not branded their technology appropriately the hospitals may have never entertained the idea of the companies technology. This experience demonstrates the importance of mission driven branding that has been discussed by Mazzucato (2018) as long term projects in deep-tech will be successful if they can tie technology to larger social issues or goals, such as improving healthcare.

Participant 3 and Participant 4 who were in institutional and policy positions, did not explicitly discuss the above theme. Participant 3 and Participant 4 implicitly validated the findings of the above theme by discussing the role of mission framing and institutional legitimacy, which will be discussed below.

CERN's Reputation as an Advantage

All five participants identified CERN's reputation as a critical advantage for building trust and reducing uncertainty, which is a very large convergence with Theme 2.

Participant 1 stated, "CERN is a fantastic trade name" and elaborated how its name creates associations. The comments of Participant 1 reflect the theory of legitimacy put forth by Suchman (1995): People find things acceptable and trustworthy due to credibility and trust.

Participant 5 also echoed this from their experience as a spin off founder. Participant 5 stated: "CERN is known as high-tech and cutting-edge... that has some huge advantages." Participant 5 continued by stating that when a medical-imaging company first contacted hospitals, they were immediately interested in talking to the company about their product. The hospital's interest in speaking with the company was based on the fact that the company was affiliated with CERN. This is a good example of Spence (1973) signaling theory; affiliation with a respected institution such as CERN is a good indicator to reduce risk for potential investors, hospitals and regulators to invest or work with a medical-imaging company.

Participant 2 (from the Marketing Side) said: "The CERN logo already builds trust before we present anything." Participant 2 demonstrated that the CERN brand could serve as an evaluation tool to help audiences quickly assess the complexities of the technologies. Participants assumed they could trust CERN, they would also trust products derived from CERN.

Participant 3 said that having CERN on their website "opens doors" for them and that having such a prestigious reputation opens the door to actual business opportunities. Participant 1 felt that being associated with the CERN name created an unrealistic expectation of what the company would be able to accomplish, that the CERN name opened many doors to audiences that were previously unattainable, but the pressure of living up to the name (having to develop products of superior quality, performance, etc.) would be overwhelming.

Participant 4 had a larger perspective on the governance and noted that CERN is perceived by the public as being both "prestigious" and "non-commercial." Thus, when people believe CERN will do good science, they may assume that CERN is not a quick or commercially viable organization to partner with, which affects how partnerships are formed.

While participants agreed on major points, their roles shaped different emphases:

- Participants 1 (engineer) gave priority to the technical knowledge base and to the participation of experts in engineering. Participants 1 stressed that the expertise necessary for an effective product or service cannot be replaced with a simple marketing campaign and therefore the scientists and engineers need to remain involved in defining the way the technology will be communicated to users.
- Participants 2 and Participant 3 (marketing) focused on the communication of information to make complex products and services understandable by a wide variety of people. Participant 2 stated that "every day it's a struggle to explain what it does and how it works... the field is too broad." Participant 2 went on to state that the very same detector technology has an entirely different meaning in medical applications, security applications, and materials research. Therefore, each application has its own unique method of describing the technology.
- Participants 4 (policy specialists) focused on structural issues. Participants 4 stated that due to the multi-national nature of CERN (24 countries), every communication must be reviewed with extreme care to avoid political bias. This slows down the approval process.
- Participant 5 (entrepreneur) focused on what stakeholders in the real world perceive. It was noted, "In any academic institute, commercialization is a long way

down their priority list." Participant 5's primary concern was that academic institutions did not have the speed required for successful commercialization.

The above differences of perspective are part of a larger context. The engineers' concerns were that they would lose technical precision, the marketers' concerns were that they had limited time to customize communications to specific target groups, policy specialists' concerns were that they had to be mindful of national sensitivities, and entrepreneurs' concerns were that they had to act quickly to stay competitive in markets.

The five participants agree in their view that it is important to frame a technological innovation within an important societal mission so that external parties can appreciate and possibly support it. This is theme 4.

Participant 3 said: "Knowledge Transfer's mission is to create impact on society, not money. We work with industry for societal benefit." This supports Mazzucato (2018) who states that if a project of deep-tech is framed as part of a major social mission, this will allow patient investors and long term partners to support it.

Participant 5 stated: "I have always framed the goal of MARS as providing better care to patients. That's been my primary motivation."

Participant 5 also stated: "Good science affects people's lives. And if it affects people's lives, it's commercial." For them, societal benefit and commercial success are connected, not separate.

Participant 2 stated: "Mission-oriented messaging, particularly in health and security, generates significantly more engagement from external stakeholders compared to purely technical explanations."

Participant 4 stated: Using healthcare as an example made it easier to explain the technology," which again illustrates how mission-based communication can enhance both internal and external understanding of an organizations' work.

Participant 1 also expressed caution regarding the importance of framing around health issues. The participant stated while they agree with the benefits of using a health problem frame as a means to create brand awareness, "Branding is even exaggerated. It's overestimated, overused, abused." This was supported by a comparison of a well-branded product to a product that was less well-branded but better quality. The participant compared a beautifully packaged, red apple purchased at a grocery store to one that had not been well-packaged and may have been less appealing. The participant noted that while the apple may look nice initially (i.e., the packaging), once opened it will likely be disappointing to consumers,

which can lead to disappointment in the brand. As such, the participant warned about creating unrealistic expectations through branding, particularly in an area of deep-tech, where products take many years to develop and build out.

The Influence of All Organizational Constraints on All Employees

All five respondents said organizational and political constraints were a major factor for all employees regarding how branding occurs at CERN. The constraints mentioned are indeed actual structural characteristics, not just issues that need to be resolved. They represent Theme 5.

Participant 3 stated: "Everything must be checked and approved... I cannot publish anything without approval. If something is slightly wrong, it can have political implications. So yes, the process is slow. Much slower than in private companies." Participant 3's comment illustrates that because CERN includes approval from multiple countries, this approval process slows down communications with customers.

Participant 1 commented on internal partnership issues with Academic Institutions (AI), citing "slow timelines" in addition to the "perception that academic motivations are very different from business motivations" which creates an environment of investor hesitancy.

Participant 5 states: "In any academic institute, commercialization is a long way down their priority list." Participant 5's comment highlights differences in organizational priorities where Academic Institutes (AIs) primarily prioritize science and private companies primarily prioritize market response.

Participant 4 also pointed out from a policy view point: Constraints arise from its nature as a politically accountable public research institution." The constraint mentioned by participant 4 was not an example of an operational failure for a public research university but rather an example of the necessity to maintain international credibility and political balance.

Participant 3 provided a quantitative measure of the opportunity cost to CERN due to delayed governance and stated "Knowledge Transfer existed for 35 years, and only the last two years, with proper marketing, brought almost the same level of visibility as the previous decades." Thus, this illustrates how the direct result of the delay in governance resulted in loss of commercial opportunity.

There is, however, an apparent paradox. The same bureaucratic and governance structure that results in slow communication also protects CERN's institutional legitimacy and credibility. Participant 4 pointed out that "CERN's institutional neutrality and scientific credibility are crucial for political and regulatory acceptance" and therefore the slow processes while

resulting in frustration regarding speed for commercial applications ultimately provide the trust that makes technology derived from CERN credible

Different views, common understanding

Each of the five participants viewed the same event(s) through their own lens:

1. The engineers in the group viewed the difficulty in maintaining the high level of technical sophistication and communicating to people who are not experts in the field.
2. The marketers in the group viewed the difficulty in finding the time or flexibility to tailor messages based upon what audience they were trying to reach.
3. The institutional communications professionals in the group viewed the difficulty in managing political sensitivities (i.e., how much information could be released and when) while increasing commercial visibility.
4. The policy professionals in the group viewed the difficulty in establishing the right balance between the institution's need for legitimacy versus its commercial responsiveness.
5. The entrepreneurs in the group viewed the difficulty as operating at a rate that was faster than that allowed by the parent institution.

However, each of the five also agreed upon the primary conclusions: Technology that is complex has less cognitive load when branding is used. A company's brand reputation is an important asset that needs to be managed carefully. Communication is slowed down by organizational constraints that help maintain legitimacy. When stakeholders view long-term benefits of mission-oriented framing, it is easier for them to understand the value of the organization. Real effort is required to translate science-based perspectives into marketing-based perspectives, and this cannot occur without some degree of thoughtfulness.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. This thesis states that, based on the CERN case study described above, branding enabled the commercialization of CERN-origin deep-tech products through providing a way for stakeholders to evaluate such products where there is a lot of technical uncertainty surrounding these products. Branding acted as a way to provide frameworks for interpreting whether the product could be used or would be relevant to the user as stakeholders were unable to validate relevance until after the products had been developed and tested due to the long time involved with developing these types of products and the complexity of the science involved in them.

2. The study found branding functioned as a cognitive frame. Branding provided stories about how to apply technology, providing ways to help people understand (interpret) complicated technology as well as helping those who invest in it, work with industry partners, regulate it and ultimately use it. Technology quality is rarely enough on its own to sustain interest unless there is something else; in this case, the other thing being the framing that occurs when branding is applied, and explains why the commercialization of technology often has slow start-up or low level of momentum in many cases.

3. Institutional endorsements were also used by the firms as legitimacy signaling for early stage commercialization at CERN. The association with CERN reduced the perception of risk for these firms; allowed them to establish an initial level of trust with their customers and other stakeholders; and provided them with access to a larger community of stakeholders than would have been possible without CERN's name behind them. However, the interview data suggests a dual role of CERN's scientific reputation: while it enhanced the firms' credibility and prestige, it may also enhance perceptions of the complexity of the firm's products, thereby raising the bar for what is expected of them in terms of their marketing efforts. This implies that effective branding for firms associated with CERN will require active management of how the firm's institutional affiliation is viewed in the marketplace.

4. The results of this research demonstrate that using a mission oriented frame to describe the social benefits of a technology can help generate stakeholder engagement when there is a delay in validating the market potential of the technology. As demonstrated in the cases studied and through the interview data collected, framing technologies as tools to achieve social missions (e.g., health care, environmental monitoring, public benefit) helped create a longer term context for stakeholders to understand the value of the technology; and

sustained interest over longer periods of time, especially in markets where the products are subject to regulatory oversight or are inherently risky.

5. As stated by the final thesis the effectiveness of the branding mechanism was dependent upon the organizational and governance context within CERN. The cognitive frames (legitimacy signalling, mission-oriented narrative articulation) were supportive of commercialisation through providing a branding mechanism to clarify the CERN knowledge transfer context studied; nonetheless, these cognitive frames occurred under organisational constraints. Branding was viewed here as having existed as an organisational capability, as part of technology transfer processes rather than as discrete communications activities. These conclusions answer the research question by showing that, in the CERN context examined, branding supported commercialization through cognitive framing, legitimacy signaling, and mission-oriented narrative articulation, operating within specific organizational constraints. Through these mechanisms, branding reduced interpretive uncertainty, structured stakeholder expectations, and complemented formal technology transfer activities.

Recommendations

These recommendations are based on the mechanisms I have identified and are specific to the CERN Knowledge Transfer context and CERN-related deep tech start-ups.

Recommendations for the structures of CERN Knowledge Transfer

1. Stages of commercialization: classify the different levels.

CERN Knowledge Transfer would establish rules for the use of the reputation of CERN as a legitimacy signal and for which technologies or spin-offs have the potential to benefit from a more self-directed announcement. As a result of the observation that CERN had a dual impact on access and positioning, which raised expectations, this recommendation emerges.

2. Embed translation responsibility within technology transfer processes.

As cognitive framing became established as a prominent mechanism in Chapter 3, CERN Knowledge Transfer might properly delegate the role of making scientific complexity amenable to application narratives. A structured collaboration between scientific and communication teams might take place as a prelude to the full development of a product, and not necessarily as a post-development activity to which the role of translation might be randomly relegated, for the reason stated in the theoretical argument regarding the empirical discovery made of the Technology Transfer Process. As demonstrated empirically, how the roles were defined and who "owned" the narratives significantly influenced the success of the translation process.

3. Enhance internal coordination of brand-related decisions.

In an effort to minimize the effects of disjointed messaging, the narrative alignment point could be incorporated into the current activities of the CERN Knowledge Transfer. The development is based on the mechanism of organizational fragmentation identified.

4. Clarify the role of mission framing in external communication.

CERN Knowledge Transfer could provide guidance on how societal missions can be used to frame technologies without overstating maturity. This responds to the empirical finding that mission narratives supported engagement under uncertainty when they remained aligned with development stage and credible evidence.

Recommendations for CERN Spin-Offs and Deep-Tech Ventures

5. Implement dual-layered communication techniques.

Spin-off companies can more formally distinguish between high level technical communication for the expert community and stakeholder communications (narrative). The rationale behind this is based on findings of both, expertise-based credibility building and framing for stakeholders, serve as complementary elements of stakeholder interaction.

6. Selectively and strategically utilize affiliation with an institution.

CERN affiliation can be used initially to establish a base level of legitimacy and at the same time, create an independent technology identity through parallel effort. CERN's prestige will likely increase the expectations of investors, consumers etc., which may make it difficult for a spin-off company to position itself commercially after an initial success, if not actively addressed.

7. Tie anchor narratives to application contexts.

Ventures should focus on articulating technologies in relation to use cases and problems rather than in a scientific manner. This suggestion is based on the empirical evidence that application-centric storytelling can overcome cognitive barriers to earlier engagement.

Recommendations for future research

8. Analyze the development of branding practices at the stages of commercialization.

Longitudinal research can trace the evolution of cognitive framing, legitimacy signaling, and mission articulation as CERN-born technologies develop from their nascent stages into

commercialized stages. This follows from the empirical observation that the process of branding occurred in a continuous, rather than stage-based, manner.

9. Compare branding mechanisms of public research Institutions.

Comparative studies with different governance structures of institutions could shed some insight into those processes that are unique to CERN and those that can be applied more widely in research institutions. The current research design is limited in terms of generalizability, given its domain specificity.

10. Explore the organizational ownership of the brand in Technology Transfer.

Future research could investigate how the allocation of narrative ownership in Technology Transfer arrangements relates to the consistency of branding and its success. This is a consequence of the observation that a diffused form of ownership exacerbated translation and coordination issues.

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Annexes

Annex 1. Interview Guide

The following semi-structured interview questions were used to collect empirical data for this research. The questions were designed to explore decision-making processes, stakeholder involvement, co-creation practices, commercialization pathways, and the role of branding in the context of CERN Knowledge Transfer.

Interview Questions

1. Many researchers say branding helps deep-tech projects build trust, explain complex ideas, and attract investment. Based on your experience, does branding really help with these things? Can you give an example?
2. There are different ways to do branding, like using visuals (logos, colors), telling a story, linking to missions like health or climate, or using CERN's name. Which of these have you used or seen at CERN? Which ones actually worked?
3. Do you think CERN's strong reputation helps when bringing new technologies to market? Can it ever be a disadvantage, or is it always helpful?
4. Have you ever had trouble explaining a technology to investors or partners who don't have a science background? How did you make it easier for them to understand?
5. In deep-tech, branding is often used to build trust, especially when the technology is new or uncertain. Have you seen this happen in practice?
6. In your opinion, how do investors or external partners usually see CERN technologies? Does good branding change how they see the risk or potential of the project?
7. Have you ever framed a project in terms of a bigger mission, like solving a health or climate problem, to help people understand or support it better? Did it help?
8. Inside project teams, do people usually agree on how to talk about or "brand" the technology? Or are there different opinions between scientists, engineers, and business people?
9. Do you think having an online presence, like a website or LinkedIn page, helps CERN technologies or spin-offs get more attention or trust? Do you know any examples?
10. If you could suggest one thing to improve branding or communication at CERN for commercializing technologies, what would it be?

These questions were used flexibly during interviews, allowing respondents to elaborate on context-specific insights and provide examples based on their experience.

Annex 2. Interview Transcripts

This section includes all interview transcripts collected during the research.

The transcripts are presented in a clean verbatim format: everything the interviewee said is kept, except meaningless fillers or broken noises. The goal is to preserve the authenticity of the conversations while ensuring clarity for analysis.

Each interview begins with a short metadata block (code, role, date), followed by the full dialogue.

These interviews form the empirical foundation for the thematic analysis presented in the Analytical Chapter.

Interview 2: P1 —Technical Lead, CERN Medipix spin-off

Interviewer: I'll repeat the question once more. Many researchers say that branding helps deep-tech projects build trust, explain complex ideas, and attract investments. Based on your experience, does branding really help you with these things? And can you give an example?

P1: Sure, it helps. It's necessary, of course, depending on the product, but in general, yes. If I can comment something important: yes, but it's not the most important thing. I have to say that.

It's necessary to have a good product, good communication, and demonstrations with customers, especially with skilled customers. This is something, from my perspective, I can comment based on the things I've been doing. And I have many reasons for that.

Ideally, or in my experience and perspective, I focus my priority – and I think the company should also – on communicating directly with experts, you know? Not through marketing, not through salespeople. They are necessary, they do the paperwork, some communication, but the important channel of communication, information and meetings should be expert-to-expert.

Interviewer: So you think that it's important, but it's not the most important thing.

P1: Correct.

Interviewer: What about attracting investments, the money flow that they bring? Because marketing and branding are the main communication with investors.

P1: Yeah, I understand. I know. That's why I'm giving these comments. I know it's maybe not common, not usual, but also for investors: I'm not saying it's useless. It's necessary, it's quite important, but not the most important. It shouldn't be the most important.

Branding is just marketing. It's on labels. I'm not saying it's useless, but it's necessary to put a good product and get good feedback to have results. This is my personal view.

Interviewer: That's very good. OK, OK, for the second one?

P1: I could even go beyond, and I could comment that branding is even exaggerated. It's overestimated, overused, abused.

Interviewer: OK. And do you think nowadays branding is having a big impact on deep tech, or still not?

P1: It's useful, but many other things are also necessary. This is what I'm trying to say. It just gets too much.

Interviewer: There are different ways to do branding: logo, colours, visuals; telling stories, sharing success stories, linking to missions like health or climate; or using the CERN name. Which of these have you used? And from your perspective, what actually works?

P1: I would say it's difficult to make rules for everything. Again, part of the answer would be: it depends on the specific product. Unfortunately, things are sometimes complicated.

I know people like to have simple rules – “this type of branding” and apply it to everything. Unfortunately, it doesn't work like that.

I'm very honest and very frank, even if people don't like to hear it.

Interviewer: That's very useful for the paper.

P1: So, I am thinking, regarding what we have, I would say it depends on the product or the customer. That's why you need skilled people, even in marketing, because if it were simple – like looks, or like "one model of marketing, one model of branding" – then everything could be done by artificial intelligence, by a computer. One model, you apply it to everything and then you go to sleep.

Unfortunately, that is not the case. The software requires more customization, even at the marketing level, if you want.

From our own experience, because we are of course a small company, very small market, very specific, ultra high-tech, very specialized – even we have different products and

different applications, different markets. Of course, they are all high-tech markets, but some are medical, some space industry, some accelerators, nuclear reactors, education, students. It's very diverse.

So my answer to your question would be: it depends. I cannot give you a perfect one-size-fits-all answer.

Interviewer: That's all right. Next question is more about CERN and CERN's reputation. Do you think CERN's strong reputation helps when bringing new technologies to the market

P1: It helps, yes. Clearly yes, for sure – which is our case now. The chip which, in our case, is the core component in the technology is from CERN, and we are a spin-off industry of the CERN Medipix collaboration. This is a technology called Medipix for 20-plus years, really so long. And that's a big branding, and it's correct. It's not just the branding, it's actually necessary, for many reasons, and it definitely benefits us. It's a fantastic trade name.

It's not just branding; it's actually necessary, for many reasons. And it definitely benefits us. It's a fantastic trade name.

Interviewer: But do you think there could be disadvantages, for example having CERN under the name?

P1: Good question. I'm thinking. I would say... no. Yeah, there can be, but I don't see it myself. I believe there can be, I don't know.

Maybe for some customers who would like to have a cheap, non-quality product, yeah. Maybe if they see CERN, then they will be scared because they know it also costs something. So sure, you can always find something negative. But 99% – I mean, in the majority of cases – it is just positive, for serious markets and serious customers who want to have quality technology.

Interviewer: You know from which perspective I'm saying "disadvantage". For example, when I went to CERN, I had a chance to speak with someone from Knowledge Transfer, and with someone from a spin-off company. There was an interesting factor: people who work under CERN are not really as interested in commercialization, as you also shared. They're more interested in scientific research. And this reputation of CERN shows investors that this could be less profitable, rather just innovative. So that would make objections for them to invest.

P1: Could be. Could be. Interesting. Yeah, I'm listening, very interesting. The world is complex, there are many different people. They must have their reasons.

Did they justify, did they explain you a little bit more why they have this view?

Interviewer: Because this is fundamental research, and when they are doing fundamental research, as I understood, they are not really trying to understand what it will do in 10 years. They care more about how it will be used in the very long-term future. Like the phone – when the phone was invented long ago, no one had any idea how it would be used now. And the people who were doing it at that time weren't interested in how it's going to work in the market, they were just interested to invent and to discover.

And as they are not interested in commercialization, investors are only interested in money. So these are two controversial things. CERN already got the reputation of not being interested in money. So that would make investors maybe double check or think three times before investing.

P1: Yes, OK, yeah, yeah, I understand what you are saying. There could be this idea. I think this idea could take place in the world.

Interviewer: The next question is more about communication. Have you ever had trouble explaining a technology to an investor or partner who doesn't have a scientific background? And how did you make it easier for them to understand?

P1: Yes, that's the case. There, I can say: yes, marketing and branding techniques help. They are valid. I acknowledge that and I use them. I'm happy. Actually, maybe that's why a colleague and I make a very good team, because we are very different.

But I acknowledge it. I know it's important, because it helps to communicate the message. Yet you also need to keep track of the complicated stuff, the core of the technology. You cannot just leave it to the marketing specialists, because at some point, sooner rather than later, questions come up – details, even at the marketing level, which are very specialized.

So ideally, the person for marketing – at least for this market, the things we're doing – in my opinion should be at least some kind of engineer, with some technical background. This is maybe a very unorthodox view, but it should be.

When I see this market, there are specialists who are very good. That's why we work in teams. The best way to approach these matters is to go together, if possible. I have done it

in fairs – I've been with a colleague in industry fairs, the Messe, industry forums. That's the ideal.

Even for me, I am a very team person. I'm not "the king of the world". It's good to have a team and answer together. And yes, I myself learn from marketing specialists and try to get some help, actually.

With investors, it's complicated because they are very busy. They are very focused just on money, and actually they become limited in their vision, because they are just too much focused on money. It's the other extreme.

So there is a spectrum of people. On one end, there are investors – banks or money investors – which is fine, it's valid, it's good that they are there. On the other end, there are people that you were mentioning from New Zealand or CERN, who only want to see research and are not really interested in technology or knowledge transfer.

And I am honestly somewhere in between. I am in the middle. I am of course a scientist, but I have gotten myself a lot into industry. I try to understand and make a deal, and understand these people. Actually, that's part of my talent – I get along with people well, I communicate.

So what happens: I pass the contact, for example. I find solutions. I even manage, with some investors when it happens, if I see they don't get the message or communication is complicated, then I give the contact or I call a colleague and say, "Hey, come help me." That's how it should be.

Interviewer: Here we come to the fifth question, about trust. In deep tech, branding is often used to build trust with clients and investors, especially when technology is new or uncertain. Have you seen this in practice?

P1: Yeah, trust – because it's a symbol. It's very important, it is valid, it's quite important at many levels. Of course with customers, but even inside the company, or with competitors, or universities.

Interviewer: I personally think branding helps people follow the same idea, and when a company internally follows the same idea, the product is good and the team is good. If product and team are good, people will also like it. When everything is aligned around a mission, the company can be more successful, maybe even become a unicorn one day.

So, the perception of technologies at CERN: in your opinion, how do investors or external partners usually see CERN technologies? Does good branding change how they see risk or potential?

P1: Yes, I agree. That's the case. They see it positively, almost always. It helps, just positively.

Interviewer: But without branding, without marketing, without this good picture – would the investor assess risks more and be less interested?

P1: It would be more difficult, and he would be less interested. So definitely it's necessary. Even if the product is great, doing some crazy things, it's always necessary and good to have some level of branding. It's an important thing nowadays because people "eat with their eyes" every day with advertisements; people see, people remember.

It's important, necessary, beneficial, convenient. But again, it shouldn't be the only or the most important thing. This is what I was trying to tell you.

Interviewer: No, of course not. I'm a person from sales and I personally think that sales is one of the most important things, because without money there would be nothing. But in CERN it's a bit different, because to get the technologies it's not about money – you need licenses and different things. So as you mentioned at the very start, it depends on the product and the industry, and nothing can be applied with the same idea to everything. And this is very true.

P1: Sure. But you say sales is the most important – that's your opinion. I don't share that. Not that it's not important, but I think that's already too much.

You need to have a good product – that should be the priority. Then of course you need branding, you need sales. I'm not saying not to have them. But it shouldn't be... It's a question of quantification, you know, engineering. The most important thing would be to have good customer service, to build the brand actually from the bottom, from the experts in our case, because we are not selling bread or potatoes. We are selling complicated things.

That's why I'm speaking like this. I see an issue that the key experts, technicians – they don't have to be super scientists, but engineers, even students using the technology – in my opinion they should be the most important. Not the managers, not even the investors.

Interviewer: But everything is important. Everything has its own importance.

P1: Yes, but there are priorities. And what I was telling you is: branding shouldn't be the most important, which is what I sometimes observe, that it becomes over-prioritized. That's why I'm giving you this comment.

Interviewer: That's very good. Very insightful comments.

P1: I'm not saying that's our case. I'm speaking in general. I observe it in the world where I'm going around. I see that happening.

Interviewer: Yeah, that's why I said, it's less about the specific company, it's more about your opinion and your personal experience, and what you gained through all this way.

Interviewer: Let's go to the next question – it's about mission-oriented framing. Have you ever framed a project in terms of a bigger mission, like solving a health problem or climate problem, to help people understand or support it better? You already do that, because you are in health – solving a health problem.

Do you think that using the idea "the company solves health problems" helps people to love it more, to have more interest? Like, "We are trying to find a pill for cancer" – people are interested because this is a global problem. Health and climate are global problems. So the question is: using this idea of "we will help solve a global problem" – do you think this is something people follow as well?

P1: Yes.

Interviewer: Great, we already covered this more or less.

The next question is also interesting. Inside project teams, do people usually agree on how to talk about or brand the technologies, or are there different opinions between scientists, engineers and business people?

P1: I'm thinking. I could say first that often this is not even open, which is not good. And when it is open, maybe it's biased or there is an imbalance. Then always someone, maybe from marketing – that's his job – decides. So then, I think I see less democracy there, fewer opinions.

Maybe there is some work to do there. I don't think it's optimal. I think one could improve – when I say "one" I mean the company or the world or society. This could be improved, I would say. It's not done yet.

Interviewer: Good, good. The next question is about online presence. Do you think that having an online presence – a website, LinkedIn page – helps CERN technologies or spin-offs get more attention or trust? What do you think about social media, websites, online?

P1: Yes, it's a necessity. It's important, it's necessary. So definitely it's important.

But then I would say maybe the extent of importance or the priority depends on the market, on the product. If one is selling something mass market, maybe a mobile phone, it's different.

Interviewer: It's easier to sell. But what about deep tech, innovative things? Is it important for them?

P1: There, I don't think it's so much appropriate or so much necessary. Necessary to have it? Yes, a minimum. It's a question of scaling. You need to quantify. If you leave answers just qualitative, it's too vague.

We have phones for a reason – we need some numbers. That's why I'm replying like this.

Interviewer: That's why we're doing the interview. If I would be interested only in yes or no, I would just send you a survey. But I want your personal insights.

P1: So it depends on the product. Again, there must be someone with brains behind the decision. If a particular product requires more personal involvement, if the end user is more a company or an individual person, then according to that it should be customized – the intensity, the extent of the online presence you mentioned.

But for sure, yes, everything should be online, at least at some basic level. This is what I'm trying to say.

What I'm also trying to comment is that sometimes I think it's just too much. People then get saturated. For example, in our case, if we are just pushing everything very intensely – I'm not saying it is like that, just as an example – if it's too much, people become saturated and don't pay attention. They get too many things they don't really need. Some things are too specific, some subcomponents or subsystems.

So there should be some strategy and compromise – some strategy how to proceed and be productive, not just saturate and flood. It happens. When I'm receiving information, it shouldn't be too much because people don't have time to read.

So it is necessary to simplify. I think today, for some things, less is better than more, because we're getting so much information everywhere – links, research, everything. It's so much information. I would even say maybe I will start thinking to do a little bit less.

So when there is a post from the company, let's say once per month, not every day, then people will pay attention. If it's coming too often and it's too big, people just stop reading it, and it becomes useless.

It's also complex. Even marketing is not simple. There are different platforms, different markets, different videos, day, night, weekend, working day...

Interviewer: Great, that's a great comment. Thank you very much.

Interviewer: Last question. It's more a suggestion for improvement. If you could suggest one thing to improve branding or communication at CERN for commercialization of deep-tech technologies, what would it be? One comment – even though you think branding is important but not the most important in CERN's case and in deep tech.

And I could agree with you if you are making business with government entities, who are not the ones who are so sensitive to marketing. One suggestion to improve branding and communication at CERN – how, for example, for the company, if CERN would do something that would make it easier for the company to push more?

P1: I'm thinking. I'm sure there can be many, many ideas, but one, connecting to what we spoke at the beginning: to try to convey, to get some info, some feedback for the branding from the real end-users, in the case of technology.

If it's some complicated X-rays or some complicated instrument, I will try to think as an engineer who is with the hands there – to make it appealing and to convey information for the branding from the real people "down" using it. Because they are the ones using the technology. They are the real ones using it.

What happens often is a broadening gap between directors of institutions, who are the ones handling money – and of course it's necessary to address them also – and the people at the end. If you ask me where to improve, I would give this suggestion, because what happens is that branding and online presence can become too abstract, too much marketing, too empty, too superficial. Sorry to tell you like that.

And I think people in this – because we are speaking of deep tech, not McDonald's – at the end there will always be people who are very overlooked, and they are the ones. Ideally they are underestimated, ignored, and that's how it is. So I think that's a pretty big mistake, and I would try to explore this more.

I'm not telling you "it must be like this", but it's a suggestion.

Interviewer: Maybe our research will be significant and it will be some game-changer, you never know.

P1: It's just too much – this is how I am. I supervise many students, I also give lectures, and sometimes it helps to give an example.

Let's say a meal, food. You go to have lunch. What happens when you see food that looks fantastic? This is sometimes my analogy with marketing. It's very bright, or a fruit: you

go to the supermarket and buy a very beautiful apple – red, bright. Actually it's not delicious. Very often, the most delicious apples are the ugly ones, or the standard ones. And that's true.

So what happens is that in the short term, you sell, you get your customers, maybe more than if you don't do it. But in the long term, you disappoint people. People get disappointed because it wasn't what it looked like. It was exaggerated, overhyped. That sometimes happens.

I even do it – I am very optimistic, of course – but I'm not telling in marketing things which are not real. I am very responsible. But I know in the short term, people prefer to dream, to think they are buying something perfect – like with electric cars. If you tell the customers of electric cars that the battery is bad and the range is not 500 but only 200, they will not buy.

So I know that. But it would be a push to be more honest, more realistic. I know it's difficult, because there is big pressure from investors. They want to maximize returns, which I think is also a mistake. In my opinion, a big mistake the society is doing is to expect big profits from high tech. I don't think that's good, but that's maybe another topic.

Interview 3: P2 — Head of Communication & Marketing, CERN Medipix Spin-off

Transcript (Clean Verbatim):

Interviewer: Yeah, I think everything is recording, everything is transcribed. Thank you very much again for joining and for recording. Sorry for the interruption, we can continue.

P2: Yeah, yeah. I just said that I hope that you are at the right address, because CERN Medipix spin-off is really an example of how the knowledge could be transferred from CERN and academia to everyday life and commercialization.

Interviewer: That's nice. That's very nice. Then, if you could tell me a bit about yourself and about your company, just to have an understanding. I didn't really search about it.

P2: OK, so about myself. At the moment I'm Head of Communication and Marketing at CERN Medipix spin-off. It means I am responsible for promotion and PR, everything that is connected with online marketing, websites, pay-per-click campaigns, Google, social media, printing leaflets, designing leaflets, brand visual identity, whatever

And also very important are events, like conferences and exhibitions all around the world. We are attending almost 40 events every year as a group of companies, because CERN Medipix spin-off is actually just one member of a group of companies.

Within this group there are five companies. All of these companies are utilising the Timepix or Medipix chips that were originally developed for the purposes of CERN, for the Large Hadron Collider. And we are basically finding new applications for this technology that was originally developed for fundamental physics.

These applications are really various and rich. We are using it for non-destructive testing as an advanced X-ray imaging camera. We are using it—

Interviewer: CT scans? For CT scans, X-rays for medical?

P2: Yeah, CT scans, radiography and many other methods of imaging through objects, where we are taking advantage of unique features of the single-photon-counting technology itself.

There are other applications in medicine, for example to make radiotherapy of brain cancer more gentle. We are just looking at the particles and secondary particles, just like they are looking at them in the LHC, but we are looking at these collisions and this secondary radiation that is created within a patient's head instead of in the LHC.

There are applications in art authentication, because we are scanning statues and paintings and looking at the bottom layers of the painting, determining the chemical composition of the paints. Therefore, it can serve as an authentication tool for historical paintings.

We are using it in space, because our detectors are quite widely used in space. We have several of them on the ISS. We are part of the Lunar Gateway Station project, which is the future space station orbiting around the Moon, and we are installed on several commercial satellites and so on. Why? Because we are looking at the cosmic radiation up there. And again, we can determine not only the overall dose of the radiation, as is usually done, but on top of that we can determine what exactly each particle is. Every single particle can be characterised, and every single type of particle has different effects on electronics in space and on human health in space. Therefore, it's quite important to know the composition of radiation.

And last but not least, there is of course a big application in electron microscopy, because electrons again are particles, and we work as a camera component in electron microscopes to make pictures in electron microscopes. We are collaborating with some of the major producers of electron microscopes in the world.

So very briefly, that's the group, that's the Advizioni group, and CERN Medipix spin-off is one part of them. CERN Medipix spin-off is responsible for the actual manufacturing of

the detectors, for finding some applications and marketing them. And then, if there is an application that has real potential, a subsidiary company is established – for example for non-destructive testing, for medicine, for electron microscopy. We have different companies that are focusing on specific applications.

But overall, the technology that was originally developed at CERN to study the meaning of matter is now serving almost everywhere, quite successfully. And that's CERN Medipix spin-off.

Interviewer: Very nice. Very, very nice. Very lovely actually. Very nice company to work at, very nice group to work in, very interesting and impactful. Great.

I will tell a bit about myself so it's a bit interactive, so you at least understand who I am and what I'm doing besides the university. I'm from sales, I'm a salesperson. I'm working in sales, I'm working in aviation. When it comes to marketing for myself, I'm very interested, I have understanding, I'm doing some startup side hustles.

For marketing I have understanding, but when it comes to the scientific side, when it comes to science and to CERN, I was all around like: "What are they talking about?" I have no clue, no understanding. And even with knowledge of sales and marketing, it would be very difficult for me to transfer this to something valuable for general people who, as well as me, don't have understanding.

So my question out of this: are you a science guy or just marketing – you just have understanding of it?

P2: Definitely I'm not a science guy. I am a former journalist. I've been working 15 years as a journalist, mainly in television, and quite a significant part of these 15 years I was a member of the scientific team in Czech Television. Czech Television is a public broadcaster, and we actually made stories about science. This is everything you can imagine: from biology to chemistry, physics, sociology, whatever. I was making stories about science.

That's my background. And then, as many former journalists, I turned to the other bridge, to the other coast – and this is CERN Medipix spin-off. Originally I was responsible for PR, public relations, in CERN Medipix spin-off, as a former journalist, but over the years I also became responsible for marketing. So I'm not a scientist at all. I have education in journalism, but I always loved science, and my current position is a nice blend of communication, science, physics. That's why I'm hopefully here.

Interviewer: OK, cool. Nice to know. OK then, let's start. Let me just open my interview questions. There will not be many of them, ten. They're pretty interesting. We already did two interviews. One of them was with a founder from a spin-off involved in similar work, I think for CT scans, this market things.

P2: Mm-hmm. Yeah, this is the CERN Medipix spin-off project, right?

Interviewer: CERN Medipix spin-off project, yes. Perfect. So the first question will be about branding and its impact. Many researchers say that branding helps deep-tech projects build trust, explain complex ideas and attract investments. Based on your experience, does branding really help with these things? Can you give me an example?

P2: What do you mean by branding?

Interviewer: By branding, I mean, for example, when we are talking about some scientific things like researching the particles and bringing it to some product that you would already sell on the market, so you can make a brand out of it to sell it. So kind of branding, marketing – pretty different meanings, but pretty much the same idea.

P2: All right. Yeah, definitely. If you want to spin off a scientific project, you have to have a company, and then you have to have a brand. Without a company it's almost impossible to sell products, mainly because of legal reasons. As academia, as scientists, you usually are not allowed to make profit. You are there to make education or science. So if you want to create profit, you have to establish a company. That's the first reason why branding is necessary for any kind of market arrival or commercialization of technology.

Interviewer: Deep-tech projects – like we're talking about deep tech startups or projects. So it's very important, crucial for them?

P2: Yeah, that's crucial for them. CERN Medipix spin-off itself is a university spin-off. It was originally a team of scientists working at a Central European technical university. As scientists, they were also involved in CERN, in the research of Timepix and Medipix. And then, when it became quite easy to see that this has commercial potential, they made a spin-off of the university.

In the first years, what's interesting, almost exclusively their customers were scientists again. So they made a brand, they made first models of photon-counting cameras, and they sold them back to academia for other projects.

Originally there was an idea that this technology would be used in medicine, especially for radiography in medicine. Nowadays, 15 years later, it's one of the fields where it is actually

not used very much, because medicine is a very legislatively complicated field. So industry can use CTs or radiography and can adopt it much easier.

So the establishing of the company, the spin-off, was essential. Without it, they could never do it, as I mentioned.

Interviewer: Good, thank you very much. So as I understood, the question is asking: can marketing and branding help deep-tech projects to build trust and explain complex ideas? Because when we're talking again about scientific things, it's pretty complex for general understanding. So how can branding help to explain this complex idea in a more simple way? Is branding something that is needed, or would it be OK just with actions, without spreading the word, without PR?

P2: Yeah, definitely. The branding and the language within the scientific community and the commercial community is very different. Scientists are asking how it works, and they don't really care about reliability or what it is for. On the other hand, the commercial environment is not asking how it works, they don't care – they care about how they can benefit from it. What problem can I solve with it? How can I save money using your technology? Where is the benefit?

So you are totally changing your language. You stop explaining the processes behind what's happening in the physics; you are explaining how anyone can take advantage of the technology. You are much more aiming at telling case stories: how it could be used in real life. You show results – how the pictures look like. Basically you are not explaining the science behind it as you would explain it at a scientific conference.

And then you have to explain the return on investment to every customer – how their investment into your goods will return. That's really important. So we are basically in our marketing trying to tell stories of our customers, success stories of our customers who use our technology, and show how they use it. Hopefully other customers will be inspired and will acquire it as well.

So it's very different. And the world of science is still a big part of CERN Medipix spin-off, because, you know, we have about 60 employees and maybe 12–20% of our employees are scientists – full-time scientists. We are still innovating, still looking for new applications, still working not just on the hardware but also on the software, because the software is the heart of it.

So yeah, I hope I answered your question.

Interviewer: Yep, more than yes. Very openly and clearly, thank you.

The second question is about different ways to do branding and marketing. This is important to explain to investors and to bring awareness. So: using visuals like logos and colours; telling stories, as you already mentioned, success stories; linking the mission to health or climate; or using the CERN name, which is also interesting – how does it help using CERN's name in branding?

Which of these have you used? We already know that you use telling stories and linking mission to health – that's your mission oriented. For example, did you use special logos or special colours to attract? And did you use CERN name in your project?

P2: Yeah, we definitely use CERN name. Not in our brand name, but if you look at our website, for example, you can find the CERN logo right on your site, and it's actually on every subpage as a partner. CERN is very important, and we have to do it – but even if we didn't have to, we would, because CERN is an institution of respect and authority.

And the second part of the question, about colours and so on – we'll get to it.

Interviewer: The third question is related. You said that CERN has a very strong reputation – on the market and in the scientific world, and generally in the world. So does CERN help to bring new technologies to the market today? And do you think CERN could be a bit of a disadvantage, because some investors could be sceptical about investing in something "from CERN" – as CERN and science don't really care about money? So that could be tricky for them. Do you think CERN could be a disadvantage, and does it still help bring technologies?

P2: I don't think that CERN could be a disadvantage for us, being connected with CERN. We are not fully independent yet – we still pay some licenses, some fees to CERN because they have the IP of part of our technology. But we are independent, we are a purely commercial company, and I don't think anyone will change their mind because of CERN.

And of course CERN is still taking care of propagation of our story and also of all similar companies that grew from their ground. We are not the only example, as you know, and CERN is trying to support them, trying to re-sell our stories and their stories. They are basically flexing with our successes, and that's very cool and nice.

They have also a specific organisation for this. The Medipix collaboration is taking care of it. The CERN Knowledge Transfer Centre is the institution whose main goal is to propagate what applications have emerged thanks to their fundamental technology.

And you already asked about colours and logos. Yeah, of course we have logo and colours, and actually we just rebranded some of our products recently, two weeks ago. Two weeks ago we used very technical names. For example, "Widepix L2 5MPX3" – this was our product. Now it's Widepix Chromatic. We made it much simpler.

On the other hand, from the first sight you cannot see technically what exactly it is, so we are trying to find a balance.

Interviewer: Yeah, sounds like a robot name to me from the first view.

P2: Yeah, yeah. So we are trying to come towards commercial customers who need easily memorable names, not "MPX3 L2 5". "Chromatic" – that's it. And that's maybe again one difference between academia / research and commercial life.

Because customers really don't care how it works. They need results, and we need them to remember our products and their names. Therefore we decided to make the names simpler.

Interviewer: Yes, but that's also some kind of marketing and branding, because by doing this you simplified the name and you simplified the general understanding for people who don't understand all those "T" and "X" and slashes.

P2: Yeah, exactly. It definitely backfires during the rebranding, because for example some of our products are still for academia – our researchers are still about 40% of our revenue – and for them, for these customers, the details are important. For example, our product which was usually called "Medipix TPX3" has a long history in research publications. If you look for this name – Medipix TPX3 – you'll find hundreds of research papers in various journals.

For our customers from the scientific field this is very important. It's important that someone used this tool to measure something. This is great.

Interviewer: It's very difficult to be on both sides. You need to cover the commercial side, but at the same time a very big piece of your pie is scientific, and you can't just give it away. Very interesting actually. We didn't meet this situation before in interviews, so it's valuable to think about.

P2: Yeah, yeah. For us, for example, you can imagine that you release a press release or a mega campaign, emailing or outdoor. This is nice. But for us, if someone publishes an

article in a peer-reviewed journal using our device for some cool results, this is even better advertisement.

So as you said, it's difficult to blend these two worlds, but there is one important point: the science customers will never scale up. If you are a scientist, you buy one or two detectors and then you play with it, you do some research. But if you are a commercial producer of an analytical device, for example, you will buy hundreds of them, because you base your new product on it.

So the scale of science is linear. The scale of commercial OEM customers is exponential. Therefore it's important to go towards the commercial customers mainly.

Interviewer: OK. The next question is pretty interesting to hear from your perspective. Have you ever had trouble explaining a technology to investors or partners who don't have a scientific background? And how did you make it easier for them to understand?

P2: Yeah, definitely. Every day. That's the issue. And what is very complicated for us is how broad the field of applications is – where it can be used.

So this is everyday struggle: to explain what it does, how it works. But then at the end of the day, the customer wants results and wants reliability. You can produce a nice device working in a lab, but the same device has to work in harsh environments, somewhere in a factory or on the Moon – anywhere. And reliability is what makes a prototype different from a serial product.

So we are all the time working on reliability, and we are explaining how we managed to make the product reliable for mass production in a factory, more than explaining how it works physically.

Interviewer: OK, understood. Next question. In deep tech, branding is often used to build trust, especially when technology is new or uncertain. Have you seen this happen in practice?

P2: Yeah. My boss, the founder of CERN Medipix spin-off – they are using the term "half-time of understanding". You know, the "half-life of an atom" is a period after which half of the atoms will split. This is a physics term, and we are using it as a "half-time of understanding": how long it takes for the general public to understand a new technology, to understand its benefits.

In our case, we are counting these half-times in 10 years. You have to do 10 years of evangelization – travelling across the world, showcasing all the time again and again – and

then maybe after 10 years the market will understand the advantages. That's how long it takes. That's the case for CERN Medipix spin-off.

Interviewer: How many years did it take for CERN Medipix spin-off? Five years, ten years?

P2: We are 13 years on the market, and in some applications it was faster, but in some applications it's still not done. We were established in 2013, so it's 12–13 years.

Interviewer: So you not only saw it in practice, you lived it in CERN Medipix spin-off. So to build trust, time is what is needed.

P2: Yeah. And then there come very unexpected paths. For example, you are showcasing nice pictures for radiography. The features of the picture are 10 times better than what the industry uses, but they answer you: "OK, that's very nice, but we don't need it. We don't need such resolution. We have our norms, our rules, and according to these rules what we are using now is enough. You don't need this detail. Why would we need to see it? It's too much."

But then technology goes on, and for example you are developing new lightweight materials like composites, or new alloys, new methods – and suddenly you need something as detailed as we can offer. And then they turn back to us and ask for our technology.

Interviewer: You pretty much explained the same thing I do on a daily basis at my job as sales in aviation. I sell software where they can search for aviation parts. When I come to a company, they tell me: "We already have our terms, we already use something. Your company is good, but we don't need it." And then when the right time comes and they really need it, only then they come back. It's just general human psychology.

P2: Yeah, yeah.

Interviewer: We are psychologically adjusted to our old things, and we're used to doing the same.

P2: Yeah. But your first visit to the company was not a waste of time. You just have to wait, because you are written somewhere in their mind. They remember you, and when they need, they will come back to you. So it's about patience also.

Interviewer: Yeah, patience is needed very much. OK, perfect. Then let's go to the next question with the investors.

Interviewer: In your opinion, how do investors or external players usually see CERN technologies? Does good branding change how they see risks or potential of the project?

P2: I hope so, because I'm personally responsible for the visual identity of CERN Medipix spin-off, and obviously if an investor is thinking about giving you money, they do very deep due diligence. They look very deeply into the company, at the financial situation, everything like that, mainly. But from my point of view, this is step five or six – the deep analysis.

Step one is that they are just looking at the company like a normal person knowing nothing. And if the first impression is really bad – like they look really bad, the logo looks like it was made in MS Paint, or the website is really outdated, or their social networks are not active – that's a red flag. You are looking at a company that has a social media account and they have no post for three months. That's a red flag. "I don't care about this company, I will not look deeper into it."

So therefore I hope that investors or customers – whoever you name – the first impression is very important. Then obviously they look deeper at what you are doing, what's the quality of your product, and what's your financial situation. That's necessary. But the first impression is like the first gate, the first door, and it has to be open.

Interviewer: OK, I see. Thank you very much, nice answer. Then, the four questions left. I don't want to take a lot of your time because it's already Wednesday evening.

Have you ever framed a project in terms of a bigger mission – you're already doing it – like solving a health or climate problem, to help people understand or support it better? Did it help? I think this is your job: to help people understand how this is important for health problems.

P2: Yeah, definitely. We are using these stories every day, these big ideas. For example, regarding the space project: we are using our technology for space weather monitoring, and space radiation is one of the most frequent reasons why up there some satellites or even people are damaged. Whenever a satellite is damaged, you cannot manoeuvre with it and then it becomes space debris. If there is too much space debris, then space flights are impossible, because orbital space is then crowded with this rubbish.

So we are actually helping humankind to go to space, because without radiation monitoring some missions would be impossible. That's about reliability of our detectors.

Regarding medical applications, it's quite obvious. For example, we have a project, as I mentioned, for making radiotherapy of brain cancer more gentle. We are helping doctors to

reduce side effects of radiotherapy. Nowadays, if someone is under radiotherapy of their brain, there could be side effects such as memory loss or vision loss. With our device, you can aim the therapeutic beam more precisely to the tumour and not damage the healthy tissue of the brain. Therefore you save the healthy tissue and save the patient's quality of living.

Interviewer: I see. So this bigger mission idea – that we are helping with cancer or helping with space problems – helps people become more warm to it, because they think: "Yeah, I'd also love to be part of saving the world." Understood.

P2: Yeah. And what's very important marketing-wise is that you can find these bigger missions in whatever product you are doing. For example, you are producing just nails or screws – but you can say: OK, our screws are just screws, but these screws are installed somewhere where it's really important; they are holding a bridge, and the bridge would fall down without us.

You can find a bigger mission everywhere. And it's also very important insight for your internal communication, because the employees need to feel a legacy.

Interviewer: That's the next question actually – about internal processes. Inside project teams, do people usually agree on how to talk about the brand and the technology, or are there different opinions between scientists, engineers, business people?

P2: It's very different. It's very different. There's a sort of internal battle running all day, because everyone is underlining something else. And me, as a marketing guy, I have to overlook. Some things I have to simplify. I have to say, "OK, this is not perfect, but we will market it anyway." But the engineers and researchers are very... they want to have everything perfect.

Interviewer: They're looking for technical perfection. Yeah, very true. So in some way you need to agree, all of you.

P2: Yeah. And then, of course, there are also some features – we are working on a new feature of the product and it's not done yet, but we already have to market it. Because in the future it will be included. But the researchers or the engineers are nervous because it's not ready yet. "Do not tell people it's there, it's not ready." But that's the whole purpose of marketing: to tell people it does something, although it's not ready yet – it will do it in the future.

Interviewer: OK, OK. What is interesting for me as well: do you think having an online presence like a website or LinkedIn page helps CERN technologies or spin-offs get more attention or trust? Maybe any examples – for your company, is it essential to have a LinkedIn page?

P2: Yeah. A web page is essential; you have to have a web page, you cannot live without it. And LinkedIn – if I can compare social networks – for us LinkedIn is like 100%. Twitter or X is like 10% importance. Facebook is like 3% importance. Instagram is like 10% and growing. But as you can see, LinkedIn is the core of it, because LinkedIn seems to be a very boring network, but in our field it's important.

Interviewer: Understood. And what about: is it difficult to transfer this idea on the site – how to transfer a scientific idea into words in social media? Because nowadays social media is very fast – you should attract attention very fast and quickly. To explain something scientific very quickly – is it possible? If yes, how?

P2: Yeah. We are very into videos. We are trying to make videos to explain things, because you can explain much more content in 10 seconds of video than in two pages of text. And no one will read the text nowadays.

So we are trying to take advantage of audio and video. On social networks we are not really explaining how it works – we explain it on our website. Sometimes there are links to more detailed versions. On social media we are showing more or less the results – for example, what conferences we are attending so people can meet us, or showcasing some videos.

We also have a podcast called "Unseen Talks", because we are CERN Medipix spin-off – "imaging the unseen", that's our claim. So we have "Unseen Talks" on YouTube, you can find it. We use it to invite our customers and tell their success stories with our product. So again, we are showing success stories of our clients.

We don't have many followers, but yeah.

Interviewer: Loyal followers are good. Three thousand on LinkedIn – LinkedIn is pretty difficult social media. Let's go, it's very difficult, very nerdy.

P2: Yeah, very expensive also.

Interviewer: And the last question is more or less your personal view. If you could suggest one thing to improve branding or communication specifically at CERN for commercialization of technologies, what would it be? How would you change it? How could they help commercialization even more? For example, for companies like CERN Medipix spin-off?

P2: OK. So, well... I guess they are trying to showcase the companies involved – the companies that are spin-offs of CERN. On the other hand, they are still using the measures of

scientific results to evaluate what the company is doing when they are reasoning whether to propagate your result or not.

For them it is important: "Was it published in a journal? Was it already at a conference? Is it proved?" Those are their first questions. They don't ask "How many pieces have you sold?" or "Who are your customers?" or "Give us a story of commercial utilisation." They are asking: "Is it published?" From my point of view, that's something that could be improved, because they are looking at it from the point of view of a scientist. For a scientist it is very important whether it was published and how many citations it has.

Interviewer: And maybe nowadays it's not very... like nowadays it's still needed, but...

P2: Yeah, they are still asking. For example, once a year they write us an email asking for stories, and we share with them ten stories of our products – where they were used, what research was done, what projects are going on. And they are asking like: "Wow, this is really cool research. Is it already done, was it published?" And we say: "No, it's running a clinical trial," or "The device is being installed right now at a customer place." And they are asking: "OK, but we need the results. We need to see the results, we need to see references."

Interviewer: And as you say, there are different types of results. They are looking for results that are not really our perspective in terms of bringing it to commercial.

P2: Yeah. So if I can propose what they could improve: look less from the purely scientific perspective and promote also other successes, not only the scientific ones.

Interviewer: OK, understood. I think that would be it from the questions for the master thesis. Thank you very much – very helpful. We need to submit it already in a month, and I think, as all students, we started one month before everything, so we are a bit in a rush. We have the work and personal life.

P2: Yeah, I can imagine. I wish you good luck. And please send me the thesis once it's ready. I would love to read it.

Interviewer: For sure. Thank you very much.

Interview 3: Participant 3 — Marketing & Communications Officer, Knowledge Transfer Group at an International Research Organization

Transcript (Clean Verbatim):

Interviewer: Tell us more about your background — why CERN and why marketing?

P3: I studied business administration and management, and I always wanted to do marketing. But it's unusual to do marketing at CERN, so that was not my first option. I did an internship at CERN three years ago, and I knew about the organization. I saw this post two years ago and I applied, Knowledge Transfer, but when I was doing my internship, I didn't even know about Knowledge Transfer. The thing is, Knowledge Transfer is not even well known. If you go ask 10 people here, I doubt maybe half of them will know what we do; half of them will not even know we exist.

Initially the post was communications, but the more I did it, the more I realized I basically do B2B marketing. That's what I do every day. And yeah, that's the background part.

Interviewer: Perfect. You can continue if you want, but I will move to the questions. So, first question: many researchers say branding helps deep-tech projects build trust, explain complex ideas, and attract investments. Based on your experience, does branding really help? Can you give an example?

P3: You mean like branding helping sell a technology?

Interviewer: Yes, how branding is important to build trust between investors and the buyer.

P3: For CERN it is very important, because CERN is an organization that exists for 70 years. Knowledge Transfer exists for 35 years. There are other communications and marketing teams at CERN, but we are the only people who do marketing more than communications. The other teams really only do communications, and their target audience is the general public — students, parents, teachers — with the objective to create awareness about CERN and what scientists are trying to discover.

Interviewer: And what you are doing is more like digital marketing for B2B?

P3: Yes. My group is called Knowledge Transfer within the Industry, Procurement and Knowledge Transfer department — IPT. We are placed under Industry because we interact with industry.

The CERN branding built over the years gives a strong base — people know CERN — but this branding was not adapted for us. Knowledge Transfer existed for decades, but only two years ago we started having a proper social media presence. Before that we were using CERN's main LinkedIn, Instagram, Facebook, because in this administrative environment, it's hard to get approval for new ideas. You cannot just say "let's create a LinkedIn page" and have it tomorrow. It's a long process.

So they told us, “Use our channels first and see how it goes.” We used them, and it created some awareness, but the audience was completely wrong — not B2B at all. It was general public, students, people we were not targeting.

We realized quickly that this branding and this audience were not correct. So we created our own LinkedIn channel, and we defined the target audience as C-level executives, CEOs, CTOs, innovation officers, managers, decision-makers from industry. This was very new for CERN as well.

We started posting very different content — business-oriented call-to-actions like “partner with us”, “apply to the program”, things like that. CERN’s main communications do things like “did you know...?” or “read more...”. More educational. So yes, branding is extremely important. Branding is everything.

Interviewer: In the second question we also ask about different branding elements like visuals, storytelling, mission connection. Which ones does CERN use, and what works?

P3: So, LinkedIn. Knowledge Transfer is active in six application areas — environment, digital, quantum, healthcare, and others. Our LinkedIn banner includes all these areas, and it’s very different from the general CERN branding. It’s really our own identity.

We also started having presence in the entrepreneurial ecosystem with the CERN Venture Connect program.

We use our own calls to action, our own tone. It’s promotional, business-oriented. We want people to sign contracts with us. Meanwhile CERN’s main pages speak to the general public.

LinkedIn is our main platform. We’re not active on others. Sometimes, when we need wider reach, we ask the general CERN communications team to post on Facebook or Instagram, but they adapt the content for those audiences.

We had Twitter/X for Venture Connect but stopped — we didn’t see enough value.

Switzerland is only one of our countries. We target all CERN member and associate states. It’s challenging because we target huge, broad audiences: all innovation-relevant job titles across all member states. It’s a big audience, and you cannot be too broad either, because it becomes ineffective.

Interviewer: It’s impossible to be specific with such complex technologies.

P3: Exactly. We also send a newsletter four times a year — so we do email marketing. And we do a lot of video marketing because it's the best way to explain complex technologies.

Interviewer: How does Knowledge Transfer work? As I understand, CERN and Knowledge Transfer are different and the same at the same time?

P3: We are CERN. We're not separate. The difference is the target audience. We do internal communication to bring CERN technical experts to us. Think of it as supplier and demand: the suppliers are CERN scientists and technical experts who create technologies.

We don't invent the technologies. Scientists develop something for the LHC or experiments, and either they come to us or we go to them, because sometimes they don't know we exist. They don't always see the societal potential of their work.

A big part of our job is helping them see that potential. For example, many cancer-related technologies at CERN were originally developed purely for particle physics, not healthcare. Later, we realized they could be used to treat patients. So we partner with hospitals and transfer these technologies.

Interviewer: How does CERN's strong institutional brand influence how external partners perceive new technologies? Does the CERN name help or slow things down?

P3: It definitely helps. We hear from partners and startups that CERN gives them credibility. Having "CERN" on a website helps them open doors, get into networks, get new opportunities. Some startups in the Venture Connect program say that thanks to CERN, they gained contacts they otherwise could not get.

The technology doesn't stop when CERN gives it to partners — they develop it further for their needs. But yes, the CERN name helps tremendously.

Interviewer: How do you simplify complex scientific technologies for the public or industry? For example, people like us — we are not scientists.

P3: You are more the target audience of the CERN general communications team, yes. But industry is similar — most industry people don't understand particle physics. It's normal.

Video marketing works the best. Showing things. Letting the technical experts talk. Letting partners talk. Giving a face to a complex technology.

When I write articles, I need a journalistic approach. Scientists assume I understand everything, but I don't have a scientific background. I ask them to explain simply — but they are in their own world, so I need to ask the right questions to get what I need.

We bought a camera two years ago and started creating videos. I think more than 30 so far. Visualization makes it more digestible. People understand better when they see.

Interviewer: So video marketing is important.

P3: Yes. And people are surprisingly open to talk.

Interviewer: Can branding or communication reduce skepticism or uncertainty? For example, for investors or regulators?

P3: So, we don't really have "investors" because CERN is funded by member states. But in general, yes, branding helps people understand and trust the technology. If a technology is from CERN, people know it's good and supported.

A lot of our contracts come from word-of-mouth — one partner had a good collaboration and told others. But nowadays, without digital presence, you basically don't exist. Marketing is mandatory. It's the only way to let people know what we do.

It's telling that Knowledge Transfer existed for 35 years, and only the last two years, with proper marketing, brought almost the same level of visibility as the previous decades.

Interviewer: Do people inside CERN agree on how to talk about the brand?

P3: Marketing is not very well understood in scientific environments. Scientists usually do communication themselves through papers, so having a marketing professional is new. Some people still don't understand what we do or why we do social media.

CERN is also very political. We deal with countries. Everything must be checked, approved, politically correct. I cannot publish anything without approval. If something is slightly wrong, it can have political implications.

So yes, the process is slow. Much slower than in private companies.

Interviewer: Does having a website or LinkedIn help technologies or spinoffs get attention?

P3: Yes, definitely. We had no visibility before. Now the LinkedIn grew fast — from September 2023 to now we have around 12,000 followers. That's good, but still small steps.

Our website is outdated and partners struggle with navigation. We are rebuilding it with SEO and better structure. Articles are important to build our brand reputation online. We cannot rely on CERN's main communications because that audience is not for us.

For general CERN communications everything works great — visitors, awareness, public outreach. But Knowledge Transfer has a lot of work ahead to increase partners and visibility.

Interviewer: If you could improve branding and communication at the organization for commercialization, what would you do?

P3: Act immediately. Not wait. Follow digital trends. The main communications team can do it because they use Instagram and TikTok. We can't, because we are political and B2B. Even sharing an article requires long approval steps. It drains energy and slows down work.

Interviewer: If you could improve branding and communication at CERN for commercialization, what would you do?

P3: We created a visual identity based on the application areas. But the most important part was defining the audience — decision makers. Before that, we relied on CERN's general audience, which was a mistake.

Interviewer: Do you think CERN will eventually embrace full branding and business communication?

P3: If we continue like this, yes. More partnerships, more awareness. Two years of digital work already made a big difference.

Our job is to make technologies understandable to innovation-oriented companies in member and associate states. Knowledge Transfer's mission is to create impact on society, not money. We work with industry for societal benefit.

Interview 5: P4 — Knowledge Transfer & Communications, CERN

Transcript (Clean Verbatim):

Question: Many researchers say branding helps deep-tech projects build trust, explain complex ideas, and attract investment. Based on your experience, does branding really help with these things? Can you give an example?

P4: I'm basing this answer both on my experience of working at CERN and my previous work as a journalist reporting on science/tech policy.

Undoubtedly, having a good brand alongside a new technology helps open doors to meetings with potential investors and can — depending on the technology — prepare future users for its adoption. But there is also a danger: a very strong brand attached to a weak or implausible technology (for example, Theranos) can be misleading.

At low technology readiness levels (TRLs), a very basic branding package — even just giving the technology a name — is usually sufficient. As the technology progresses and moves toward larger investments (e.g., from seed to Series A), stronger branding becomes more important.

Question: There are different ways to do branding — using visuals, storytelling, mission framing, or CERN's name. Which have you used or seen at CERN? Which ones work?

P4: CERN's Knowledge Transfer mission is not necessarily to commercialise technologies. Often the goal is simply to bring the technology to society, whether through licensing, joint R&D, collaboration agreements, or open access.

One example is the FLUKA software, which has its own branding style, name, and visual identity. It is widely used in niche areas, but its adoption comes primarily from the quality of the technology rather than marketing or branding efforts. More branding could perhaps increase adoption, but that is not always CERN's priority.

A strong product does require some branding to succeed, but strong branding cannot compensate for a weak product.

Question: Does CERN's strong reputation help when bringing new technologies to market? Can it ever be a disadvantage?

P4: Our impact study showed:

- A majority of respondents said CERN's collaboration helped them increase sales or obtain additional funding.

- Many emphasised that CERN's reputation gives market trust, increases visibility, and makes organisations more attractive to talent.

- Others said working with CERN improved credibility for their long-term vision and even helped sell existing products.

Overall, CERN's reputation is overwhelmingly beneficial. If there are disadvantages, they are minimal in comparison.

Question: Have you ever had trouble explaining complex technology to investors or partners without a science background?

P4: CERN's communications and marketing teams do not aim to attract investors for technologies. Instead, they aim to attract industry partners who want to bring the technology to society — not necessarily through commercialisation. So in that sense, the answer is no.

Explaining complex technology to a general audience is always a challenge. The right approach always depends on the audience and the communication format available.

Question: Has branding helped build trust in deep-tech cases you've seen?

P4: A relevant example is the CERN Venture Connect portfolio. Some technologies there have stronger branding than others.

It is difficult to say whether branding directly increases trust — from a CERN perspective, trust usually comes from the strength of the product. But if I were an individual inventor building a new technology outside CERN, I might have a stronger need to build a brand early.

White Rabbit is a popular technology with a strong brand, but I cannot comment directly on whether the brand itself created trust.

Question: How do investors or external partners usually see CERN technologies? Does branding change their perception of risk or potential?

P4: Based on the same impact study, CERN technologies are generally perceived as credible, high-quality, and trustworthy. Branding plays a role, but the core driver of perception is still the strength of the technology and the reputation of CERN.

Question: Have you ever framed a project in terms of a bigger mission — health, climate, etc. — to help people understand or support it? Did it help?

P4: A relevant example is the CAFEIN platform (federated learning). It can be used for many different applications, but the developers deliberately chose to apply it first to stroke treatment through two EU-funded projects.

This framing — using healthcare as an example — made it easier to explain the technology. It was not driven by the Knowledge Transfer or marketing teams, but it helped position the technology within a meaningful context.

The goal is not to sell the technology, but to help society. The communication is therefore aimed at potential users (e.g., hospitals) and at industry partners who might be interested in applying the technology.

As it becomes used in more fields, examples like this will help illustrate its value.

Question: Within project teams, do people usually agree on how to talk about or "brand" the technology? Or are there different opinions between scientists, engineers, and business people?

P4: There are always different opinions.

Question: Does having an online presence — website, LinkedIn — help CERN technologies or spin-offs attract attention or trust?

P4: Some online presence is necessary today. But CERN's goal is not to attract "more customers" in the commercial sense — instead, it aims to find the right partner for a given technology.

I'm sure that today it is a necessity to have some sort of online presence. But again, CERN isn't trying to get more and more customers to adopt a certain technology, but rather looking for the right partner to use a given technology for the betterment of society. A lot of this happens through the work of CERN's knowledge transfer officers (KTOs), who build their own network of industrial partners. The KTOs play a very vital role in getting CERN tech to society. First of all, they are the experts on the capabilities of the technology, so they know what it does and how it can be used. They identify possible business cases for the technology — it can be unexpected, but I can't think of any examples that are not confidential at the moment — and then approach a company working in that field to see if they might need the tech. It can also happen more organically where a KTO meets a company representative at a conference or event and they realise that there is a common use for a certain technology, or even just CERN expertise.

Key takeaway — CERN isn't necessarily trying to get more and more innovation partnerships, but rather is looking for the right partnerships. In that sense, we're not really interested in advertising tech to anyone, but often take a more targeted approach based on what we already understand about a technology's capabilities.

LinkedIn / websites can be useful for finding go

Interview 5: P5 — CTO & Co-Founder, CERN Medipix Spin-off (Bioimaging)

Transcript (Clean Verbatim):

Interviewer: Apparently, when we came to CERN, we had already spoken to a few people and they told us that CERN is not really focusing on marketing and branding, it's not really what they're doing.

P5: Yeah, that's sort of true. They actually have quite a big effort, not so much for the technology, but for the institute. They have a big push on reputation and branding because they're not selling things to consumers in the normal sense — but they are effectively "selling" to the European governments to get a billion a year.

So marketing and branding are very important. They need the European countries to support them. Their logo is important, people's opinions of them are important. It's just that they're not selling a product in the traditional consumer sense.

Interviewer: So, for our research, we constructed ten questions, and we would love to record the interview if you're alright with it, because we're going to transcribe it and use it in our research. Can we start?

P5: Of course.

Interviewer: Thank you. So I'll start. Thank you for joining, first of all, we really appreciate your time. If you could tell us a bit: what are you doing, generally, what is your company?

P5: I'm the Chief Technology Officer and one of the founders of a spin-off company. We're taking high-energy physics technology to the medical market, in particular around imaging, and more particularly around spectral photon counting.

Interviewer: And what is your main responsibility?

P5: It's evolved a lot over the years. Early on, it was about proof-of-concept and demonstrating that the technology would be valuable. Nowadays my role is different because the company has grown quite considerably.

As CTO, my goal is to guide the company on the future product roadmap and the markets that the technology will address. I keep an eye on what adjacent technologies there are, relationships with customers, relationships with investors – but all from the technology-founder kind of perspective.

I've often heard it described that the founder is the heart of a company, but it's actually everyone else who makes a company work in the same way as a body. If you take out the heart, you have something that's sort of very functional, but most founders need the support of people who have all the complementary skills: marketing, finance, compliance, all of those kinds of things.

Interviewer: It's not a formal question, but generally – how do you see the role of marketing in a startup or company in medicine?

P5: Marketing in the broader sense is absolutely essential, particularly for deep tech. For what we're doing, we need high-profile customers and partners. For example, we work

with a major hospital in New York. We wouldn't have got through the door of a hospital like that if we didn't have the appropriate marketing and branding.

And I don't mean just marketing collateral. I mean the logo and, more importantly, the perception of us and our technology – that's what got us through the door and into the discussions. The perception of who we are and what we deliver is absolutely critical.

Interviewer: So, based on our theoretical part, many researchers say that branding helps deep-tech projects build trust, explain complex ideas, and attract investments. Based on your experience, does branding really help with these things? Can you give an example?

P5: Yeah, absolutely, it does. To me, branding is the name and the logo, but, as I say, it's more the perception that you need to have in the person's mind.

We have sold research scanners against a number of high-profile institutes around the world. To even start conversations with those customers, they need to be aware of what we do, what we deliver, and the quality of our technology. So, in that sense, branding is essential: people have heard of our brand.

The company has been around for a long time within the research market. People I've never met have heard of us. I've emailed people and they say, "Oh yeah, we've heard of you." In that sense, branding and marketing are absolutely critical, because I know that we're dealing with leaders in the field, key opinion leaders, and they have to have heard of and understood what we do before we contact them. Otherwise, you simply won't get a response.

Interviewer: Yeah, because I'm in sales, it's my day-to-day job – I annoy people with emails and calls.

P5: Yeah, yeah. And early on in this phase, we're not trying to sell to a thousand customers next week. We're trying to pick out the key opinion leaders in the field. So it's absolutely essential that those key opinion leaders have heard of us. That means they need to have a perception of who we are and what we deliver before we turn up.

Interviewer: So it's not really B2B then?

P5: No, it's not really B2B. Our customers are hospitals and research labs.

Interviewer: B2G, more or less?

P5: B2...?

Interviewer: B2G – business to government.

P5: Yes, sometimes. Although many of them are private institutes. So they're universities, hospitals, that kind of thing. In the U.S., a hospital is often a business; in Europe, a hospital can be a government entity. It depends whether it's a private or government hospital.

Interviewer: There are different ways to do branding: using visuals like logos and colours, telling a story, linking the mission to health or climate, or using the CERN name. Which of these have you used or seen at CERN, and which one actually works?

P5: We use all of them. The CERN reputation is obviously very critical for the reputation of our products.

Our brand name was actually developed by someone who was a marketing manager at a major pharmaceutical company. They deliberately chose a name that sounded medical and futuristic and aligned with things like MRI, CT, ultrasound – so short and sweet. They came up with that as a specific medical marketing branding person.

Our logo was designed by a design agency in another country. They went for three coloured triangles. I'm always intrigued when people say how that fits with what we do, because it actually went the other way around: we found something that looked good, and then people started associating it with us.

So the marketing and branding really worked. I've been staggered to turn up at large conferences – you know, 40,000-people conferences – and people are aware of who we are, what we do, and they recognise our logo.

Interviewer: You already partly answered this, but: do you think CERN's strong reputation helps when bringing new technologies to the market? And does it have disadvantages, or is it always helpful?

P5: It has a huge amount of value in terms of quality and novelty. Because CERN is essentially an academic institute, that does have some hindrances too. But in terms of novelty, quality, and being a world leader, it's absolutely out there – almost unbeatable.

Interviewer: CERN has a strong reputation, but what comes to my mind is disadvantages: for some investors or people, CERN might be scary because it sounds difficult.

P5: Oh, absolutely. Over the years I've certainly spoken to investors who will not work with an academic institute.

Interviewer: So that would be one of the disadvantages?

P5: Yeah. Sometimes it's "too complex", and timelines are slow.

The motivation for an academic institute doing commercialisation is very different from the drivers of a small business trying to commercialise. CERN has a reasonably good reputation compared to some, but this is a general issue.

We were associated with a university in another region for a while. There were a number of investors who just said, "I won't work with universities. The IP is too insecure. The processes and contracts are too slow. There's too much uncertainty."

Quite reasonably, they look at an academic institute and say: the academic motivations are very different from business motivations, so there's always going to be misalignment.

Interviewer: Because I think some investors understand that CERN is doing fundamental research and they're not really focused on monetising all their projects.

P5: Yes. I haven't so much heard that they're "not willing" to monetise, but I've heard criticisms around timelines and priority. In any academic institute, commercialisation is a long way down their priority list, and other things supersede it. Whereas if you're dealing with a business, it's more straightforward. They are there to make profit, and if working together makes profit, then you work together. It's more transparent and clear.

With an academic institute, it's a bit more opaque, particularly to business people who have often never worked in a university.

Interviewer: Coming out of this: have you ever had trouble explaining your technology, or CERN-related complex technology, to investors or partners who don't have a scientific background?

P5: No, I don't think I have. There are plenty who don't care how it works – they're concerned about whether it does what it's meant to do and whether there is a market for it. Beyond that, they don't care how.

That's perfectly reasonable: does it work, will someone buy it?

Those who are interested in how the technology works – I've not really struggled to explain it. That may be because the people who are interested in learning have the right kind of brain to understand it.

And as I say, there are plenty of business people I've worked with who just say, "It doesn't matter. Does it work? Is there a market? Stop."

Interviewer: Generally, deep-tech branding is often used to build trust, especially when technology is new or uncertain. How have you seen this happen in practice?

P5: Early on, when we were just selling research scanners, we had a lot of users, and they were citing their work as "done on a [company name] scanner". That attracted new users and people asking, "Can you use it here? Can you use it there?"

In that sense, branding was pretty important.

Interviewer: And what about trust – how do you build it?

P5: Trust comes down to relationships. One of the good and bad things about our company is that we're selling high-value products, so you only have a few customers. You end up working with them quite closely.

A lot of trust comes from personal relationships and personal trust. If we were selling a \$10 widget, we'd have tens of thousands of customers, and the whole concept of trust would be quite different. When you have only a few customers per year with half-million to million-dollar products, there's a much more personal relationship that develops over time for each sale.

Interviewer: In your opinion, how do investors or external partners usually see CERN technologies? Does good branding change how they see the risk or potential of the project?

P5: Not so much related to branding in the narrow sense. CERN is known – and it's not just branding, it's their perception in the market. They're known as being very high-tech and very cutting-edge. That has some huge advantages, but in other areas, some disadvantages.

For example, you and I have no scientific background. When we walk around and see these reactors and big machines, it's just like: "No idea." But if it were explained more from a marketing or branding point of view – "this does X, this can lead to Y benefit, this generates money or value" – then as a person from sales, it would make more sense.

So yes, I think good explanation and framing can change perception.

Interviewer: Do you think that if things were explained in a better branding way, perception would change significantly?

P5: Yeah, I think so. One of the changes I've actually seen at CERN in the last 20 years is that they've put much more effort into marketing themselves to business.

I don't know if you were at the workshop yesterday?

Interviewer: No, we're working at IdeaSquare.

P5: Ah, OK. So yesterday the Knowledge Transfer group here talked about the number of licences and dollars of revenue that CERN has got over the last 20 years. In the last five years, it's basically doubled.

I think that's because, as an organisation, they started prioritising partnerships and commercialisation. Ten or fifteen years ago, it wasn't a priority at all. The priority was fundamental science.

One of the things that has shifted here – and they're quite open about it, it's on their website – is that they now push the message to the public that if you do fundamental research, you will have spillover technologies that help communities. I think that's a message that works really well for their branding: "We are helping the community."

You know, like NASA and Teflon – that kind of story. It's why the public should fund these high-energy physics experiments and fundamental research: because you're going to have spinoff technologies that help the community.

Interviewer: Is that particularly about Knowledge Transfer or the whole CERN?

P5: I guess it's the whole CERN, because Knowledge Transfer at CERN has grown. Their comms department has grown. They've clearly changed their own view from "the only thing we do is science" to also including commercialisation.

It's interesting they call themselves "Knowledge Transfer", not "Commercialisation Office". It's about how they get the knowledge in CERN out to the public. One way is commercialisation, some of it is training people, and they now also have quite a large programme for outreach to high schools and education. That all fits under Knowledge Transfer.

From their perspective, and as a public institution, they're not trying to say "we're selling widgets"; they're saying "we develop knowledge and we provide that to the public". For some things, the right way to do that is a commercial licence.

CERN developed the World Wide Web, and one of the reasons it took off compared to Gopher (the other protocol at the time) was that it was open and free. So for some bits of knowledge transfer, you're going to commercialise – that has the most impact – and for others there are better methods.

For a lot of deep tech where you've got a physical object, you almost certainly have to go through a commercialisation process, because someone has to pay for the object. But if you've got software code, the way to have the biggest impact might be to release it free.

So they're going through that process: how do they take their knowledge and provide it to the public in the best possible way – and sometimes that's commercialisation.

Interviewer: Next question will be a bit funny but important: have you ever framed a project in terms of a bigger mission, like solving a health or climate problem, to help people understand or support it better? Did it help?

P5: Absolutely. I have always framed the goal of the company as providing better care to patients. That's been my primary motivation. One of the metrics I would use for success is how much money we make along the way, but I see that as a separate step.

My goal is to produce a transformative technology that makes medical imaging better. As I said earlier, if you're going to do that, you're going to have to sell product. And if you're selling product, you should be making money. So I would say making money is a by-product of success.

You take the money and invest it back into making the product better. If we can't make money, then we're not doing something useful. It's as simple as that. It's not that I see money as a bad thing – it's just that, in my mind, I want to deliver a product that helps patients and doctors and makes healthcare more efficient. If you're doing that, you've got a product and you should be making money.

Someone once told me – that was a senior scientist here at CERN – "good science affects people's lives. And if it affects people's lives, it's commercial."

Interviewer: Inside the project teams, do people usually agree on how to talk about the brand and the technology, or are there different opinions between scientists, engineers, and business people?

P5: Totally different opinions. Inside the company, the branding is essentially left to the commercial/sales/marketing people. The engineers just go with whatever branding we've got.

Externally, with partners like CERN and others, people have different opinions. But it's never really been a problem; we've not had conflicts that needed to be resolved. It's not about conflict, it's just that everyone has a different opinion because everyone has a different background. Scientists see branding one way, engineers another, business people another.

Interviewer: Just out of curiosity, whose opinion fits best, in your view?

P5: That's an interesting one. Even within the commercial people I've worked with, there are different views on branding. People who come out of purely tech or finance have a different view of branding.

Our logo and visual identity, and our name, came from a professional branding person at a major pharmaceutical company. They knew the medical market they were talking to. I've heard different opinions of our logo from commercial people who say "it's out of date" or whatever. Logo is difficult.

I'm inclined to trust the person at the pharmaceutical company who's branded dozens of drugs, on how to brand in the medical market. Branding for the medical market is quite different to branding for a phone, for example.

Interviewer: These questions are very relevant in 2025. Do you think having an online presence – like a website or LinkedIn page – helps technologists and also CERN technologies or spin-offs get more attention or trust?

P5: It's essential for everybody, isn't it? I mean, who doesn't have a website?

Interviewer: For example, I work in aviation. Some companies there don't really care about having a website because aviation is pretty old and built on trust. For them, having a LinkedIn page or website is not super essential.

P5: Yeah, I think for most people we talk to, one of the first things they do is go to a website. So I think it's essential. And it's important to have a good website, too.

Interviewer: So you think it's important.

P5: Yeah. We found you even on LinkedIn, right? One of the things I know happens is: if we go and talk to someone, going to the website makes it "real". It shows that you have real products, a real organisation.

It's not just our website either. When I first started talking to radiologists in U.S. hospitals, they would have gone to our website. But I also know they went to the CERN website and validated that this is real.

It's almost intrinsic. When we first started talking to the innovation unit at a major hospital, they commented: "Oh, we've seen you on the CERN website." That immediately validated us. It's not just that we have a bit of CERN technology and we're proudly showing it – CERN is proud of us too. That mutual respect and linkage is really important. It all builds trust.

Interviewer: And the last question: if you could suggest one thing to improve branding and communication at CERN for commercialisation of technologies, what would it be? You mentioned timing.

P5: If I were at CERN, around branding and commercialisation, I think there almost needs to be an internal focus first. I think there are a lot of people in an institute like this who see commercialisation and knowledge transfer as something that shouldn't happen here – that it dilutes the science.

Not so much in the Medipix collaboration unit you're with, but certainly in other areas, people say, "We should be doing pure science." Whereas I'd come back to the statement I made earlier: if you're doing good science, you should be getting it out to your community. One of the ways to do that is commercialisation.

I've seen this at many universities: people interested in commercialisation are seen as "polluting" the science. I think it's actually the opposite. One of our board members used to work in a commercialisation office at a university. They observed that it was actually all the good scientists who had the commercial projects, because they had something that was useful to people.

So if I had one suggestion for CERN: work on the internal culture so that commercialisation and knowledge transfer are not seen as something dirty or secondary, but as a natural extension of good science.

Interviewer: I think that's all from the question list.