Navigating Civilian Market Opportunities for Autonomous Ground Vehicles

Adapting the Market Opportunity Navigator for Deep-Tech Commercialization

Master's thesis in Management and Economics of Innovation

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Abstract

Unmanned ground vehicles represent a rapidly emerging technology with potential applications across a wide range of industrial sectors. However, most current autonomous systems rely on GNSS for navigation, limiting their utility in environments where satellite signals are unavailable or disrupted. This study examines the civilian market (non-military market) for autonomous ground vehicles operating across three levels of technological sophistication, from remote control through standard autonomy to fully signal-independent navigation, with the aim of supporting strategic market selection for an early-stage Swedish deep-tech venture.

The study applies and adapts the Market Opportunity Navigator as the primary strategic framework, integrating technological sophistication as a strategic variable to enable dynamic strategizing across autonomy levels. A qualitative case study design was employed, combining two ideation workshops with twenty semi-structured interviews across eight industries, analysed through a deductive thematic analysis.

The findings identify several characteristics that shape UGV adoption across industries. Safety and operational necessity as purchasing drivers appear to accelerate adoption more than efficiency arguments. Closed and controlled operational environments reduce the effective regulatory challenge, explaining why industries such as mining and nuclear have progressed further than agriculture and construction. Organizational inertia manifests in two distinct ways depending on industry structure, and near-peer reference customers play a significant role in accelerating diffusion.

The Market Opportunity Navigator proved effective as a strategic foundation but required several adaptations to function well in this high-uncertainty context, including treating the process as iterative rather than linear, applying product fit as a separate screening step, and integrating technological sophistication as a strategic variable. The case study concludes with a concrete go-to-market strategy for the case venture, identifying a primary market within fire & rescue services as well as a parallel growth option within mining to purse now, and two backup options within mining and nuclear power to possibly pursue later.

Keywords: unmanned ground vehicles, GNSS-independent navigation, market opportunity navigator, deep-tech commercialisation, market selection, autonomy levels, dynamic strategizing.

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Elias Fredriksson & Jonathan Svensson, Gothenburg, June 2026

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

AI	Artificial Intelligence
B2B	Business to Business
CAGR	Compound Annual Growth Rate
GDPR	General Data Protection Regulation
GNSS	Global Navigation Satellite System
LiDAR	Light Detection and Ranging
LoU	Lag om Offentlig Upphandling (Swedish Public Procurement Act)
MOA	Market Opportunity Attractiveness
MON	Market Opportunity Navigator
MSB	Myndigheten för Samhällsskydd och Beredskap (Swedish Civil Contingencies Agency)
MVP	Minimum Viable Product
NEA	Nuclear Energy Agency
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
RADAR	Radio Detection and Ranging
R&D	Research and Development
RISE	Research Institutes of Sweden
SLAM	Simultaneous Localization and Mapping
SPCI	Security Protection Classified Information
SSI	Semi-Structured Interview
TCO	Total Cost of Ownership
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
VMA	Viktigt Meddelande till Allmänheten (Important Public Announcement)

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1
Introduction

This chapter introduces the technological, industrial and theoretical context underpinning the study. It traces the emergence of autonomous ground vehicles and the navigational constraints that define the operational frontier, introduces Eira Systems as the subject of the analysis, and frames the strategic approach guiding the research. The chapter concludes by defining the study's purpose and research questions.

1.1 The emergence of Unmanned Ground Vehicles (UGVs)

Historically robotics and automation have mainly been associated with closed-off highly structured environments, such as production floors where machines perform monotonous, repetitive actions under controlled circumstances. Over the last decades, unmanned ground vehicles (UGVs) have begun to leave the controlled environments of production floors to operate in unstructured environments outdoors and underground (La Regina et al., 2025). This development is driven by transformation in communications technology, digital transitions and sensor technology advancements. Together with exponential increases in computing power, advanced simulation tools, AI, and machine learning, this shift is becoming ever more of a reality in many industries (La Regina et al., 2025).

The driving forces behind industries choosing to invest in UGV and automation technology are mainly connected to safety, efficiency, and cost savings. Using unmanned systems allows for human personnel to be removed from dangerous environments, such as warzones or areas affected by large scale natural disasters where destroyed infrastructure and unstable terrain constitutes a threat to human life. This can be seen in the mining industry's "SmartMine" vision, which strives for a "zero human presence" operational model, aiming to eliminate the need for personnel to work in high-risk underground areas prone to gas leaks and structural instability (Konieczna-Fuławka et al., 2025). Beyond the aspect of safety, the technology enables a higher level of operational efficiency in environments where human endurance is a limiting factor. Thus, the trend has moved from simple remote controlled units that need constant radiolinkage and a dedicated operator, towards extended autonomy where the vehicle can make its own decision based on machine learning and sensor data.

Today, globally, UGVs are starting to be used within industries such as defense, agriculture, and rescue missions (Ersü et al., 2024). However the reviewed literature suggests that operational deployment remains limited, with most documented applications representing research prototypes or pilot projects rather than use in production (Halder & Afsari, 2023; Konieczna-Fuławka et al., 2025). Within the mining sector UGVs are starting to be trialled for autonomous inspection of underground environments through 3D-mapping in high risk environments (Konieczna-Fuławka et al., 2025), whilst in the defense industry they are increasingly being tested for logistics, surveillance and rescue missions in hostile environments (Ersü et al., 2024). The future vision of the technology extends much further. Currently, extensive use cases within civilian sectors are being explored. Spanning from civilian crisis management and search-and-rescue missions (Ersü et al., 2024), to infrastructure inspection in environments such as bridges and tunnels (Halder & Afsari, 2023).

1.2 Navigation challenges in GNSS-denied environments

Despite the fast growth and technical progress within the UGV-sector, large parts of today's autonomous systems rest on a technologically fragile foundation. Most of today's autonomous solutions, whether aerial or ground-based, are fundamentally dependent on two external factors: continuous access to global navigation satellite systems (GNSS) and stable, high performance communication links (Chang et al., 2023). This vulnerability creates a critical bottleneck for the system's reliability in what the research literature calls GNSS-denied environments.

The problem is particularly noticeable in those environments where autonomous UGVs could create the most value, in underground mines, complex concrete structures or in dense and remote forests where satellite signals are partially or fully blocked by physical obstacles (Abdukodirov & Benndorf, 2025). Further, electrical interference or jamming in crisis- and conflict zones can lead to autonomous systems completely losing their ability to navigate and coordinate (Westbrook, 2019).

Consequences of this dependence extend beyond technical instability; it results in considerable economic risks in the shape of expensive downtime within industrial context, or in the worst-case scenario, failed rescue missions where time is a critical factor. As requirements on precision and reliability increase, traditional navigation methods for UGVs will not be enough to ensure that missions can be completed in harsh environments (Abdukodirov & Benndorf, 2025). This motivates the shift towards resilient technologies that are able to operate where the vehicle is fully operative even in environments where all external signals are denied (Alghamdi et al., 2025). Eira Systems positions itself in the centre of this challenge by developing UGVs that can navigate independently of both GNSS and continuous radio links.

1.3 Eira Systems

Eira Systems is a Swedish UGV technology start-up addressing the critical gap in autonomous navigation within hostile and signal-denied environments. While the UGV industry has made significant progress, most current systems remain vulnerable in warzones, large-scale natural disasters, or deep industrial sites where destroyed infrastructure and degraded communication networks prevent reliable operation. The company develops resilient, land-based autonomous ground vehicles designed to navigate harsh, off-road terrain without relying on external dependencies such as GNSS or continuous radio communication. By utilizing camera-based sensor processing and onboard intelligence, Eira's technology aims to enable UGVs to maintain navigation and coordination even when signals are jammed or physically obstructed.

As a startup in an early development phase, Eira Systems currently operates with a small team and faces the multi-dimensional uncertainties typical of deep-tech ventures. The company is simultaneously navigating several critical fronts: from refining the core technological product to investigating the complex legal and regulatory frameworks governing autonomous land vehicles. Strategically, Eira is at a crossroads, evaluating diverse market trajectories that span from high-stakes military applications to civilian crisis response and industrial automation.

The core vision of Eira Systems is to facilitate safe medical logistics, equipment transport, and evacuation in environments where human presence or traditional vehicles face unacceptable risks. As a startup navigating both civilian and defense-adjacent markets, Eira Systems represents a useful case for exploring how deep-tech ventures can identify near-term commercial entry points while simultaneously developing technology toward more advanced and uncertain applications.

1.4 The New-Market Conundrum and Technological Fungibility

The technology behind Unmanned Ground Vehicles (UGVs) and their navigation is transitioning quickly, which opens up many possibilities for potential uses but also creates challenges in navigating the market. As McDonald and Eisenhardt (2020) argue, new markets function like "science fiction's wormholes," where the "conventional rules of time and space no longer apply". In a new market, the questions that usually define a company's strategy like where to play and how to win are difficult to answer. Companies in these new markets usually do not know which business model is best or even which market they should enter. Furthermore, they often struggle to know who the customer really is and what they truly value (McDonald & Eisenhardt, 2020).

According to Gruber et al. (2012), technological resources are fungible, meaning they can generate value across a wide range of market environments. The challenge for deep-tech startups lies in identifying the optimal organizational habitat, the specific market where the technology does not merely function, but where its unique characteristics are most critical to the customer's needs. However, finding this habitat requires a deliberate search process. Gruber et al. (2008) argue that identifying a set of alternatives drastically improves the odds of success, revealing a non-linear positive relationship between the number of identified market opportunities and venture performance. Yet, this relationship is characterized by diminishing marginal returns; there is a "sweet spot" where the benefits of strategic choice are maximized before the cognitive cost of evaluating additional options outweighs the incremental value they provide.

1.5 The Market Opportunity Navigator as a Strategic Tool

To help entrepreneurs manage this complexity and systematically identify this optimal set of opportunities, the Market Opportunity Navigator has emerged as a framework. Developed by Gruber and Tal (2024), the tool is recognized as the fourth tool in the Lean Startup methodology and is utilized by tens of thousands of entrepreneurs globally. Its primary function is to operationalize the search for the optimal habitat by providing a structured three-step process to identify, evaluate, and prioritize market opportunities before a firm commits to a specific business model.

Despite its global adoption, Gruber and Tal (2024) explicitly call for further research to test the Navigator's performance when applied to highly novel and disruptive technologies. They argue that in these cases, the framework must function as a "learning companion" for emerging markets, a process that requires deep-tech founders to successfully *de-link* their specialized expertise from a current, concrete application. Furthermore, the authors suggest the tool is particularly valuable for dynamic strategizing, allowing innovators to identify existing markets for immediate commercialization while simultaneously developing the technology for later entry into entirely new, emerging domains.

1.6 Specializing the Framework

This study directly addresses this call for research by testing how the Navigator can be adapted for a complex deep-tech case. To move beyond a generic evaluation, the study adapts the framework to distinguish between different degrees of technological sophistication, recognising that for a venture like Eira Systems, the technology is a versatile capability rather than a static product.

The motivation for this adaptation draws directly on Gruber and Tal (2024) argument that the Navigator is particularly valuable in emerging and high-tech markets for enabling dynamic strategizing, allowing innovators to identify existing markets for immediate commercialisation while simultaneously developing technology for later entry into more advanced domains. By distinguishing between technological layers, Eira Systems can identify stepping stone markets at lower autonomy levels to generate near-term revenue while building toward the most disruptive Layer 3 entry.

To operationalise this, the study integrates three distinct autonomy levels into the evaluation framework (hereafter referred to as the multi-layer framework), providing a structured lens to assess which specific market needs require each level of autonomy and where signal-independent navigation creates critical rather than marginal value. The three layers are illustrated in Figure 1.1.

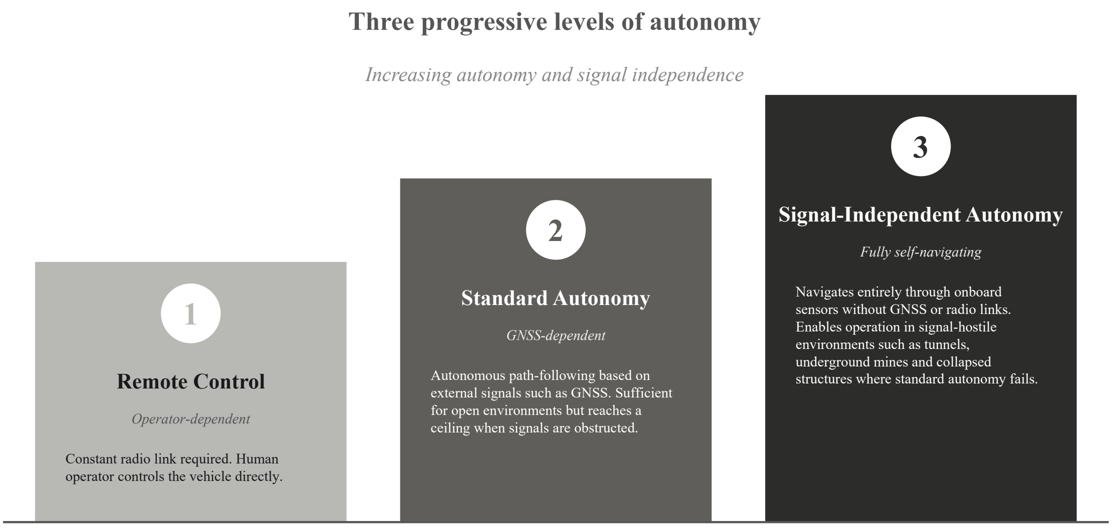

Figure 1.1: The progressive levels of Autonomy and signal independence

By integrating these layers into the Navigator's Attractiveness Map (stage II of the navigator), this study tests whether such a specialized approach can effectively guide a venture to identify the "sweet spot" where their most advanced technology is not just an improvement, but a necessity.

1.7 Purpose of the Study and Research questions

The purpose of this study is threefold, understanding what drives adoption of UGV technology in various industries as well as aiming to bridge the gap between entrepreneurial theory and the practical commercialization challenges of deep-tech ventures.

First the study addresses the empirical foundation of the study by exploring what makes industries more or less receptive to UGV adoption. Understanding the general drivers and constraints across sectors is necessary both to inform where UGV technology is most likely to find viable markets and to contribute broader insight into how deep-tech innovations diffuse into industrial settings. To address this, the study asks:

RQ1: *Which general tendencies and characteristics drive or constrain the adoption of UGV technology across different industrial sectors?*

Second, the study serves an academic purpose by testing and specializing the Market Opportunity Navigator (MON) for highly novel and disruptive technologies. While MON is an established tool for market selection, its utility in nascent and high-uncertainty environments, such as GNSS-denied navigation, remains underexplored. This research investigates how the framework can be adapted through the integration of a Multi-Layer Value evaluation and other adaptions, contributing to the entrepreneurship literature by exploring how deep-tech founders can utilize technological sophistication as a strategic variable to navigate the new-market conundrum and mitigate commercialization risk. This is addressed through the following research question:

RQ2: *How effective is the Market Opportunity Navigator as a strategic framework for deep-tech ventures in high-uncertainty sectors, and how can it be adapted to enhance its ability to support market selection and strategic decision-making?*

Third, the study serves a practical purpose by providing strategic decision support for Eira Systems. By applying the specialized Navigator to Eira Systems' specific technological constraints, the study aims to identify and prioritize the most viable market, ultimately resulting in a transferable decision-making framework for their market entry strategy.

2
Literature

The following chapter establishes the theoretical foundation required to analyse the market entry and commercialization of Eira Systems' disruptive UGV technology. The review is structured around the Market Opportunity Navigator (MON) framework, which serves as the primary operational tool for this study. To ensure a comprehensive analysis of both the potential and the challenges inherent in deep-tech markets, the navigator is supplemented with established theories to support the different evaluation parameters. Together, these perspectives provide the analytical lenses necessary to evaluate the technical and commercial viability of various industrial habitats.

2.1 Market Opportunity Navigator (MON)

The Market Opportunity Navigator serves as the primary analytical framework structuring this study's methodology and evaluation approach. This section outlines the framework's theoretical foundation and how it is operationalized across its three stages.

2.1.1 Introduction to the MON Framework

Within entrepreneurial studies a large focus has traditionally been on how companies create business models and execute plans. However, Gruber and Tal (2017) argue that a critical step in the process is often overlooked: the choice of the initial market. For deep-tech businesses and start-ups, whose technologies are often versatile and capital intensive, this choice is linked with great uncertainty. The Market Opportunity Navigator (MON) is designed to help address this gap. It serves as a strategic framework helping deep-tech ventures identify, evaluate, and prioritize market opportunities before committing to a specific business model (Gruber & Tal, 2017). It is designed to help entrepreneurs understand their market opportunity strategy, and as the name of Gruber and Tal's book suggests, "Where to Play", a step often overlooked by entrepreneurs. Another benefit of the MON framework, besides choosing direction, is according to Gruber and Tal (2017) making sure you remain agile. Whilst resources and energy should be directed at the chosen path, it is important for entrepreneurs to keep options open. The main opportunity you are pursuing might reach a dead end, and then it is important to be able to pivot to a back-up alternative. Without a systematic assessment of market opportunities entrepreneurs risk falling into what the authors call "the innovator's trap", a cognitive bias where they get locked in towards the first and most obvious application for the technology, rather than that of the most value.

By overlooking this important step in the startup process, Gruber and Tal (2017) say entrepreneurs risk running fast, but in the wrong direction. The framework emphasizes the importance of maintaining strategic agility throughout the whole process. Even though resources and energy should be focused on the primary opportunity, Gruber and Tal point out that businesses should identify and prepare reserve alternatives. This approach minimizes the risk if a potential dead end of the primary market opportunity was to be reached, because the business would be able to pivot quicker through taking advantage of the technologies modularity and the synergy between market opportunities.

2.1.2 The fourth tool in the Lean Startup Methodology

The Market Opportunity Navigator framework is recognized as the fourth tool in the Lean Startup methodology, alongside the Business Model Canvas, Customer Development, and Agile Engineering (Gruber & Tal, 2024). Whilst the traditional tools in Lean Startup focus on quickly figuring out “product-market fit” within an already decided market, they offer little guidance on where the search should begin. Gruber and Tal (2024) argues that MON fills this gap by offering a wide-lens perspective allowing businesses to explore different market domains before “zooming in” to design specific business models or test MVPs. Steve Blank, one of the founders of the Lean Startup movement, notes that MON works as a link minimizing the risk in the startup process through ensuring the business launches on more “fertile ground” (Gruber & Tal, 2024). Many innovative projects are forced into painful restarts because they have gone down the wrong path. By using the MON framework these costly mistakes can be avoided through strategic thinking from an earlier stage. Foundationally, the tool helps the user understand “where to play” as an important prerequisite before deciding on “how to play”.

2.1.3 The three steps of the MON Framework

Market Opportunity Navigator is built up as a step-by-step process guiding entrepreneurs from a wide exploration phase into a focused but agile strategic decision. This systematic methodology is designed to emulate the decision-making process of experienced serial-entrepreneurs, where they “look before they jump” to ensure the business is launched on the best possible foundation.

2.1.3.1 1: Identification of market opportunities

The initial step in the process aims to generate a broad portfolio of potential markets, a so-called Market Opportunity Set. To be successful in this the entrepreneur needs to look beyond the technologies immediate applications. According to Gruber and Tal (2017) a process of “de-linking” the technological capabilities from a specific product context is necessary to instead understand them in their own right.

By looking at the technology independently from a single application the user can identify between 5 and 10 different arenas where the technology can create value. This way of working helps entrepreneurs break free from what Gruber and Tal call their accustomed "prior knowledge corridors", which otherwise might often limit the search to a market they already have experience in.

2.1.3.2 Step 2: Evaluation of market attractiveness

When a wide range of opportunities has been identified the process moves over to a rigorous evaluation to ensure every market's inherent attractiveness. This evaluation is done with the help of an Attractiveness Map, where every opportunity is analysed from two main dimensions: potential and challenges (Gruber & Tal, 2017). The potential dimension aims to discover what value a given market opportunity can generate, independent of the businesses own resources and capabilities. Gruber and Tal (2017) describes potential figuratively as the altitude of a mountain in a landscape of markets, the higher the mountain, the more value a market can offer. The challenge dimension measures how difficult it will be to actually take advantage of the value that the market offers. One core thing that Gruber and Tal (2017) highlights is that the challenge is not only an attribute of the market itself but is equally shaped by the businesses own capacity and prerequisites. Pictorially the challenge is described as your chance to conquer the mountain that is a market opportunity. Down below, all av the evaluation criterias are described, with the first three being potentials and the second three being challenges.

1. Compelling Reason to Buy: The first factor is about whether there is a genuine and un-solved need on the market, and if the business is able to address this need better than existing alternatives. Gruber and Tal (2017) believe that three key questions should be answered: Is there a real unmet need? Can the business offer an effective solution? Can this solution deliver noticeable value compared to what already exists? If a compelling reason to buy is lacking then the market will not sustain demand, regardless of the market's volume size or economic viability.

2. Market Volume: This factor examines the markets size, how many potential customers there are, and how big the addressable market is today and in the near future (Gruber & Tal, 2017). A big market has a higher ceiling for what is commercially possible to achieve, a foundational prerequisite for scalability. The volume should however always be weighed against the other factors, because a big market without meaningful willingness to pay or a clear reason to buy offers little in terms of potential.

3. Economic Viability: The third factor assesses the economic conditions for building a profitable business in a chosen market. Gruber and Tal (2017) divide it into three parts: margin between value created and cost of delivery, customers' willingness and ability to pay for the solution, and customer stickiness. Even though these exact numbers can be difficult to determine, the authors note the importance of making well-founded assumptions based on comparable offers and interviews with potential customers.

4. Implementation Obstacles: Assesses the difficulty both in developing the solution and reaching commercial impact. It is partly to do with technical and product complexity, and partly the challenges connected to selling and converting the potential customers (Gruber & Tal, 2017). In B2B contexts lengthy and complex decision making processes can pose a barrier, whilst consumer markets might require investments in consumer consciousness and behaviour.

5. Time to Revenue: Refers to the timespan that is expected to run from start until the market generates income. Gruber and Tal (2017) includes development time, time to achieve market readiness, and the length of the sales cycle. An opportunity can be technically viable and have strong potential, but still constitute high risk if the time horizon until actual income is long. The factor is thus distinct from implementation obstacles, it is specifically a temporal dimension of risk and capital requirements.

6. External Risks: The last factor touches on external conditions in the market's environment that to a large extent is beyond the businesses control, but which still can decide if the opportunity is able to capture the value of the market. Gruber and Tal (2017) structures these risks into three categories: competitive threats (how intense is existing competitions and how easily can competitors respond?), barriers to adoption (including technical compatibility, legal requirements, and customers receptiveness for innovation), and third-party dependencies (the extent to which the business model relies on external actors whose cooperation cannot be guaranteed).

Together these six factors act as a structured framework for learning, where the entrepreneur successively replaces initial assumptions with empirical data from customer interviews and market analyses (Gruber & Tal, 2017). Each factor is evaluated on a scale from low to super-high, and the combined points for Potential and Challenges respectively places each opportunity in the Attractiveness Map. Opportunities with high potential and low challenge represent Gold Mines, whilst opportunities with high potential and high challenge are classified as Moon Shots. This visual categorisation gives a common and comparable foundation to enable evaluations between fundamentally different markets.

2.1.3.3 Step 3: Designing an agile focus strategy

In the last step the aim is to make the strategic decision of which market will become the business primary focus, as well as create an agile plan for the future. Instead of only choosing one path and ignoring all other alternatives, Gruber and Tal (2024) advocate for the creation of a portfolio of "real options". With the help of an Agile Focus Dartboard the most promising markets are prioritized through three categories: the primary market for immediate focus, the back-up options that are kept open in case of need for a pivot, as well as future growth options (Gruber & Tal, 2017). By analyzing how related technologically and marketwise the different opportunities are, the entrepreneur can choose a primary market that enables synergy effects with the back-up options. This way of strategically working to minimize the risk of premature lock-in ensures that the business can pivot quickly if the chosen market would reach a dead-end (Gruber & Tal, 2017).

2.2 Theoretical Perspectives on Market Potential & Challenges

While the market opportunity navigator provides a structured and comprehensive framework for evaluating market entry, its primary function is to serve as an operational tool rather than an exhaustive theoretical model for each individual evaluation parameter. Consequently, to ensure a rigorous academic analysis of Eira Systems, it is necessary to supplement the navigator with established theories that address the underlying dynamics of market potential and implementation challenges.

2.2.1 Creating New Market Space

Blue Ocean Strategy as developed by Kim and Mauborgne (2005) offers a framework for creating new market space by making the competition irrelevant. The core logic of this theory rests on the concept of value innovation which occurs when a firm aligns innovation with utility, price, and cost positions. Rather than engaging in head-to-head competition within existing market boundaries characterized by bloody competition or red oceans, firms should seek to create uncontested market space or blue oceans. In a red ocean, industry boundaries are defined and accepted, and companies try to outperform their rivals to seize a greater share of existing demand. As the market space gets crowded, prospects for profits and growth are reduced, leading products to become commodities. Conversely, blue oceans are defined by untapped market space, demand creation, and the opportunity for highly profitable growth. Value innovation challenges the conventional strategic trade off between differentiation and low cost. Traditional strategy suggests that companies can either create greater value for customers at a higher cost or create reasonable value at a lower cost. In contrast, those seeking blue oceans aim to drive up value while simultaneously driving down costs by eliminating factors that the industry has long competed on but which no longer provide value.

To reach this state of value innovation, the theory provides the four actions framework to reconstruct buyer value elements in crafting a new value curve (Kim & Mauborgne, 2005). This framework asks which factors that the industry takes for granted should be eliminated, which factors should be reduced well below the industry standard, which factors should be raised well above the industry standard, and which factors should be created that the industry has never offered. By answering these four questions, companies can systematically look across conventional boundaries of competition to find commercially important blue oceans. This involves looking across alternative industries, strategic groups, buyer groups, and complementary product and service offerings. The theory also emphasizes the importance of reaching beyond existing demand by focusing on non-customers. Instead of concentrating on customer differences through fine grained segmentation, the strategy focuses on powerful commonalities in what buyers value. This approach allows a firm to aggregate demand and unlock a new mass of customers who were previously turned away by the limitations of existing industry offerings. The success of this transition into a blue ocean is often predicated on the solution offering a radical improvement rather than an incremental gain. In deep-tech commercialization, this is frequently operationalized through the 10x rule, which suggests that for an innovation to overcome organizational inertia and status quo bias, it must provide a tenfold improvement in a critical performance dimension (Thiel, 2014). This exponential leap ensures that the value innovation is significant enough to motivate non-customers to switch to the new technology

Applying the Blue Ocean lens allows Eira Systems to evaluate market opportunities based on their potential for uncontested growth across various levels of technological sophistication. This theory assists in identifying two distinct paths to a blue ocean. First, Eira Systems can target industries where remote controlled or standard autonomous vehicles are already present but where higher autonomy levels fundamentally reconstruct the value proposition. Second, the framework helps locate entirely untapped sectors where the introduction of a UGV itself creates a new market space by reaching non-customers who currently rely on manual labor.

In the evaluation stage of the Market Opportunity Navigator, this perspective complements the assessment of a compelling reason to buy by highlighting where a specific technology layer moves a solution from a marginal improvement to a critical necessity. It may also contribute to economic viability in terms of competition. It also serves as a tool for dynamic strategizing, allowing Eira Systems to weigh the external risks of competing in established red oceans against the rewards of creating new demand.

2.2.2 Market Diffusion and Growth Factors

Rogers (2003) states that technology diffusion follows an S-curve across a normal distribution of five adopter categories: innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%), and laggards (16%). This categorization depends on "innovativeness", an actor's relative speed in adopting new ideas. While innovators tolerate high technical uncertainty due to financial cushions, early adopters act as local opinion leaders. As diffusion accelerates past these groups, it reaches a "critical mass" before entering the pragmatist majority. Crucially, Rogers highlights a socioeconomic paradox, where resource-rich actors adopt innovations faster, meaning technological development can temporarily widen industry gaps.

However, Moore (2014) argues that high-tech commercialization is not a smooth transition but is interrupted by significant cracks, most notably the chasm between early adopters (visionaries) and the early majority (pragmatists). Visionaries seek strategic advantages and tolerate incomplete tech, making them ideal partners for Eira Systems' signal-independent navigation in high-risk environments while pragmatists demand reliability, industry standards, and a "whole product" solution with full support. To cross this chasm, Moore (2014) prescribes a beachhead strategy: focusing resources on a narrow market niche to achieve dominance and build the credible references that pragmatists require.

Further, according to Rogers (2003), diffusion depends on opinion leaders whose early adoption increases the observability of a technology, signaling legitimacy to the wider social network. In high-tech B2B contexts, Moore (2014) operationalizes this mechanism as a prerequisite for crossing the chasm, arguing that pragmatic majorities strictly demand credible peer references before abandoning legacy routines.

In this thesis, these frameworks serve as analytical tools to explain why industries with similar economic conditions adopt UGVs differently. By identifying whether specific industrial segments are populated by visionaries or pragmatists, Eira Systems can strategically select an optimal beachhead market, minimizing commercial risk and accelerating scalable adoption.

2.2.3 Organizational Inertia

A significant implementation obstacle in deep-tech commercialization is the structural resistance within customer organizations. Hannan and Freeman (1984) theorize that structural inertia is an outcome of selection processes that favor organizations with high levels of reliability and accountability. To achieve the reliability required for survival, organizations utilize highly reproducible routines. However, this same reproducibility creates strong inertial pressures, meaning the speed of internal reorganization is typically much lower than the rate of environmental change.

Central to this theory is the distinction between an organization's core and its periphery. Inertia is strongest at the core, which includes stated goals, forms of authority, core technology and marketing strategy. While peripheral structures are relatively plastic, changes to the technical core are rare and costly. Hannan and Freeman (1984) argue that any attempt at radical core change temporarily lowers an organization's reliability of performance.

Furthermore, Hannan and Freeman (1984) identify several specific factors that reinforce this inertia and make certain industries more resistant to change. First, inertia tends to increase with organizational age and size, as routines become institutionalized and part of the firm's identity over time. Second, the authors emphasize the importance of accountability; organizations operating in environments with high safety and traceability requirements prioritize predictability over innovation. Departing from proven routines to implement a radical technology involves a political and organizational risk that often outweighs the technical benefits. Finally, sunk costs, such as prior investments in specific infrastructure and specialized employee skills, act as an anchor that locks the customer into their current technological path. The more capital a customer has tied up in systems that the new technology might replace, the stronger the internal resistance to change.

This internal structural resistance is further strengthened by the resource allocation patterns identified by Christensen and Bower (1996). Their research demonstrates that established organizations are often held captive by their existing value networks and powerful customers who demand incremental, sustaining improvements rather than disruptive architectures. Since resource allocations are usually guided by the market, the most support goes to projects that meet current customer needs. Meanwhile, projects aimed at new or unproven markets often fail because they do not receive enough funding or attention. These inertial forces are also practically manifested through the switching costs identified by Burnham et al. (2003), who categorize the barriers to adopting new solutions into procedural, financial, and relational dimensions. Procedural costs involve the time and effort required to master new routines, while financial costs refer to the direct loss of prior investments in legacy infrastructure. Relational costs encompass the psychological risk of breaking established partnerships. A key conclusion from this research is that switching costs often exert a stronger influence on customer retention than actual product satisfaction. Even if a customer is unhappy with a current solution, they may remain due to the high burden of change. Furthermore, the study identifies that in complex technological markets, procedural costs typically represent the most significant barrier to entry.

For Eira Systems, this integrated theoretical perspective explains why technical superiority alone cannot overcome organizational inertia, as the perceived risk and cognitive effort of switching often outweigh the benefits of a more sophisticated UGV system. In the context of this study, these theories provide a foundation for evaluating implementation obstacles within the Market Opportunity Navigator. By identifying industrial sectors where procedural and financial switching costs are lower, or where the organizational core is less rigid, Eira Systems can strategically prioritize markets where the friction of adoption is minimized.

2.3 Strategic Prioritization and Entrepreneurial Logic

To understand how deep-tech startups navigate the new-market conundrum, it is necessary to examine the underlying decision-making logic of the entrepreneurs. Sarasvathy (2001) introduces the theory of effectuation as a contrast to the traditional causation model that dominates many management curricula. While both logics are integral to human reasoning, they are suited for fundamentally different environmental conditions.

2.3.1 The Contrast Between Causal and Effectual Reasoning

Causation processes take a specific effect as given and focus on selecting between means to achieve that effect (Sarasvathy, 2001). This logic rests on a predictive paradigm where the ability to control the future depends on the ability to predict it. Causal reasoning is most effective in stable, linear environments where historical data exists and goals are pre-set.

In contrast, effectuation processes take a set of means as given and focus on selecting between possible effects that can be created with those means (Sarasvathy, 2001). The underlying logic here is a control paradigm where the ability to control the future removes the need to predict it. Effectuators begin with three categories of means: who they are, what they know, and whom they know. This logic is particularly relevant in nascent markets where neither the customer nor the product is fully defined.

2.3.2 Core Principles of Effectuation

Sarasvathy (2001) outlines several principles that distinguish effectuation from causation. Instead of calculating the expected return or net present value of a market opportunity, entrepreneurs pre-determine how much loss they can afford. They focus on experimenting with various strategies within those bounds rather than seeking the single optimal path. Furthermore, rather than conducting extensive competitive analyses to protect a market position, effectuation emphasizes building a network of strategic partners and pre-commitments to co-create the market and reduce uncertainty. Finally, instead of viewing unexpected events as obstacles to a linear plan, effectuators treat surprises as opportunities to pivot and reshape their goals.

2.3.3 Means-Driven vs. Market-Driven Development

Traditional causal logic suggests that a firm should begin with a market analysis to identify a gap and then adapt its product to meet the specific requirements of that chosen market (Sarasvathy, 2001). Effectuation reverses this process by positing that entrepreneurs should start with their specific means, which include who they are, what they know, and whom they know, rather than a pre-defined market opportunity. This means-driven approach allows the firm to focus on what the technology can already do, seeking out partners to co-create value rather than over-engineering for a market that does not yet exist. Furthermore, this logic shifts the evaluation of market attractiveness from external metrics like total market volume to the internal ability to exert control through strategic alliances and pre-commitments from visionary customers (Sarasvathy, 2001). By focusing on the controllable aspects of an unpredictable future, the firm maintains strategic agility, viewing unexpected contingencies as opportunities to pivot rather than obstacles to a rigid plan.

For a deep-tech startup like Eira Systems, this means that the core technology of GNSS-independent navigation and off-road autonomy serves as the fixed starting point for strategic exploration. The challenge is not to fundamentally alter this technological toolbox to fit a specific industrial niche, but rather to identify which market habitats can be inhabited or created using these existing capabilities. By applying effectuation to the attractiveness map, Eira Systems can prioritize markets where they can secure early partnerships that reduce commercialization risk. Ultimately, this effectual logic justifies maintaining shadow options in high-uncertainty markets, where the conditions for commercialization are still forming and the most valuable opportunities may only become visible through direct market engagement.

2.4 Theoretical Synthesis

The theoretical frameworks presented in this chapter serve two complementary purposes. The first is to provide analytical lenses for understanding which characteristics drive or constrain UGV adoption across industries, addressing RQ1. The second is to structure the application and adaptation of the Market Opportunity Navigator, addressing RQ2. The MON itself forms the theoretical backbone of the study, providing the overarching structure within which the supporting theories are integrated across its three stages.

In the identification stage, the principle of technological fungibility guides the delinking of Eira Systems' core capabilities from specific products, enabling a broad exploration of market opportunities across industries. Effectuation theory complements this by anchoring the search in what the technology can already do rather than in a predefined market target, reflecting the means-driven logic appropriate for an early-stage deep-tech venture.

In the evaluation stage, Blue Ocean Strategy and the 10x rule inform the assessment of compelling reason to buy by distinguishing where a specific autonomy level represents a marginal improvement versus a critical necessity. Diffusion of innovations and crossing the chasm are used to evaluate adoption timing and categorise potential customers, informing time to revenue assessments and helping explain why industries with similar economic conditions adopt UGVs at different rates. Organizational inertia and switching costs provide the theoretical basis for evaluating implementation obstacles, explaining why structural resistance within customer organisations often constrains adoption independently of how strong the technical or economic case is. Together these theories provide the analytical foundation for answering RQ1 by identifying the underlying mechanisms that shape adoption across different industrial contexts.

In the prioritization stage, effectuation logic and the relatedness dimensions of the MON guide the selection of a primary market and the structuring of backup and growth options. Rather than prioritising on market volume alone, the study weights product fit and platform compatibility more heavily, reflecting the means-driven logic of Sarasvathy (2001) and the specific resource constraints of an early-stage deep-tech venture.

3 Methodology

This chapter describes the research design and methodological choices shaping the study. It describes how data was collected and analysed across the three stages of the Market Opportunity Navigator, and discusses the quality, limitations and ethical considerations of the research.

3.1 Research Design

The methodology was based on the principle of methodological fit to ensure that the research questions, design, and intended contributions were internally consistent. By applying the contingency framework of Edmondson and McManus (2007), the study was positioned as a bridge between nascent and intermediate stages of theory development. This active positioning allowed us to navigate the dual challenge of exploring the novel GNSS-denied UGV industry while simultaneously refining the established constructs of the Market Opportunity Navigator (MON).

In practice, the study was positioned between nascent and intermediate theory development, as described by Edmondson and McManus (2007). This allowed us to both build on the established MON framework and extend it through new relationships with specialized adaptations for deep-tech ventures in emerging markets, whilst simultaneously employing open-ended qualitative inquiry to explore an industrial landscape where prior literature remained limited.

To execute this, the research was conducted as a qualitative case study, focusing on Eira Systems as a revelatory unit of analysis. The logic of Gerring (2004) was followed, who defines the case study as an intensive study of a single unit with the aim to shed light on a larger class of units, in this case, deep-tech ventures navigating emerging markets. As Gerring argues, this strategy is superior when the research goal is to explore causal mechanisms in depth rather than achieving statistical breadth. Using Eira Systems as our focal point allows for the contextual depth that Eisenhardt (1989) identifies as a key advantage of the case study approach.

The data collection followed a hybrid logic where workshops were used for idea generation of market opportunities together with semi-structured interviews to capture the qualitative depth needed for pattern identification regarding the potential and challenges with each layer within different markets. This was complemented with quantitative data collections for aspects within the MON where such data were available.

This twofold research design was a deliberate choice to address the specific complexities of Eira Systems' technology. We actively balanced the need to build upon existing strategic frameworks (intermediate) with the need for open-ended inquiry into a new industrial application (nascent). Consequently, our findings contributed to both a suggestive theory that invites further research into the UGV sector and a provisional theory in the form of an adaptation of the MON framework.

3.2 The Research Process

The research followed a structured, three-step methodological process designed to translate Eira Systems' technical capabilities into a validated market strategy, as illustrated in Figure 3.1. This framework served as the operational roadmap for the study, transitioning from broad opportunity identification to a finalized commercialization path.

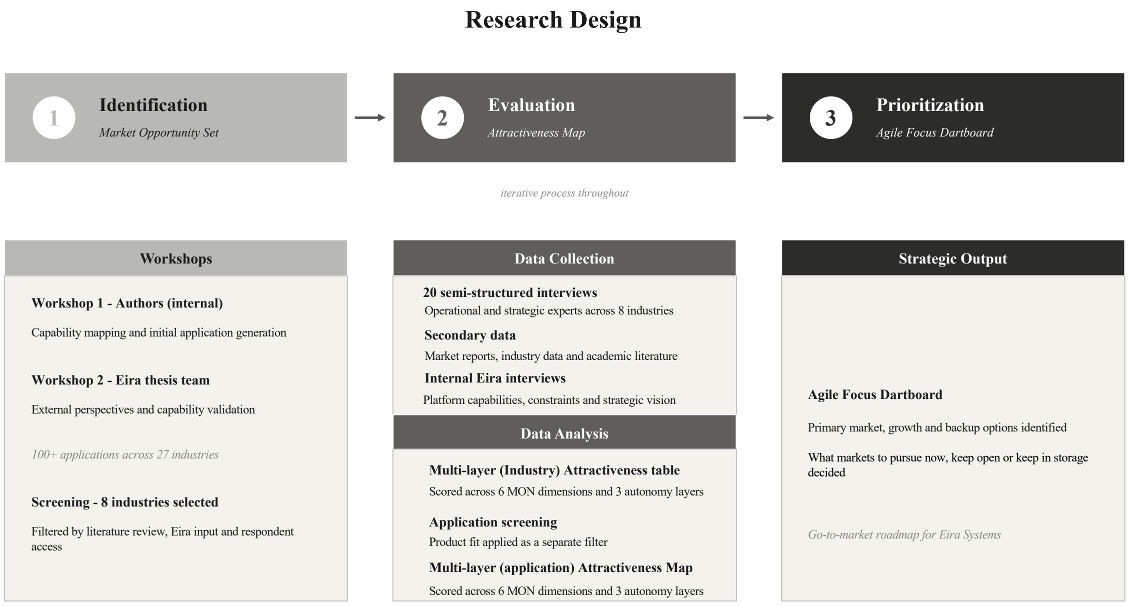

Figure 3.1: Practical methodological framework

However, as shown in Figure 3.2 the development of this framework was not a linear path but an iterative process split into an Exploratory Phase and a Data Collection Phase. We iterated between framework development and empirical data collection. Initial meetings and literature reviews provided a baseline, which was then refined through workshops, interviews and qualitative data collection. This recursive loop ensured that the parameters we used to evaluate markets evolved as we gained deeper industry insights.

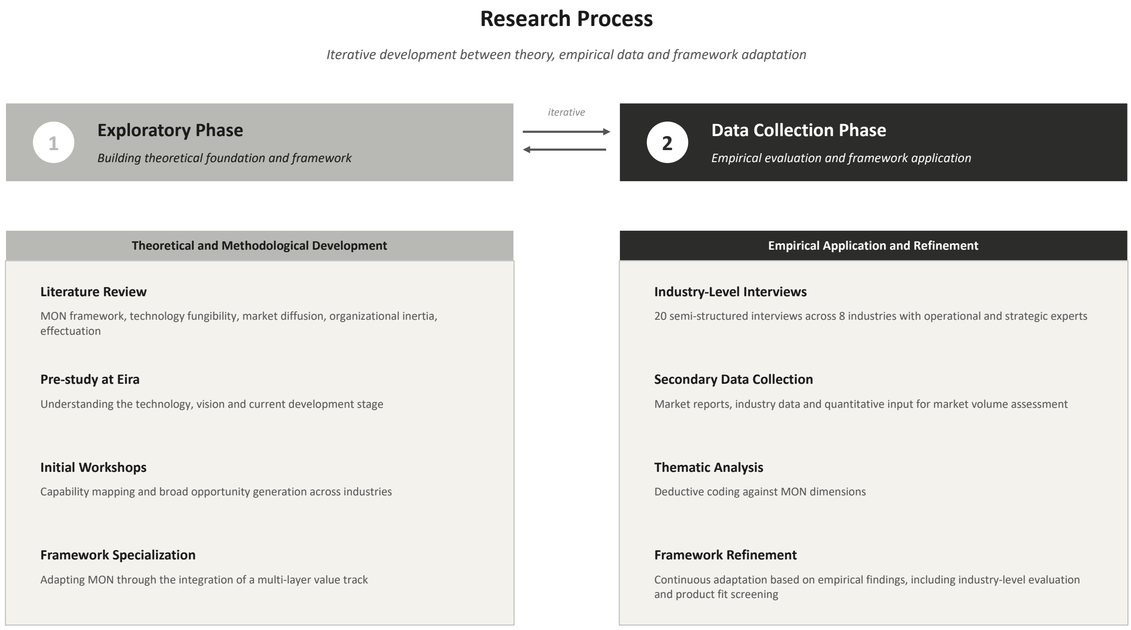

Figure 3.2: The research process

3.3 Data Collection

Data collection was structured around the two first stages of the MON framework, combining workshops, semi-structured interviews, and secondary data. Each method was chosen to address the specific informational needs of its corresponding stage.

3.3.1 Identification Workshop

To generate the initial basis for the Stage 1, Market Opportunity Set, two structured workshops were used as the primary data collection method. The purpose of this stage was explorative, to widen the perspective and identify as large a set of potential market opportunities and application areas as possible before conducting any screening. Workshops were chosen for their capacity for divergent thinking and co-creation (Storvang et al., 2018). Distinct from other standard methods like focus groups or interviews that primarily record current opinions ("what is"), workshops are designed to be generative, allowing participants to collaborate creatively, focusing on potential futures such as market opportunities (“what might be”) (Storvang et al., 2018).

Workshops Step-by-Step

The workshop followed a structured five-stage sequence designed to progressively narrow down from abstract capabilities to concrete market opportunities, building on the structure from Worksheet 1 in the MON framework (Gruber & Tal, 2017). Participants first worked individually before sharing with the group, following the recommendation of Storvang et al. (2018) and Ritter and Mostert (2018) that individual ideation precedes group discussion to reduce conformity and improve idea originality.

1. In the first stage participants were handed four sticky notes each and asked to write down one core capability of Eira Systems' UGV per note. These were then placed on a shared whiteboard and clustered anonymously by similarity, with the group agreeing on a label for each cluster. The resulting capability clusters served as the fixed foundation for all subsequent stages, anchoring the ideation in the technology rather than in a pre-conceived product.

2. In the second stage, participants were asked to identify broad and general applications enabled by any combination of the identified capabilities, deliberately avoiding specific use cases or customers at this point. The instruction was to think at the level of transport, mining etc., rather than for example, autonomous log transport for forestry contractors. These general applications were again clustered on the whiteboard into broader categories.

3. In the third stage participants were asked to connect potential customers or customer groups to each application category, using the general applications as a guide. The question was simply: who could benefit from this type of application? Duplicates were removed, and an open discussion followed to identify gaps or overlooked customer groups.

4. In the fourth stage, participants combined the customer groups and application categories to generate specific market opportunities. Concrete situations where Eira Systems' technology could solve a real problem for a specific type of customer. This stage was the most generative and formed the primary raw output of the workshop. Finally, a dot-voting round was conducted to identify the opportunities that participants collectively considered the most promising, providing an initial priority signal before formal screening.

3.3.2 Evaluation

The evaluation phase drew on three complementary data sources to populate the Attractiveness Map: semi-structured interviews with industry representatives, secondary data for market-level metrics, and internal interview with Eira Systems.

3.3.2.1 Semi-structured interviews

Interviews formed the primary basis for understanding customers' and markets' actual needs in this study. Aiming to identify "pains" that current solutions and technology does not solve, their current use of autonomous technology, and its potential use cases especially when ground-based. This was done by structuring the interviews around the six factors of the Attractiveness Map in Stage 2 of the MON framework, thus shaping the interviews to serve as the main data collection method for the evaluation phase.

Whilst surveys and quantitative data can help describe surface-level metrics, interviews allow digging deeper into the underlying motivations, frustrations and processes of the interviewees. The methodology used for the interviews is that of semi-structured interviews (SSI). According to Adams (2015) these are interviews utilising a mix of predetermined questions and open ended probing, facilitating dialogue and allowing the researcher to uncover detailed personal insights, discover unforeseen issues, and exploring "unchartered territory" rather than sticking to a script.

It is acknowledged that they are comparatively more time-consuming and labor intensive than alternatives such as surveys with sample sizes also being inherently smaller, limiting statistical precision (Adams, 2015). Given that the aim of the SSI data collection is to identify deep qualitative value drivers, constraints for adoption, and specific use cases, this trade-off is deemed necessary.

3.3.2.2 Secondary data

The qualitative insights gathered through primary interviews and workshops were complemented by secondary qualitative data. Secondary data is data that can be found in documents, books, statistics and other sources, and it is defined as data that was originally collected by someone else for a different purpose (Johnston, 2014). This type of macro level data was mostly used as direct input for market volume.

Most literature such as papers and journals has been collected through targeted searches on Google Scholar, making use of their AI-assisted Labs function to better execute the searches. Scopus and Scopus AI has also been used to a lesser extent in retrieving previous research and studies supporting this thesis. Data such are found through various Market Research Reports through databases together with consultant reports.

3.3.2.3 Internal interviews

Collecting primary internal data was necessary in supporting the primary and secondary external data needed to populate the Attractiveness Map and determine which market opportunities to pursue. The primary need for internal data is in determining capabilities in terms of the implementation obstacles and time to revenue dimensions. Internal data is further required to evaluate strategic fit and technical feasibility of potential ventures, thus this phase of data collection serves as a calibration mechanism, ensuring identified opportunities are not only theoretically attractive but also executable within the constraints of Eira Systems. Furthermore, in the final selection phase (step 3 of MON), opportunities need to be weighed against resources and vision. The data is collected through conversation with internal Eira Systems' personnel.

3.4 Selection of Respondents

The selection of respondents are divided into workshop participants for the initial phase of MON and qualitative semi-structured interviewees for the second phase.

3.4.1 Workshop participants

The first workshop was conducted by the authors. The choice was motivated by the need to establish an initial set of opportunities based on existing knowledge, before introducing external perspectives. This session was conducted after a previous literature review in which the authors independently examined the current state and use of UGV technology in various industries. This grounding in existing knowledge ensured that the workshop started from an informed foundation rather than abstract speculation, allowing the authors to map out preliminary areas of opportunity with some knowledge of where the technology is already being applied and where potential gaps in use may exist.

For the second workshop thesis workers with direct knowledge of the technology and its underlying capabilities were chosen. Their proximity to the development process allowed for a more precise description of what the technology can and cannot do, which helped to delineate the opportunity space around what is technically grounded.

3.4.2 Interviewees

The study employed a purposive sampling strategy to recruit respondents with deep insight into the operational and strategic challenges of the identified sectors. Two primary categories of respondents were targeted. The first consisted of operational experts and end-users with direct field experience, such as site managers, innovation leads or technical specialists, whose participation was vital for providing the data needed to identify where current solutions fall short and where signal-independent navigation creates critical value. The second consisted of strategic decision-makers and industry analysts, including innovation managers and senior executives, whose role was assess whether operational needs translate into viable business cases.

In practice, most respondents combined both perspectives to varying degrees, with few fitting neatly into either category alone. A total of 20 interviews were conducted across the eight industries, as shown in table 1. The number of interviews per industry varied between one and four, primarily reflecting differences in respondent availability and willingness to participate across sectors.

Date & Length	**Code Name**	**Role**	**Organisation**	**Industry**
20 Mar *~30 min*	N1	Area Manager / Senior Development Engineer	Swedish national nuclear waste management organisation	Nuclear Power (Waste)
25 Mar *~45 min*	M1	CTO	Large Nordic mining corporation	Mining
30 Mar *~45 min*	M2	General Manager	Small-scale Swedish gold mine	Mining
31 Mar *~30 min*	C1	Production Manager	Large Swedish construction contractor	Construction
31 Mar *~45 min*	I1	Researcher & Programme manager	Swedish national infrastructure research programme	Infrastructure
7 Apr *~55 min*	FR1	Project Manager	Large metropolitan fire and rescue service	Fire & Rescue
9 Apr *~50 min*	CM1	Technology & Product Development	Global construction equipment manufacturer	Construction & Mining
10 Apr *~50 min*	N2	R&D Manager	Swedish state-owned energy company, nuclear operations	Nuclear Power
14 Apr *~50 min*	C2	Innovation Manager	Large Swedish construction and civil engineering company	Construction
15 Apr *~50 min*	P1	R&D Manager	Swedish state-owned energy company	Power Grid
16 Apr *~50 min*	N3	Senior Specialist, Decommissioning	Swedish state-owned energy company	Nuclear Power (Decommissioning)
17 Apr *~45 min*	I2	Unit Manager, Railway Maintenance	Swedish national transport infrastructure authority	Infrastructure
17 Apr *~60 min*	FR2	Senior Strategist	Mid-sized Swedish fire and rescue service	Fire & Rescue

Date & Length	Code Name	Role	Organisation	Industry
21 Apr *~35 min*	A1	Digital Lead Smart Farming Services	Large Nordic agricultural services cooperative	Agriculture
21 Apr *~35 min*	P2	Maintenance Manager	Swedish electricity distribution network operator	Power Grid
22 Apr *~35 min*	P3	Head of Network Construction	Swedish municipal energy company	Power Grid
22 Apr *~20 min*	P4	Head of Grid Projects	Swedish municipal energy company	Power Grid
24 Apr *~45 min*	FR3	Mine Rescue Specialist	Swedish fire and rescue service	Fire & Rescue (Mining)
24 Apr *~45 min*	A2	Head of R&D	Large Swedish agricultural cooperative	Agriculture
27 Apr *~50 min*	F1	Project Lead	Swedish forestry research institute	Forestry

Table 3.1: Overview of interview respondents

3.5 Data Analysis

The purpose of the data analysis was to systematically convert the collected empirical data into strategic insights able to answer the research questions. As the study aims to evaluate market opportunities for a technologically complex innovation, an analysis of the collected data was done continuously and followed the structure in the Market Opportunity Navigator framework. The process aimed to systematically transform unstructured data from workshops and interviews to strategic insights validated through secondary data. The data analysis was divided in three phases: identification, evaluation and prioritization.

3.5.1 Data Analysis of Workshops

The analytical work following the workshops focused on converting a large volume of unstructured raw data into structured and manageable set of market opportunities that could guide the interview and validation phase. The output from both workshops was organized into a series of tables, separating the identified capabilities, general applications, customer groups and specific use cases. This organization made it possible to trace the logical chain from a core technological capability through to a proposed market opportunity, and to identify cases where the connection was speculative or weakly grounded.

Screening of the workshop output applied two criteria in combination: feasibility and relevance, drawing on Eira Systems' core capabilities and the insights generated through the literature review. Since in-depth interviews could not be conducted for every identified opportunity, industries were assessed at a surface level against whether the operational environment plausibly demanded the type of capability. This delimitation was deliberately kept light, as more rigorous evaluation would have required assumptions only testable through direct market interactions. The second criterion was whether credible interview respondents could be identified and reached. The second filter was not purely logistical, in several cases, the difficulty of reaching respondents itself signalled how open or closed an industry was to external technology providers. The screening process was iterative, with some industries added or removed from consideration as early conversations revealed adjacent opportunities or showed that initial assumptions were unfounded.

3.5.2 Methodological adaptation

A deliberate methodological adaptation was made at this point regarding the level of specificity at which market opportunities were defined. The MON framework defines a market opportunity at the level of a specific application combined with a specific customer group. In this study, however, opportunities were first defined at the industry level rather than at the level of a specific application within the industry. This choice reflected the nascent state of Eira Systems' technology and the high uncertainty surrounding which specific applications within a given industry will prove most commercially viable.

3.5.3 Interview and Secondary Data Analysis

Data analysis in the second phase was conducted as a theoretical thematic analysis based on the guidelines developed by Braun and Clarke (2006). The approach was deductive, where the Attractiveness Map's evaluation criteria acted as a predetermined coding framework. The aim was to systematically triangulate qualitative insights from the semi-structured interviews, quantitative secondary data and strategic limitations from internal data to populate the Attractiveness Map. The process followed five steps, based on the six-step thematic analysis framework by Braun and Clarke (2006), combined with the methods from the market opportunity navigator proposed by Gruber and Tal (2017), with case specific adjustments.

The initial step focused on preparing and organizing the different datasets. Transcripts from semi-structured interviews were reviewed to ensure accuracy, with researchers immersing themselves in the data, a process Braun and Clarke (2006) describes as vital in familiarizing with the data. This was followed by an iterative coding process where data was mapped directly against the six parameters in the Attractiveness Map. Because the analysis is theoretical, the coding was driven by the framework specific dimensions rather than open research.

Once the data were coded into their respective theoretical themes, a synthesis phase followed to triangulate the magnitude of each parameter. Importance of the identified incident was analysed to decide if the need for the latter layer solutions were of incremental improvements or a critical necessity. In this step the synthesized data was translated into a qualitative evaluation (low to super high) in accordance with the Market Opportunity Navigator, for each of the six parameters and layers (Gruber & Tal, 2017). Each author independently ranked every industry across all layers, after which the individual rankings were compared and discussed jointly to determine the most appropriate score.

Once the industry evaluations were completed, specific applicatons were analysed to find the best target for Eira Systems. Selection was based on industry evaluation combined with product fit and strategic alignment with Eira Systems and was moved on for further evaluation. Here, the application scores were discussed regarding potential adjustments, especially in areas where what product was built has a high impact, such as implementation obstacles. The final step integrated the scores into the Attractiveness Map. The individual scores aggregated into a collective value for Overall Potential and Overall Challenge respectively.

3.5.4 Prioritization and market selection

In the final phase of the analysis, the results from the Attractiveness Map were synthesized to determine the optimal market entry strategy for Eira Systems. While the Attractiveness Map provided a visual distribution of opportunities based on Potential and Challenge, the selection process is rarely a binary choice (Gruber & Tal, 2017). It requires a deeper analytical layer that incorporates the firm's specific risk profile, internal values, and technological synergies.

The prioritization went beyond external data by integrating qualitative insights from internal interviews. The decision-making framework weighed the Attractiveness Map against Eira Systems' core values, internal technical roadmap, and the team's specific expertise. This strategic fit ensured that the chosen habitat was not just profitable on paper but also feasible within the current organizational constraints. Further, to optimize resource allocation, the analysis incorporated analysis regarding relatedness (Gruber & Tal, 2017). Even if two opportunities appeared similarly attractive, we prioritized the one that shared the highest degree of technological fungibility or capability overlap with secondary markets.

3.6 Research Quality

Research quality in qualitative case study research is evaluated differently than in quantitative research. Following Elo et al. (2014), this study addresses research quality through the criteria of credibility, dependability, confirmability and transferability, originally proposed by Lincoln and Guba (1985).

Credibility is strengthened through our purposive sampling of respondents with direct operational and strategic expertise, ensuring that the data reflects genuine industry knowledge rather than peripheral observations. The use of open-ended semi-structured interviews reduced the risk of leading respondents toward predetermined conclusions.

Transferability is limited by the single-case design and the restricted number of interviews per industry. The findings should be treated as suggestive of broader patterns rather than definitive conclusions, as discussed further in the next section. However, to support transferability, the study provides detailed descriptions of the respondents' roles and industry contexts, alongside rich descriptions of each industry analysed, allowing readers to assess the degree to which the findings may be relevant to other deep-tech ventures or markets, consistent with the recommendations of Elo et al. (2014).

Dependability is addressed through a structured and documented analytical process. The thematic analysis followed a predetermined coding framework based on the MON dimensions, ensuring consistency across industries. Interview guides were developed in advance with a consistent set of core questions mapped to the MON dimensions, while specific questions were adapted to each respondent's industry context and area of expertise, consistent with the semi-structured interview format (Adams, 2015).

Confirmability is addressed by the authors acknowledging that scoring MON dimensions involves subjective judgement, and to mitigate this, assessments were discussed and agreed upon jointly by both authors throughout the analysis, consistent with the recommendation by Elo et al. (2014) that analysis performed by more than one researcher increases comprehensivity and interpretive soundness. Nevertheless, it is acknowledged that involving additional independent raters to compare rankings would further strengthen confirmability.

3.7 Limitations

Several limitations should be considered when interpreting the findings of this study. Most fundamentally, the study is based on a single case, Eira Systems, which means that both the strategic recommendations and the framework adaptations proposed should be treated as provisional rather than fully generalisable conclusions. The number of interviews per industry ranged from one to four, which is sufficient for identifying patterns between sectors but too limited to make strong generalisations within any individual sector. The study is further limited geographically to the Swedish and Nordic context, and the regulatory, cultural and competitive conditions identified may not transfer directly to other markets.

3.8 Ethics

The execution of this study followed established ethical guidelines for academic research to ensure the integrity of the data and the protection of all participants, guided specifically by the four primary requirements of research ethics: the information requirement, the requirement of consent, the confidentiality requirement, and the utilization requirement (Vetenskapsrådet, 2017). In accordance with Bryman and Bell (2011), the study prioritized informed consent and the prevention of harm to participants by briefing all individuals involved in the identification workshops and semi-structured interviews on the study's purpose and their right to withdraw at any time without penalty. This transparency was particularly crucial given the strategic and sensitive nature of discussions regarding autonomous systems and dual-use technology.

Due to the high-stakes industries involved, anonymity was a primary concern throughout the research process. Therefore, all primary data was de-identified to mitigate the risk of disclosing competitive intelligence or sensitive operational data (Bryman & Bell, 2011). Respondents are referred to by generic titles, and specific organizational details were omitted to protect the commercial interests of the participating firms. Furthermore, it was ensured that audio recordings and transcripts were stored on secure servers with access restricted solely to the research team. In line with the utilization requirement (Vetenskapsrådet, 2017), the collected data was used exclusively for the purposes of this specific research project and will be disposed of upon the completion and final examination of the study.

3.9 Use of AI

AI tools have been used to support the writing of this report. Tools such as Gemini were used to improve the linguistic quality, such as spelling, grammar and structuring of sentences, to ensure that the content of the thesis was communicated clearly and precisely. This further assisted in keeping a consistent and professional tone, contributing to the flow of the report. Even though AI tools offer great advantages when it comes to linguistic refinement, using it comes with risk. One primary concern is the risk of the original meaning being subtly altered. Because AI tools prioritize fluidity and stylistic flow they can sometimes rephrase technical descriptions in a way that subtly alters the original intent or affects scientific accuracy.

Another risk involves losing the voice of the authors or the introduction of hallucinations, where the AI can suggest additions that are not supported by the research data. To eliminate, and minimize, these risks a human-first or human-in-the-loop approach was always maintained when using AI tools. It is important to note that all ideas, arguments, and conclusions are that of the authors own, and all AI generated refinements and suggestions were reviewed and edited thoroughly to ensure accuracy, academic integrity and preservation of the original intent.

4

Market Opportunity Case Analysis

This chapter presents the empirical analysis of Eira Systems' market opportunities, structured around the three stages of the Market Opportunity Navigator. The chapter is organized as follows:

Section 4.1 reports the results of the two identification workshops, documenting how the initial Market Opportunity Set was generated and how eight industries were selected for deeper evaluation. Section 4.2 constitutes the core of the analysis, evaluating each industry against the six dimensions of the Attractiveness Map across the three autonomy layers. Each industry is assessed dimension by dimension, with each dimension scored on a four-point scale from Low to Super-High. These scores are then aggregated into overall Potential and Challenge values, which are summarized in a comparative table at the end of section 4.2. Section 4.3 shows the application-level screening that narrows the analysis from industries to four specific use cases, which are subsequently plotted on the Attractiveness Map. The industries which contains the applications selected to move forward are fire & rescue services, mining and nuclear. Section 4.4 then translates these findings into a go-to-market strategy using the Agile Focus Dartboard, assigning each application a strategic role and resource allocation decision. An overview of each industry analyzed and its current use of UGVs and aerial drones, as reported by the respondents, is provided in Appendix B.

4.1 Initial Ideation and Screening

The two structured workshops were conducted to generate the initial Market Opportunity Set, together producing over 100 specific market applications across a broad range of industries and customer groups. Across both workshops, 27 unique industries or customer segments were identified, of which 17 emerged from workshop 1 and a further 10 from workshop 2.

The two workshops produced notably different outputs. Workshop 1 generated broader and more general applications such as transport of people, general rescue, agriculture and handling of hazardous goods, while workshop 2 quickly became more specific than planned, producing applications such as mountain taxi, powerbank and drowning accidents. Despite this difference in specificity, looking at the output in retrospect, all eight industries subsequently analysed in stage 2 were represented in workshop 1 alone, and approximately nine of the specific applications identified there later surfaced concretely in the interviews. Workshop 2 contributed additional breadth but only around three independently new applications that appeared in the interviews, largely overlapping with workshop 1.

The eight industries selected for analysis emerged from a combination of three sources. Several appeared consistently across both workshops, including agriculture, mining, forestry, electricity grids, nuclear and rescue services, suggesting a robust initial signal of relevance independent of any single ideation session. The rescue services were additionally pre-identified by Eira Systems before the workshops began, reflecting an existing strategic interest in that domain. A further subset, including infrastructure inspection and mining, was reinforced by the literature review, where GNSS-denied navigation challenges in underground mines and infrastructure inspection environments are explicitly identified as frontier application areas for UGVs. These industries also showed ongoing research projects and implementations. Construction emerged primarily from workshop 1 and subsequent interview access. The final selection was further shaped by the ability to identify and reach credible respondents, which as noted in the methodology also served as an early signal of how open a given industry was to external technology engagement.

4.2 Opportunity Evaluation

In this chapter, each industry is analysed separately and on an aggregate level. The six dimensions of the Attractiveness Map, three assessing potential and three assessing challenge, will serve as the basis for evaluation, with innovation and market theories strengthening the analysis. The industries in which interviews have been conducted will be analysed one by one, with the different use cases within them being part of that industry's section. Later on, this will help guide the selection of a few applications that will be plotted on the attractiveness map. Each criteria within each industry and with each layer will be evaluated as either low, mid, high or super-high based on the results of the interviews combined with product specific parameters described below in 4.2.1.

4.2.1 Technology-specific Characteristics

Before diving into the individual industry analyses, it is worth establishing a set of product-specific characteristics that apply across industries, based on the interview with Eira Systems and general observation of the industry specific interviews. They are intended to provide a reference point to avoid repeating the same reasoning across every industry section, but should be understood as general tendencies rather than absolute rules, since the relevance of each characteristic will vary depending on the specific operational context.

Layer 1 remote control requires a dedicated human which limits its ability to reduce labor costs in contexts where labor reduction is the primary value driver, since the operator remains a fixed cost of operation. At the same time, Layer 1 carries a lower upfront cost and lower technological complexity than higher layers, which may make it an accessible entry point in industries where the primary value is remote access to difficult or dangerous environments, or where customers want to test autonomous concepts before committing to full autonomy. Its attractiveness therefore depends considerably on what specific problem the customer is trying to solve.

Layer 2 standard autonomy removes the operator dependency and enables the vehicle to follow pre-planned paths independently, which addresses the core value proposition of reducing labor and enabling continuous operation in many industrial contexts. However Layer 2 remains dependent on GNSS and external communication links, meaning its operational reliability is contingent on signal availability. In most open outdoor environments this is unlikely to be a limiting factor, but it does represent a potential ceiling on operational reliability in environments where signals may be disrupted or obstructed.

Layer 3 signal-independent autonomy removes this dependency by enabling the vehicle to navigate entirely through onboard sensors without relying on GNSS or radio links. This is Eira Systems' core differentiating capability. However it comes with inherent trade-offs: higher technological complexity means longer development time, higher unit cost, and a price point that in most cases will need to be justified by a genuinely critical operational need. Across industries, a central analytical question for Layer 3 is therefore whether the specific operational environment creates situations where GNSS-denial is a sufficiently real and costly problem that standard autonomy cannot adequately address.

With these product-specific tendencies established, the following sections analyse each industry on its own terms, focusing on what is specific to that context rather than restating what is already generally true of the layers. To see a more detailed explanation of the current use cases and development of autonomous vehicles within each sector, see Appendix B.

4.2.2 Agriculture

Compelling Reason to Buy

Multiple high-friction jobs exist in agriculture where current solutions fall short, with chemical spraying standing out across both interviews. A1 highlights how camera-equipped aerial drones can optimize pesticide dosage, reducing chemical input in a regulatory and cost context where this matters significantly, while A2 points to the physical discomfort of operating in chemical environments as a further motivator. Mechanical weeding is described as completely unfeasible manually, and labor scarcity and cost are identified as core value drivers across the industry broadly. A2 describes harrowing for hours as genuinely unpleasant even for machine-enthusiastic operators, suggesting automation would be welcomed rather than merely tolerated. Further, both respondents are unambiguous that the primary value driver in agriculture is economic efficiency. A1 states directly that the main driver is always whether the farmer can save money and become more efficient, and that any sales conversation must answer concretely how many people can be saved and what the farm-level savings are.

Among the layers, the compelling reason to buy is clearest for Layer 2. A2 confirms that tractors already largely drive themselves, meaning standard autonomy represents a natural and incremental next step with labor and productivity gains that farmers can readily quantify. For Layer 3, the case is weaker in the general agricultural context today. However, as full autonomy becomes the industry norm and GNSS dependency deepens across operations, this might change. Kim and Mauborgne (2005) argue that blue oceans emerge when a solution creates entirely new demand rather than competing within existing boundaries and GNSS-independent navigation could at that point define a new category of resilient autonomous systems that standard autonomy cannot substitute, particularly given that GNSS jamming is already documented as a real operational problem in the Baltic countries according to A1.
Assessment: *Low for Layer 1 / High for Layer 2 / High for Layer 3*

Market Volume
Agriculture is a large industry with a total production value of SEK 90.7 billion in Sweden in 2025 (Jordbruksverket, 2026), yet despite this scale the production structure is highly concentrated. A2 notes that 80% of production is carried out by 20% of farmers, pointing to a professional segment that increasingly operates at an industrial scale rather than a traditional smallholder model. These large professional farms possess the risk tolerance and financial resources characteristic of early adopters, while smaller hobby farmers map onto the late majority, described by A2 as likely to follow only once systems are fully standardized.

The long-term volume trajectory is significant. A2 envisions retrofitted autonomy systems becoming widespread within 10 years, with a full generational replacement of equipment within 30 years. However, the short-term addressable market is narrower, limited largely to the professional farming segment already on the early part of the adoption curve. Furthermore the number of viable use cases and the addressable market within each case are considerably broader for Layer 2 and Layer 3 than for Layer 1.
Assessment: *Low for Layer 1 / High for Layer 2 / High for Layer 3*

Economic Viability
The economic conditions for building a profitable business in agriculture are constrained across all three dimensions Gruber and Tal (2017) identify. On margins, A2 describes Sweden as a challenging location for competitive farming, with thin margins that limit willingness to invest in unproven technology while simultaneously creating pressure to find efficiency gains which UGV's may entail. On willingness to pay, A1 is explicit that any sales conversation must answer concretely how much money the farmer saves. The authors note that given these thin margins, willingness to pay for a premium Layer 3 capability is unlikely unless it addresses a

specific and quantified operational failure. On stickiness, A2 highlights a significant switching cost dynamic where adopting a smaller autonomous tractor requires replacing existing implements sized for larger conventional machines, which he frames as requiring farmers to "go all-in." Retrofitting existing tractors with autonomous systems rather than full replacement is identified as a more accessible intermediate path, though tractors averaging a 20-year lifespan makes any fleet transition slow and capital-intensive. Burnham et al. (2003) identify financial switching costs as often exerting a stronger influence on retention than product satisfaction, and this dynamic is clearly visible here.
Assessment: *Low for Layer 1 / High for Layer 2 / Low for Layer 3*

Implementation Obstacles
The implementation obstacles in agriculture are significant and multi-dimensional. Hannan and Freeman (1984) argue that structural inertia is strongest at the organizational core, and in agriculture this is clearly visible. A2 describes how farmers have built up entire ecosystems of implements, such as harrows, ploughs and seed drills, calibrated to fit their existing tractors. Introducing a new autonomous tractor that does not match this existing equipment disrupts not just the vehicle but the entire operational core of the farm, since all implements would need to be replaced simultaneously. The respondent frames this as requiring farmers to go all-in, raising the initial investment threshold considerably.

A1 highlights two further frictions. First, the logistical challenge of transporting vehicles between different fields, where field boundaries function as safety zones and current systems cannot navigate between them autonomously which significantly weakens the business case compared to large-field markets such as the US, Canada or China. Secondly, while respondents from other industries focus on how UGVs improve safety by removing humans from danger, these respondents mentioned how autonomous ground vehicles may introduce new liability risks around incidents. Responsibility and insurance coverage for such incidents remain legally unclear, creating a psychological and financial barrier.

The authors note that Eira Systems' platform, designed primarily as a robust transport vehicle for difficult terrain, differs fundamentally from the purpose-built agricultural machinery that dominates the sector. The primary use cases identified in the interviews, chemical spraying, mechanical weeding and soil preparation, require specialised implements and precision at low speeds that may go beyond Eira Systems' core transport capability. A further concern is ground pressure: agricultural operations require careful weight distribution to avoid soil compaction, a constraint that a two-tonne off-road vehicle is not inherently designed to meet. However, selling the navigation system itself to be able to add to current systems may be an alternative.
Assessment: *High for Layer 1 / Super-High for Layer 2 / Super-High for Layer 3*

Time to Revenue
The early adopter segment of large professional farms is already present and pos-

sesses the technical competence required to handle automation. A1 notes that these farmers already work with field boundary software and route optimization tools, shortening the cognitive distance to autonomous systems compared to less digitized industries. However the transition to the early majority is likely to be slow. A2 describes this segment as wanting "finished systems that work," consistent with Moore (2014) pragmatist customer who requires proven references and complete product ecosystems before committing. The current state of autonomous agricultural systems, where even proven solutions like AgXeed require certified personnel for zone setup and cannot yet navigate between fields (A1), suggests the chasm has not yet been crossed. The insurance gap identified by A1 compounds this: without insurers willing to cover autonomous vehicle incidents, commercial scaling is blocked regardless of technical maturity, and the respondent suggests public-funded risk validation projects would be a necessary precondition for mainstream adoption.

A further delay is embedded in the equipment replacement cycle itself. A2 notes that tractors have an average lifespan of around 20 years, and that farmers are unlikely to replace functioning equipment before it breaks down. For Layer 1, time to revenue could in theory be shorter given lower regulatory complexity, but the commercial use case is weak since it does not address the core driver of reducing labor. For Layer 3, the use case for GNSS-independent navigation is not yet widely recognized among farmers as a priority problem, making the time horizon the longest of the three layers. Once again, since the product differs significantly from Eira Systems' current vision, development would most likely take a while.
Assessment: *Low for Layer 1 / Mid for Layer 2 / High for Layer 3*

External Risks
External risk in agriculture is shaped primarily by regulatory, geopolitical and competitive factors. Legally, the regulatory bottleneck around certification, the public road restriction and the insurance gap have already been discussed and together they represent a persistent external barrier to commercial scaling that Eira Systems cannot directly influence.

Geopolitically, the GNSS jamming situation in Baltic countries creates a dual signal. It simultaneously validates the need for GNSS-resilient systems and represents an external risk to all Layer 2 systems currently dependent on GNSS. A2 frames this as a national security concern, noting that regulatory requirements for GNSS-free or manual operation fallback may eventually follow, making this one of the few external risk factors that works in Layer 3's favor.

Competitively, the market is increasingly active, with John Deere, Fendt, Valtra, Claas and various startups all investing in autonomous agricultural systems. A2 believes John Deere has progressed furthest, and Claas has invested in a driverless tractor startup covering tillage, seeding and haulage. Kim and Mauborgne (2005) describe this intensifying head-to-head competition as characteristic of a red ocean where prospects for profitable growth are reduced as products become commoditized. For Layer 2, Eira Systems would be entering precisely this red ocean. For

Layer 3, competition is lower but the market need is also not yet validated at scale, making it a high-uncertainty space rather than a clear blue ocean.
Assessment: *Low for Layer 1 / High for Layer 2 / Mid for Layer 3*

4.2.3 Infrastructure Inspection

Compelling Reason to Buy
I2 describes how Railway inspection in Sweden relies on dedicated camera-equipped vehicles running every eight to ten weeks, with manual inspection still required for certain components and daytime inspection in high-traffic urban areas largely impossible due to train conflicts. Snow further prevents inspection of certain components during winter in northern Sweden, and the respondent notes that even routine track presence carries an elevated safety risk, making personnel removal a further motivation (I2). I2 ranks the value drivers of automation clearly as inspection quality first, cost efficiency second and personnel safety third. Applying the Blue Ocean lens of Kim and Mauborgne (2005), this represents a fundamental trade-off between inspection frequency and operational disruption that current solutions optimize within rather than eliminate. A UGV capable of moving off-track when trains pass and operating independently of timetables would reconstruct this constraint entirely, creating value that neither current rail-mounted inspection vehicles nor aerial drones can fully replicate.

For Layer 1, a dedicated operator per vehicle does not meaningfully reduce the scheduling constraints that drive the need, limiting the compelling reason to buy. For Layer 2, the ability to operate without an operator and move off-track independently addresses the core pain directly. For Layer 3, the railway environment is predominantly open and outdoor, meaning GNSS-denial is not a real operational constraint in normal conditions. Tunnels may be an exception where the respondent confirms inspection takes place, though they do not raise signal availability as a concern and the authors treat this as speculative rather than validated.

For road infrastructure, the open environment means Layer 2 standard autonomy is largely sufficient for the monitoring jobs I1 describes such as real-time pothole detection. For Layer 3, I1 directly states that GNSS resilience will become a requirement in the future as jamming incidents are already increasing validating the need for Layer 3 directly, though it comes from a research perspective rather than an active procurement decision-maker.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Market Volume
The infrastructure inspection and maintenance sector represents a significant scale in Sweden. Trafikverket's annual spend on railway maintenance reached approximately SEK 17.7 billion in 2025, covering the state-managed railway network, with road maintenance adding a further SEK 18.2 billion, together illustrating the enormous capital committed to keeping national infrastructure operational (Trafikverket,

2025). Institutional research interest in condition monitoring is further reflected in I1's company's active project portfolio, where I1 notes roughly a fifth to a quarter of their approximately 200 projects concern operations and maintenance.

However the customer base is dominated by public sector institutions. I2 describes current digital inspection as still in pilot phase and anticipates regulatory adaptation taking roughly two years. Moore (2014) characterises this type of customer as pragmatist, requiring proven references and complete solutions before committing at scale, suggesting near-term volume is likely limited to pilots and incremental expansions rather than broad deployment.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Economic Viability
I1 identifies a fundamental structural problem around willingness to pay. Even where the societal value of automation is clear, the economic benefit frequently falls to a budget disconnected from the one bearing the procurement cost. She illustrates this with the example of robots preventing elderly people from slipping on ice, where the savings land in the regional healthcare budget while the procurement cost falls on the municipal infrastructure budget. The respondent also raises combining services as a potential workaround, for example a robot that simultaneously delivers food and sweeps the street. However they are equally clear that this is difficult to make work in practice. Tax-funded procurement structures further constrain willingness to pay, and I1 notes that smaller machines are easier to sell into this sector than large ones requiring extensive validation periods.

For railway inspection specifically, the regulatory requirement to inspect at fixed intervals means the need is recurring and does not disappear, which in principle supports stickiness once a solution is established and trusted. Further, the procurement model through contracted firms and competitive tendering however suggests limited pricing flexibility regardless of the value delivered indicating low margins for Eira Systems.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Implementation Obstacles
The most immediately visible implementation obstacle is rooted in professional identity. The safety management system has been built around the certified inspector's judgment and authority, and when camera-based systems began detecting faults that manual inspectors had missed, the result was what the respondent describes as a genuinely sensitive internal discussion. Hannan and Freeman (1984) argue that inertia is strongest in systems built around human judgment and accountability, and the authors note this obstacle is likely to increase as autonomy level rises, since a fully autonomous system represents a more direct challenge to the inspector's role than a remote controlled one where a human operator remains visibly in control.

I1 reinforces the broader institutional pattern from the road maintenance side, warning that arriving with a finished product and expecting rapid adoption will not work and that end customers must be involved early. The budget misalignment identified under economic viability further compounds the implementation challenge, since the party responsible for procurement is often not the one that would benefit from the solution, making internal advocacy for the investment difficult.

The physical environment presents specific technical challenges. Railway corridors require precise low-speed manoeuvring in narrow safety-critical spaces, and I2 notes that vehicles must be able to clear the line independently when trains pass. Operating in live road traffic places further demands on real-time obstacle detection. I1 notes that the primary value driver in the sector is condition monitoring rather than transport, meaning Eira's platform would require significant additional instrumentation to be relevant.
Assessment: *High for Layer 1 / High for Layer 2 / High for Layer 3*

Time to Revenue
For Layer 2, the early adopter phase is already underway. I2 confirms active pilot projects and describes digital inspection as a current high strategic priority, suggesting the path to initial revenue is shorter here than in industries where autonomous systems are not yet piloted at all. However the regulatory requirement for human verification of automated findings creates a delay. The respondent is explicit that current rules require a person to physically verify any anomaly before a maintenance decision can be made, and estimates this will change in approximately two years. Until then, full commercial deployment at scale is constrained regardless of technical readiness.

For Layer 3, while I1 anticipates that GNSS resilience will become a requirement, this has not yet translated into active procurement demand. Anticipating a future need and actively seeking to purchase a solution are meaningfully different positions, and given the slow-moving budget cycles and regulatory processes characteristic of this sector, the time horizon remains medium to long term. Adding robust monitoring systems will also add to the development time.
Assessment: *Low for Layer 1 / Mid for Layer 2 / High for Layer 3*

External Risks
I1 notes that airspace rights for aerial drones remain legally ambiguous, with responsibilities fragmented across multiple authorities, and that noise and safety concerns in populated areas create additional friction. Ground-based UGVs face a comparatively clearer regulatory path, particularly on managed corridors such as railway lines, which is a meaningful external risk differentiator in favour of ground-based solutions across all layers.

Competitively, I1 points to NIRA Dynamics as one example of a data-focused new entrant successfully disrupting road condition monitoring, suggesting the landscape is not entirely closed to new entrants. Beyond this single example however the interviews provide limited basis for a broader competitive assessment, and the authors note that the business model challenge of identifying who will actually pay is as

significant a market entry barrier as any direct competitive threat.
Assessment: *Low for Layer 1 / Low for Layer 2 / Low for Layer 3*

4.2.4 Power grids / networks (Cables)

Compelling Reason to Buy
The respondents identify several operational problems where an autonomous UGV platform appears to be a valid solution. The central unsolved needs in the sector are a combination of security risks and information quality. P3 sees firsthand how a UGV following along an open shaft can record cable locations and replace manual site-manager visits, confirming a potential business case. P4 sees potential in autonomous pre-surveying of cable locations prior to excavation, a need P4 on one hand could se working with manual ground-penetrating radar, but on the other hand do not believe would be as scalable as a UGV solutions. The primary driver for both cases is to reduce risk of excavators damaging unknown infrastructure, with both describing deviations of several meters between what is documented and reality, also posing a physical risk to personnel.

P2 and P1 emphasizes that personnel today must be in close proximity to live lines and equipment to perform inspections, something the organizations want to change. P2 describes how helicopters were replaced by aerial drones precisely to take personnel away from the lines, a decision where safety outweighed the cost, and argues that the same logic applies to ground-based systems. P2 also sees a clear fit for autonomous patrolling in switchyards, a confined and well-known environment that suits the type of repetitive autonomous driving a UGV offers. He assesses the regulatory hurdle as lower for a ground based vehicle rather than for an aerial drone in the same environment. One use case he believes in for ground based vehicles is pole inspection, but the fit is more technically demanding as the mission requires physical interaction with the pole in addition to movement, which requires specialized tooling in addition to the platform itself.

P1 nuances the picture and assesses that ground based systems are generally better suited to closed and structured environments than open terrain, and that fully autonomous operation in sensitive facilities is still somewhat in the future. P1 summarizes by saying that the vehicle is fundamentally a sensor platform and that it is sensor data that creates the value. P1's assessment points to remote operation, Layer 1, being the realistic approach in the most regulated environments, while Layer 2 autonomy is well suited for the limited and repetitive cases such as switchyards and excavation work. Layer 3, GNSS-independent navigation, addresses a narrower but real unmet need in tunnel environments and facilities with blocked GNSS-signal, environments in which P1 already operates with flying systems and which none of the other solutions on the market fully cover.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Low for Layer 3*

Market Volume
The sector is characterized by massive geographical spread but fragmented demand.

P2 describes their power grid as approximately two laps around the globe, and P3 describes continuous excavation projects (shafts) of several kilometers that run in parallel in several network types within the same city. The theoretical number of inspection points and project opportunities for the technology is thus large, but is limited by P1's distinction between standardizable applications with repetitive logic and unique assignments where each inspection is sufficiently different that the economies of scale of autonomy are reduced. Sweden's electricity grid spans approximately 600,000 km across all voltage levels and network types (Energiföretagen Sverige, 2024).
Assessment: *Mid for Layer 1 / High for Layer 2 / Mid for Layer 3*

Economic Viability
No respondent describes a positive short-term economic outcome compared to the current method. P1 notes that aerial drones for powerline inspection today cost about the same as helicopters, and that adoption is still happening because more defects are found, personal risk is reduced and the CO2 footprint is lower. P2 confirms that P2's company deliberately pays a higher price at an early stage to sponsor technology development with the expectation that costs will decrease in the long term, a pattern consistent with Moore (2014) description of early market adoption in B2B where strategic buyers take a premium level in exchange for technology shaping and first-mover advantages. P3 and P4 see a more direct economic argument in documentation and preliminary investigation, where the consistent accuracy of an autonomous vehicle can replace recurring manual site visits and the indirect costs of excavation damage to misplaced lines or pipes.

An important distinction concerns who is actually the customer. P1 points out that the line inspection is typically procured every three years in competitive contracts, which means that it is the contractor who buys the technology and stickiness would be low. If however, the grid owner chooses to own the system itself, more likely for integrated facilities such as switchyards, the picture changes. P2's reasoning that their company actively sponsors suppliers' technology development and builds internal experience around specific systems points to a deeper dependence where switching costs rise.

In general, willingness to pay can be considered relatively high. However, Layer 1 provides limited cost reduction as the operator remains and use cases are limited, Layer 2 has the strongest profile for documentation and monitoring cases, and Layer 3 lacks a direct economic argument in the interviews.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Low for Layer 3*

Implementation Obstacles
The obstacles are of two types: technological requirements for the vehicle and systems requirements linked to critical infrastructure. P2 assesses that the terrain requirements in power line streets are a fundamental technical obstacle and that it is "a long way off" before a UGV can get there and perform inspections, and P1 confirms that ground systems are generally better suited to closed indoor environ-

ments, which indicates that the most urgent UGV cases and the current technical capacity do not yet fully coincide for the most difficult environments. P3, P4, and P1 independently highlight that critical status places strict restrictions on where data can be stored and how it can be transferred. P1 describes how aggregated data from facilities risks being SPCI-classified and requiring its own secured server solutions, an obstacle that affects all autonomy levels equally but that is potentially simplified with local data processing without wireless transmission. Organizationally, resistance to the technology shift is limited. P3 and P1 describe that personnel performing hazardous inspections readily welcome automation, while P4 mentions industry conservatism as a factor of inertia but not as a blocking obstacle.
Assessment: *Mid for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Time to Revenue
The gap between product maturity and market maturity is significant. P1's assessment is that integrated stationed systems in facilities are three to four years away, and that the immediate period is about using vehicles as tools that you take in and out with you, an iterative adoption logic where the first revenue might arise in pilot form. The sales cycle is a further obstacle since power line inspection is typically procured every three years in competitive contracts. It is a pattern that Christensen (1997) describes as institutional inertia, where the procurement structure slows down adoption regardless of technical maturity. Facilities with high self-control, such as switchyards and transformer stations, have shorter and more flexible decision cycles and are more realistic first markets. P3 describes short start-up times for pilots and supportive leadership, while P4 is at an earlier stage and is awaiting the results of ongoing ground radar tests.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

External Risks
The regulatory hurdle varies by environment. P3 assesses it as manageable in fenced-off shaft environments, whilst P2 raises the issue of open power line streets and believes that it is not realistic to obtain permission to drop a ground vehicle autonomously at one end of a line section and pick it up several kilometers later, and that the regulations would likely put a stop to it. He sees the switchyards as regulatory simpler precisely because a fenced off UGV cannot deviate outside the area in the way an aerial drone can.

Information security constitutes a more sector-specific external risk. P3 and P4 are uncertain whether cloud-based supplier solutions are compatible with the security protection requirements for critical infrastructure. P1 describes how aggregated plant data risks requiring its own secured server solutions, which limits which system architectures and suppliers are compatible with procurement requirements. This is a requirement that must be addressed early in the system design and potentially favors solutions with local data processing.
Assessment: *Mid for Layer 1 / Mid for Layer 2 / High for Layer 3*

4.2.5 Fire & Rescue Services

Compelling Reason to Buy

The fundamental purchasing argument for fire & rescue services is centered around protecting personnel in environments where the risk exceeds what is acceptable for human entry. FR1, FR2 and FR3 unanimously describe situations where existing solutions are inadequate. Examples of these are buildings with weakened structures where no personnel can go in, tunnels with single entry points hundreds of meters in, and mine shafts filled with fire and smoke where personnel advance at a couple of meters per second without GNSS or reliable radio coverage. The common feature is that the greatest need is not about efficiency but about accessibility. The technology is needed in situations where the alternative is to either accept an unacceptable personnel risk or leave the operation unfinished. All three respondents agree that the willingness to substitute personnel with technology is high in situations involving risk to personnel.

In addition to the purely life-threatening scenarios, FR1 highlights an operationally important but less urgent purchasing argument, which is to streamline logistics during forest fires and high alert. Today, experienced fire fighters drive water and equipment in rotating loops to supply the front, which takes qualified personnel from where they are needed most. FR1 describes how an operator monitoring 10 to 20 autonomous vehicles could replace this completely, freeing up personnel and reducing the physical strain over long distances and difficult terrain. The same logic applies to transporting injured people. FR1 points out that the distance between the vehicle parking area and the scene of the accident increases significantly during high alert, which forces firefighters to carry heavy equipment on foot before the work even begins. When transporting injured people, care must also be interrupted during the transfer, as simultaneous treatment and carrying is not possible. A transport platform would enable a paramedic to go along and treat during transport, something FR1 describes as a clear weakness at the moment. FR2 reinforces this through its multifunctionality argument. A platform that can handle logistics, equipment and transport injured people in varied terrain significantly strengthens the investment calculation. It is a purchasing argument mainly based on efficiency and personnel allocation rather than immediate safety risk, seen as concrete and economically justified.

How well Eira Systems' technology meets these needs depends on which layer is addressed. For Layer 1, the purchase need is commercially validated, Leo 1 is in operation and FR2 rescue service has made its own purchasing decision, but Eira Systems will need to differentiate because remote operation is already offered by established players. For Layer 2, the logistics argument is real and feasible, but the market has not yet taken the step from planning to procurement. For Layer 3, Eira Systems technology potentially meets a need that no existing commercial solution covers. FR3's description of the mining environment's navigation challenge and FR2's emphasis on GNSS independence becoming a requirement rather than an option point to a specified need that standard autonomy cannot meet. This extends beyond mines, collapsed buildings, underground parking, and tunnel environments

all share the same property of blocking external signals, meaning Layer 3 becomes a prerequisite for any meaningful autonomous operation in those contexts. FR2 adds a geopolitical dimension, where growing GNSS interference in the Baltic Sea region creates a vulnerability that may be formalized as a regulatory requirement, moving Layer 3 from a niche solution to a strategic necessity. Importantly, Layer 3 resilience is not only relevant to the navigation challenge in extreme environments, but also the logistics and casualty transport use case. A system dependent on GNSS or continuous radio link introduces a single point of failure in the scenarios where reliability matters most. A Layer 3 capable platform is therefore not only more operationally capable, but more trustworthy as a logistics solution in high-alert and crisis situations, where infrastructure cannot be assumed to function.
Assessment: *High for Layer 1 / High for Layer 2 / Super-High for Layer 3*

Market Volume
Sweden has approximately 120-130 fire & rescue service organizations with varying sizes and resources. From large associations to individual municipal administrations with less than 10 000 inhabitants (FR1). FR1's Leo 1 is the first firefighting robot in the country and FR2's is the only other organization that has so far made its own purchasing decision, with FR1 assessing that more will follow. The organizations are formally independent but cooperate in practice through resource pooling agreements, where FR2 describes how their command center serves 14 municipalities. FR2 notes that it is not reasonable to expect that every organization should be able to afford it, and that municipalities in northern Sweden with the greatest operational needs often have the least financial resources. The cooperation structures mean that the number of actual purchasing units is likely to be lower than the number of organizations, but that a purchase can cover a wider area.

For mine rescues the volume is limited by the fact that these operations requiring external assistance from fire & rescue services take place approximately every five years in smaller facilities and possibly once a year in the largest ones (FR3). The volume is estimated to be potentially larger for simpler transport platforms for logistics in forest fires and during high alert, a segment FR1 identifies as broader and more frequent than the specific operational environments.
Assessment: *Mid for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Economic Viability
None of the respondents describe a direct cost reduction argument. FR1 and FR2 converge on a current price range of 2-4 million SEK, but that the price point probably have to come down closer to SEK 1-3 million, with tanker truck's cost of 5-6 million SEK as a benchmark, for wider adoption. The ability to pay is good among the larger rescue service associations as stable municipal operations, but FR2 is explicit that the obstacle is financial rather than motivational, and that the investment competes directly with vehicle purchases. FR1 suggests an incremental logic that partially addresses this which is adding an autonomous module to existing vehicles for around 1 million SEK of additional cost which would transform the decision from a discrete capital expenditure to an upgrade of the existing vehicle stock. FR2 adds

that multifunctionality may be a requirement for the investment to pay off. A platform limited to a single use case is used too rarely to justify the cost, while one that solves logistics, reconnaissance and transport in a broader spectrum of operations creates an acceptable calculation. Customer stickiness is assessed as moderate to high once the technology is integrated, as certification requirements and operator competence create switching costs (FR2, FR3).
Assessment: *Mid for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Implementation Obstacles
The implementation obstacles in fire & rescue services are of both technical and organizational nature. Navigation packages in GNSS-blocked environments are the single most important technical obstacle (FR3). To integrate underlying radar and positioning technologies for reliable orientation in smoke-filled underground environments has not yet been commercially solved and may be a challenge. FR1 notes that radio coverage underground varies physically in ways that cannot be predicted, and that real-time interpretation of sensor data requires operational expertise that is widely lacking in the sector. Further, a technical obstacle is the engineering tension that arises when a single platform is expected to reliably perform several different functions across environments that place conflicting demands on its design. A platform that operates in both outdoor offroad terrain and confined indoor environments, carry casualties, and switch between tasks without dedicated technicians on site, may face requirements that pull in different directions. Robustness, compactness, modularity and reliability might be difficult to optimize simultaneously.

At the macro level, public procurement under the LoU is the dominant structural inertia factor. FR1's three-year timeline from discussion to operation, imply that the cycle is long regardless of technical maturity, in line with Christensen (1997) description of institutional inertia. FR2 highlights an underestimated regulatory cascade. New equipment triggers certification and training requirements that are not reflected in the original investment calculation. Cultural inertia in command functions further reinforces this. Commanders making decisions to use the technology often lack sufficient understanding of its capabilities.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Time to Revenue
Layers 1 and 2 are in what Moore (2014) describes as the chasm, early adopters have acted but the technology has not reached the credibility required for the pragmatic majority to follow but there are indications that they are not too far away and that it is mainly a question of cost. The validation process is observation-driven and slow, driven by experience reports from pioneering organizations and pilot tests. For Layer 3, the picture is reversed. The technology requires further development and FR3 assesses that acceptance in extreme environments such as mines require an extensive period of demonstrated reliability under realistic conditions. The sales cycle is a limitation at all layers, as each organization constitutes a separate procurement unit under LOU. FR2's observation that control centers serving up to 14 municipalities could eventually enable shared investments is relevant, but this struc-

tural change takes time to formalize. For mining applications, the decision maker is with the mining companies rather than the fire & rescue services, which means a separate buying journey with a different time horizon and different investment criteria (FR3).
Assessment: *Low for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

External Risks
Legally, the right of the fire & rescue services to "interfere with the rights of others" provides a regulatory advantage that applies to all three layers. Vehicles can operate in a closed and legally controlled perimeter in a way that airborne systems do not, which reduces third-party liability and enables operations without complex permits that UAVs require (FR1). Geopolitically, GNSS jamming has a dual effect. It increases vulnerability of Layer 2 and at the same time strengthens the strategic argument for Layer 3. If requirements for signal-independent reserve capacity are formalized in the national security strategy, which FR2 assesses as likely, Layer 3 moves from a niche capability to a baseline requirement. Applied to Kim and Mauborgne (2005) framework, the Layer 1 segment presents a red ocean, where established players such as Rosenbauer and Milrem-based systems compete with known specifications and limited room for differentiation. Layer 3 represents a blue ocean, where signal-independent navigation in complex indoor and underground environments lacks commercially established solutions. FR3 adds that the mining niche's investment driver is primarily the cost of production shutdown rather than safety budgets, creating a third-party dependency that Eira Systems does not directly control but which, if addressed, could offer an entry route that bypasses the municipal procurement cycle.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Low for Layer 3*

4.2.6 Mining Industry

Compelling Reason to Buy
All three respondents converge on a description that M1 describes as "Dirty, Dangerous and Dull". Underground environments expose personnel to compound risk and some of these were brought up in the interviews. For example, seismic pressure waves at depth was experienced at one of the company's mines, while continuous diesel exhaust that requires a mandatory four-hour ventilation stop between 02:00 and 06:00 before personnel can return was experienced at another. M1 is clear that the primary investment motive is to move personnel from exposure to control rooms, and that machines, unlike humans, are insensitive to gases and can be run continuously. CM1 confirms this independence from a supplier perspective and identifies underground safety as one of the single strongest drivers, specifically for M1's company. The productivity argument follows directly. Ventilation hours represent unused production capacity that M2 identifies as an immediate opportunity for autonomous systems to activate.

Further, recruitment is a compounding challenge. M1 describes difficulty attracting the right competencies to remote parts of Sweden, where mines are often found, and notes that autonomous systems allow a small number of operators to monitor several machines simultaneously, reducing vulnerability to absence. M1 references a mine in Chile, 100 kilometres from Santiago, that runs largely remotely due to the near-impossibility of staffing it otherwise. CM1 notes the same reality in Australian mining, where 24/7 operations in remote locations make automation a necessity rather than an efficiency gain.

The economic necessity is separate from the safety argument. M1 formulates it as a competitive pressure. Non-ferrous metals are traded at global market prices and low concentration ore can only be profitable through high throughput and low unit cost. CM1 adds a TCO dimension, noting that personnel costs constitute a large proportion of cost per tonne in many markets, making any reduction in operator dependency directly visible in the plant's financial performance. M2 adds that gold prices have historically been too low to justify this type of capital commitment, but that current price levels create the conditions for the first time to seriously evaluate the investment.

Among the use cases that emerge from the interviews, two are particularly relevant to Eira Systems' platform. The first is internal transport of samples and small goods between units at large facilities, where M1 describes trials with smaller UGVs as a response to the impracticality of having personnel cover distances of several kilometers on foot, a format closely related to Eira Systems. The second one is ore transport within the mine, which M1 identifies as the highest priority area for autonomy overall, as it accounts for the largest proportion of time and requires the least human intervention of all underground tasks. M1's fleet of eleven autonomous trucks in their open-pit mine demonstrates the economic logic, with the same argument applying underground.

Suitability differs significantly between layers. Layer 1's requirement for a dedicated operator per vehicle leaves the financial and productivity challenge intact, but addresses the recruitment problem by allowing operators to work remotely. Layer 2 is GNSS-dependent and by definition cannot navigate underground, but addresses the productivity and recruitment drivers in open pit mines where GNSS is available. Layer 3 is the only layer that fully addresses the safety and productivity needs of underground environments, and no commercially established solution exists for this context. Combining Layer 3 autonomy with remotely controlled machines, is seen as the option with the strongest case.
Assessment: *High for Layer 1 / Mid for Layer 2 / Super-High for Layer 3*

Market Volume
The Swedish mining industry generated SEK 69 billion in turnover in 2024 across 13 active metal mines, with a total workforce of approximately 8,800 including subcontractors (Rudebeck, 2025). Sweden ranks ninth globally in mining investment attractiveness (Mejía & Aliakbari, 2026), reflecting both the industry's scale and its openness to new technology. To showcase the scale further, M1 manages an investment portfolio of 10+ billion SEK spread over more than 10 facilities in Sweden, the

northern Nordic countries and Ireland. CM1 adds that approximately 5 000 of the 150 000 trucks CM1's company sells annually operate in mining and quarrying environments, which provides a picture of the relevant machinery fleet. In Rogers (2003) framework, M1 exhibits early adopter characteristics with resources and willingness to co-develop technology with suppliers, while M2's pronounced wait-and-see attitude places them among the late majority and concentrates the addressable volume in the short term to larger players, thus drawing general conclusions about adoption characteristics here is difficult. Layer 2 is technically limited to open pit mines by its GNSS-dependency, while Layer 3 can address both open pit and underground mines.
Assessment: *Mid for Layer 1 / High for Layer 2 / Super-high for Layer 3*

Economic Viability
Economic viability is treated as a formal requirement in the industry. M1 describes a disciplined investment process where all major commitments must meet internal return requirements, although early test installations are classified as OPEX and provide some flexibility.

The underlying business case on the input side has been demonstrated in open pit mining as M1 acquired a fleet of autonomous trucks in one of their open pit mines which was economically motivated by the logic that low concentration ore can only be globally competitive through high throughput and low unit cost, which can be achieved through higher efficiency with vehicles replacing human staff. M2 illustrates that the threshold is also price-sensitive on the output side. The conditions for this type of investment are only now emerging as gold prices reach levels that support the capital commitment. CM1 puts break-even in operational terms and estimates that a business case is solid at uptime rates of 80-85% or above.

Customer stickiness is deemed high. M1 describes long-term test bed arrangements with suppliers built around mutual influence on product development, a form of partnership that Moore (2014) describes as strategic buyers who accept a premium in exchange for technology design. M2 notes that the replacement of a fleet of approximately 30 machines is a commitment of such a scale that the decision-making process is deliberately kept slow and requires board approval. Layer 1 retains the operator and thus offers only marginal cost reduction. Layer 2 is proven in open pit mining. Layer 3 has a higher initial cost but the lack of direct commercial alternatives in underground environments creates the conditions for a higher price point.
Assessment: *Mid for Layer 1 / High for Layer 2 / High for Layer 3*

Implementation Obstacles
Infrastructure is the most fundamental obstacle. M2 currently lacks WiFi or 5G coverage underground and describes connectivity as a near-necessary prerequisite, with network expansion starting the spring 2026. M1 has rolled out 5G in all mines but notes that remote-capable equipment and control room infrastructure are not yet fully developed with machine suppliers. The geometry of the ore bodies introduces a problem specific to smaller operations. M2 describes approximately 1

400 separate ore bodies in a labyrinth tunnel system, where each setup risks taking longer than the productive life of the relevant work area. M1's larger ore bodies allow a configuration to be kept in place for longer periods. CM1 adds a technical dimension with broader validity. Mining continuously changes the terrain the system must navigate, requiring constant map updates beyond what is needed in stable surface environments.

In addition, M1 and M2 notes that some tasks rely on sensory capabilities that technology has not yet reliably replicated, such as hearing how the rock reacts when drilling and feeling if a surface sounds hollow when scraping, creating potential technical challenges for Eira Systems to incorporate. These are predominantly Layer 1 applications that would also require specific tools and capabilities that might not be transferable, making the system less modular. For Eira Systems' sensor platform, wet gravel roads underground create a continuous cleanliness problem for cameras and sensors that require practical solutions to maintain operational reliability. The technical challenges vary significantly depending on the application and thus the implementation obstacles for Eira. The two use cases mentioned previously both fit well with Eira's capabilities, but the smaller size of the internal transport of smaller-goods case fits best with the current platform. Whilst the size and weight requirements for ore transport would require a significantly larger and stronger platform, even though the capabilities remain relevant.
Assessment: *High for Layer 1 / Mid for Layer 2 / High for Layer 3*

Time to Revenue
Layer 1 has the shortest path to revenue. Remote control does not require GNSS signal or the same level of regulatory certification, and the required connectivity infrastructure is now being actively rolled out at facilities such as M2's. Layer 2 is already generating revenue in open pit mines, where M1's open pit mine's deployment is live, but the layer is technically unsuitable for underground applications. Also, M1 estimates that the regulatory certification of autonomous vehicles is several years away, with smelters not expected to reach autonomous operation until 2028/2029. Layer 3 has the longest horizon. In addition to regulatory and infrastructure requirements M2 describes a process where trust in the technology must be built in stages and investment decisions of this magnitude require board approval. This corresponds to Moore (2014) description of pragmatic customers requiring proven references before committing, and M2 is clear that full autonomy underground is years away even for actors with their resources and ambitions. However, the combination of remote-controlled and Layer 3's sensor-driven autonomy is seen as a shorter step.
Assessment: *High for Layer 1 / Mid for Layer 2 / High for Layer 3*

External Risks
The regulatory barrier is described by M1 as definitive. The EU directive requires certification of specific components before autonomous vehicles can be approved, with time horizons of several years. Both M1 and CM1 note that China has advanced significantly faster thanks to a more permissive regulatory climate and that

European pace creates a competitive disadvantage for both operators and technology suppliers. CM1 adds that integrating AI risks further complicating the tech-certification process. A counteracting factor is that mines are private, closed facilities, which gives operators greater freedom to define their own safety protocols compared to public environments. Furthermore, third-party dependency is a barrier to entry. M1 describes established long-term collaborations with large OEMs, whose R&D resources are difficult for a new player to match. CM1 notes, however, their company is exploring more open interfaces to third-party solutions, which points to a possible path for a specialized underground autonomy to enter without having to displace established full-service players.
Assessment: *Mid for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

4.2.7 Forestry

Compelling Reason to Buy
F1 highlights three primary drivers towards automation, with the strongest being labor shortage. Recruiting operators to remote environments in boreal forestry is almost not practically possible. It is a need with no working current response and the situation is worsening over time and Layer 2 and 3 autonomy are the only categories that can actually reduce staff dependency. Layer 1 does not address it directly because the operator is only relocated, and current regulations require human presence in the machine's immediate vicinity, preventing true remote operation. The second driver is health risks. Operators in soil preparation are exposed to whole-body vibrations that F1 describes as directly harmful, providing a stand-alone argument for automation. The third is quality in planting, where the current system of seasonal workers on piecework contracts means that incentives for placement precision are lacking, a value that autonomous solutions can by definition provide and whose economic value is realized in the long term.

The use cases that F1 considers to be the most commercially realistic in the short term are linked to forwarding and log transport. The first is autonomous shuttles that autonomously transport logs to the landing site while the harvester continues to work, eliminating the need for a dedicated operator for the transport phase. The second is a companion vehicle, a lighter vehicle that operates on the same track as the driver-controlled forwarder and doubles the load per trip. F1 highlights that forwarders have reached their practical size limit without causing ground damage, which makes the companion vehicle a capacity-increasing alternative without increasing ground load. In both cases, the navigation requirements are simplified compared to fully autonomous systems, but the GNSS dependency remains as a vulnerability. This is where Eira's Layer 3 technology has its most concrete relevance. Forest land degrades satellite signals already under normal conditions, and F1 explicitly emphasizes that local signal-independent positioning is desirable to enable geofencing that cannot be interfered with from the outside, which is a functional requirement for safe autonomous operation in these environments.
Assessment: *Low for Layer 1 / High for Layer 2 / Mid for Layer 3*

Market Volume
F1 describes a limited market, where forestry machinery is sold in volumes too low to justify the development costs. Most field work is carried out by small to medium-sized contractors on behalf of forestry companies or forest owners' associations, and adoption among these contractors is likely to require financial support from the larger companies or associations, pointing to a prolonged and indirect purchasing process. Secondary data partly supports this. While the Swedish forestry industry accounts for 9–12 % of Swedish industrial turnover and invested SEK 65 billion in new technology, equipment and facilities between 2020 and 2024 (Skogsindustrierna, 2025), the directly relevant machinery market is narrow. Approximately 500 forwarders were registered in Sweden in 2025 (Skogen, 2026). Based on an indicative figure from 2018, the global cut-to-length market was estimated at roughly 3,500 units annually, of which approximately 60 percent are forwarders and 40 percent harvesters (Land Skogsbruk, 2018).
Assessment: *Low for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Economic Viability
F1 does not identify any existing business case for fully autonomous forestry machines. A central reason is the risk of unplanned stoppages. A more complex system has more points of failure, and the production environment demands continuous operation, which makes robustness an economic condition as much as a technical one. The remote-controlled soil preparation project provides a concrete negative reference case, where the technology was tested but found too expensive relative to the value of the measure. The forwarding-related use cases are described as having a clearer logic, but F1 sets an explicit condition: the technology must cost less than the combination of the existing machine and operator, a narrow cost window. Autonomous planting rests on a quality argument rather than direct cost reduction, which is more difficult to translate into a concrete business case in a context with short contracts. Burnham et al. (2003) identify financial switching costs as a central adoption barrier, and the primary customer category, resource constrained contracting companies, probably lacks the capacity to carry the investment.
Assessment: *Low for Layer 1 / Low for Layer 2 / Low for Layer 3*

Implementation Obstacles
The most common technical obstacle is sensor robustness. The forest environment combines extreme lightning conditions, dirt, moisture and temperature changes in a way that makes hardware with the right IP rating still fail in practice. F1 describes how cameras develop condensation and become unusable, and how vegetation hides objects in a way that neither LiDAR nor stereo cameras handle reliably in all situations. Terrain accessibility and local route planning is another key unresolved issue. Forestry operations require the machine to follow a specific route during ongoing work with limited margin of deviation, and F1 notes that many players have tested smaller machines and failed. The gap between demonstration-grade and production-grade robustness is therefore a direct and central product development obstacle for Eira Systems in this environment. In addition, GNSS coverage is a technical implementation barrier already at the system level. F1 notes that coverage is lacking at

many logging sites, making satellite positioning unreliable as a basis for autonomous systems regardless of regulatory barriers. For Layer 1, the primary implementation obstacle is not connectivity but legislation. The requirement for human presence in the immediate vicinity of the machine means that remote control is not permitted in practice, eliminating the operational benefit of the concept. Established machine systems and workflows create an organizational inertia in accordance with Hannan and Freeman (1984) which makes it difficult to introduce new technology to the contracting companies that constitute the primary customer category.
Assessment: *Low for Layer 1 / High for Layer 2 / High for Layer 3*

Time to Revenue
Most of the field work is carried out by small to medium-sized contractors on behalf of forestry companies or forest owners' associations, and adoption by these is likely to require financial support from the clients, which points to a prolonged and indirect purchasing process.

F1 draws a clear line between what has been demonstrated, autonomous soil preparation and planting since 2022, and what is commercially viable, and notes that the distance is large. AirForestry is used as a reference case. They have been working since 2020 and are not yet on the market. The closest thing to a commercial step is partial autonomy where individual steps are automated with the driver remaining, something that is already underway from several manufacturers. Applied to Moore (2014), the industry is early on the adoption curve without reference customers who can drive the transition to the pragmatist market. The sales cycle is further extended by the fact that purchase decisions are spread across a fragmented chain of contractors that probably require support from above to act. Layer 3 has the furthest path to revenue because the need for signal-independent navigation is not yet recognized as a priority problem in the industry.
Assessment: *Mid for Layer 1 / High for Layer 2 / Super-high for Layer 3*

External Risks
The most substantial external obstacle is the Machinery Directive (Maskindirektivet), which requires the manufacturer to prove that the machine is safe in all situations. F1 is explicit that it can not be lobbied away, and that it is more difficult to meet in unstructured forest land than in an agricultural environment. In addition, Swedish legislation requires human presence in the immediate vicinity of the machine, which in practice eliminates the labor-saving benefits of autonomy. F1 promotes the RISE model, a framework where machines demonstrate regulatory compliance against defined standards, as a possible way forward although an equivalent solution is missing for forestry today. Increased GNSS interference constitutes a growing systemic risk in a sector that is already dependent on GNSS. Geofencing via satellite is not permitted as a security solution and physical banding is required, which is operationally uneconomical. F1 explicitly emphasizes that local signal-independent positioning addresses both the security problem and the regulatory obstacle with banding, a direct argument for Layer 3. The AI act adds additional requirements around cybersecurity and protection against antagonistic threats, an

area F1 assesses as likely more challenging than the pure security requirement. The one factor that counterbalances these high external risks is that there is currently minimal competitive pressure within the industry.
Assessment: *Low for Layer 1 / High for Layer 2 / High for Layer 3*

4.2.8 Nuclear power- and Waste Management

Compelling Reason to buy
Across all three nuclear contexts, the primary value driver is removing personnel from environments where radiation levels make human presence impossible, unsafe or legally constrained. N2 confirms that at one plant, radiation levels during operation are too high for personnel to enter certain areas, and gives a concrete example where a aerial drone investigation resolved a suspected leak remotely, avoiding the need for human entry entirely. N3 describes decommissioning as approximately 90% manual, with workers performing repetitive radiation measurement and cutting pipes across large surfaces, and frames the value of robotics explicitly as removing people from dangerous or monotonous work. At N1's company the constraint is most acute, approximately 200 tonnes of backfill material per day are deemed operationally infeasible to handle manually, and personnel cannot be exposed to radiation from nuclear fuel capsules for extended periods, making autonomous handling a regulatory and operational necessity rather than an efficiency choice.

The use cases that emerge across the three contexts follow a consistent pattern. Active operations require continuous monitoring along pre-defined routes without a dedicated operator per unit, a task N2 envisions for future autonomous systems similar to those already deployed in China reading analogue meters autonomously. Decommissioning requires area scanning after component removal and logistics moving loads of one to two tonnes between work areas, the latter of which N3 explicitly identifies as a realistic automation target and one that maps directly onto Eira's core capability of heavy transport in GNSS-denied indoor environments without requiring specialised instrumentation. Brokk robots currently handle the most physically demanding tasks at Layer 1, establishing the baseline that any more autonomous solution would build upon. N1's company requires fully autonomous underground transport at scale, where Layer 2 autonomous route-following is already in active deployment but relies on SLAM-based onboard navigation developed internally, meaning Eira Systems would not add value at Layer 2 in this specific context. The dynamic underground terrain that N1 describes as continuously changing through rock falls and new tunnel construction is however precisely where Eira Systems off-road capability and signal-independent navigation could offer meaningful differentiation.

For Layer 1, remote control is the established baseline across all three contexts but insufficient at N1's company given scale and radiation constraints. For Layer 2, autonomous route-following addresses the core need in decommissioning (outside). For Layer 3, all three indoor and underground environments share the same GNSS-unavailability by definition, making signal-independent navigation a functional requirement for any fully autonomous system rather than an optional feature. At N1's

company this is already operational reality rather than future aspiration.
Assessment: *Mid for Layer 1 / Low for Layer 2 / High for Layer 3*

Market Volume
The nuclear sector in Sweden is institutionally concentrated and geographically limited. Sweden currently has six reactors in active operation across three plants, Forsmark, Oskarshamn and Ringhals, planned to run until approximately 2040, alongside at least six reactors in active decommissioning across Barsebäck, Oskarshamn and Ringhals, plus Ågesta (Strålsäkerhetsmyndigheten, 2026). N1's company manages the nuclear waste disposal program. This small and countable customer base means near-term volume in Sweden is inherently limited.

The decommissioning context adds a temporal dimension. N3 notes that Swedish decommissioning projects typically run six to eight years compared to ten to twenty years internationally, which creates acute near-term efficiency pressure but also limits the duration over which returns on investment can be realized from highly specialized solutions developed for a single site.

The international dimension partially offsets the domestic volume limitation. N1 notes that Sweden and Finland are among the most advanced globally in autonomous systems for nuclear waste disposal, and that Sweden participates in NEA forums where autonomous systems and robotics are discussed across the international nuclear community. If solutions validated in the Swedish nuclear context can be transferred to international programs, the addressable market extends considerably beyond the domestic customer base.
Assessment: *Low for Layer 1 / Low for Layer 2 / Mid for Layer 3*

Economic Viability
The economic drivers vary across the three contexts but share a common pattern, with health, safety and operational necessity driving the business case more than cost savings alone. N2 frames the primary value in active operations as dose reduction and safety, while N3 is more explicit in decommissioning, noting that procurement requires concrete calculation of personnel cost savings and radiation risk reduction. N1 presents the strongest case, where manual alternatives are not merely expensive but operationally infeasible.

On willingness to pay, all three respondents describe organisations willing to invest when the safety and efficiency case is clearly demonstrated but requiring robust justification. Burnham et al. (2003) identify procedural switching costs as often the most significant barrier in complex technological markets, and N3 confirms this directly by describing the need to rebuild the entire justification case at each new site even when the technology has already been validated elsewhere.

Stickiness is not explicitly addressed by any respondent. The authors note that regulatory inspection requirements suggest recurring need in principle once a solution is established, though this remains an inference rather than something grounded in

the interviews.
Assessment: *Mid for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Implementation Obstacles
N3 describes how nuclear organisations consider themselves high-technology but are in practice deeply conservative and slow to adopt new methods. He notes that each Swedish decommissioning site is a legally separate entity meaning that technology validated at one site must be re-argued from scratch at the next, and describes the stark contrast between the rapid pace of robotics development at the European Robotics Forum and the cautious response of nuclear practitioners. Hannan and Freeman (1984) describe precisely this dynamic, inertia is strongest in systems built around accountability and reliability, where established routines become institutionalised and any deviation temporarily reduces the organisation's perceived dependability.

A specific and concrete obstacle raised independently by both N2 and N3 is data sovereignty. Any autonomous scanning system generates data about the plant's internal layout, triggering concerns about data storage location and export control regulations. N2 describes having a dedicated internal data centre that cannot be used within the nuclear context, while N3 describes organisations making conservative interpretations of export control regulations that effectively block technology deployment even when the underlying regulatory requirement may not strictly demand it. The authors note that this obstacle is specific to the nuclear context and that it being raised independently by two respondents from different operational contexts within the same organisation suggests it is a deeply embedded barrier.

For the physical environment, N3 notes that nuclear buildings present significant navigation challenges including fire compartmentalization requirements, frequent level changes and floors constantly obstructed by cables and components. N1 describes how the underground context offers a contrasting picture, with more structured and predictable routes and a SLAM navigation system handling dynamic changes from ongoing construction. The authors note that while this makes this context more tractable, the dynamic and GNSS-denied nature of the underground environment is precisely where Eira's offroad and signal-independent navigation capability offers the most critical differentiation. The authors further note that high-radiation environments place demands on electronics hardening that go beyond standard commercial sensor platforms. For monitoring and scanning use cases, specialised radiation measurement instrumentation and hardened electronics would need to be integrated before Eira's platform could be relevant. For the transport and logistics use cases however, which N3 identifies as a significant portion of the operational need, the technical challenge is considerably more tractable. The primary requirement shifts from specialised instrumentation to load capacity and the ability to handle heavy payloads reliably in confined indoor environments, a challenge that is more directly aligned with Eira's core platform characteristics.
Assessment: *Mid for Layer 1 / Mid for Layer 2 / High for Layer 3*

Time to Revenue
For active operations, N2 describes active pilots and a clear strategic direction toward increased automation. However the regulatory requirement for human verification of automated findings and the conservative interpretation of what is permitted creates a delay before full commercial deployment is possible.

For decommissioning, Moore (2014) chasm framework helps explain why validated technology does not automatically spread across the sector. Each decommissioning site effectively requires its own crossing of the chasm, since proven references at one site do not transfer to the next under the current regulatory interpretation model described by N3. N3 notes that one plant might start moving more decisively within about a year as cost pressure increases, but that widespread adoption will take considerably longer.

For N1's company's underground disposal context, the technology is already operationally deployed, but as described in greater detail under external risks, N1's company and their commercialisation partners function as an established competitor rather than a potential customer. Time to revenue in this specific context is therefore not a near-term opportunity for Eira Systems but rather a competitive reference point that validates the technical feasibility of Layer 3 in demanding underground environments.
Assessment: *Mid for Layer 1 / Mid for Layer 2 / High for Layer 3*

External Risks
Legally, the nuclear sector operates under some of the strictest regulatory frameworks of any industry analysed. N2 notes an interesting international comparison namely that in the US, regulatory bodies maintain their own technical competence and actively drive some innovation, while in Sweden the regulator requires the industry to build and document its own safety case, a different but not necessarily worse pathway though it requires more effort from the operator. The data sovereignty concerns described under implementation obstacles also constitute an external legal risk in the sense that export control regulations are set by international bodies outside any single operator's control, creating barriers that cannot be resolved through product development alone.

Competitively, N1's company case presents a specific and important risk for Eira Systems. N1's company has not only developed and deployed fully autonomous GNSS-independent UGVs for underground navigation, but has actively commercialised this technology through preferred partner companies, with over 100 organisations using technology originating from N1's company's development program. N1's company and their commercialisation partners therefore function not only as a potential customer but as an established competitor with deep domain knowledge, a validated solution and existing customer relationships in the underground disposal context specifically.
Assessment: *Mid for Layer 1 / High for Layer 2 / High for Layer 3*

4.2.9 Construction

Compelling Reason to Buy
Three distinct needs emerge from the interviews, with arguably the most compelling being the productivity cap imposed by the eight hour working day. C2 frames construction productivity stagnation as a societal problem, and points to autonomous trenching for cable laying as a concrete near-term case where machines could work overnight while workers arrive the next day to continue. Applying the Blue Ocean lens of Kim and Mauborgne (2005), an autonomous system that eliminates this constraint does not merely improve on existing solutions but reconstructs the operational model entirely.

The second is road maintenance in live traffic, which C2 describes as the worst working environment in the sector where accidents occur. C1 independently identifies traffic management and placing of road signs and barriers as repetitive and dangerous tasks that should be automatable. Removing humans from this environment entirely would address both the safety and the labor dimension simultaneously.

The third is GNSS-denied tunnel environments, which C2 confirms as a real operational condition. C1 describes scanning of tunnel walls and surfaces as a near-term application, noting that helmet-mounted cameras are already used and that the logical next step is a self-propelled system. CM1 reinforces that underground environments and quarries with radio shadow near rock walls are specific cases where GNSS-independent navigation is a necessity rather than an enhancement, making this the clearest Layer 3 use case in the sector.

For Layer 1, neither respondent identifies remote control as a compelling standalone solution since it does not reduce human involvement meaningfully. For Layer 2, road construction and earthmoving in open GNSS-accessible environments represent the most credible near-term value proposition. For Layer 3, the tunnel and underground contexts confirm GNSS-denial as a real operational condition making signal-independent navigation a functional requirement rather than an optional feature.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Market Volume
The Swedish construction market was valued at approximately USD 49.3 billion in 2024, projected to reach USD 77.8 billion by 2030 at a CAGR of 6.6% (Next Move Strategy Consulting, 2026). However the sector contracted by 2.6% in real terms in 2025, driven by falling building permits, rising material costs and low investor confidence in residential construction, with recovery projected at an average annual rate of 4.2% from 2026 to 2029 (Research and Markets, 2026). However the sector is highly fragmented at the project level. C2 identifies project orientation as a fundamental feature of the industry, where the decision-making unit for technology adoption is often the individual project rather than the organisation as a whole. Hence, one may argue that despite large companies like C2's company and C1's company being involved, the near-term addressable market is significantly smaller

than the industry's overall size would suggest.

Applying Rogers (2003) diffusion framework, the construction sector maps clearly onto the late majority or even laggard profile. C2 explicitly compares the sector's development pace to the hunting and fishing industry, unchanged over 30 years. C1 reinforces this through his observation that the sector's culture, dominated by older workers in established positions and a relentless focus on short-term profit delivery, systematically blocks innovation from taking hold even when individuals within the organisation are enthusiastic.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Economic Viability
Margins in construction are notoriously thin, with the C2 noting that a single project running over budget can erase the profit on several others. This cuts both ways. On one hand it creates a high bar for automation to clear, requiring solutions to be not only economically superior in aggregate but reliable enough that project managers trust them not to cause delays or cost overruns on their specific project. On the other hand, when automation does deliver, the gains are proportionally significant precisely because margins leave so little room for waste. C2 illustrates how adoption works when this bar is met through the example of robotic lawnmowers, where the technology was waited out until mature and verified before C2's company adopted it for municipal grass cutting contracts, at which point the economic case became self-evident and adoption grew steadily.

On willingness to pay, the fundamental tension C2 identifies is between the cost of the technology and the cost of a skilled worker. If a machine does not work immediately, the easier and safer choice is simply to hire another worker. This calculation limits willingness to pay for unproven systems while simultaneously creating significant upside for solutions that do deliver reliably, given the productivity gains from extending the working day identified under compelling reason to buy.

On stickiness, C2 describes machinery manufacturers moving toward selling capability rather than equipment through service packages of up to 20,000 hours, which in principle supports recurring revenue. However he notes this transition is slow and it therefore represents a future rather than current stickiness dynamic.
Assessment: *Low for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

Implementation Obstacles
The primary obstacle in construction is the project-based organisational model, already introduced under market volume. Unlike manufacturing where automation can be implemented once and runs continuously, each construction project is unique and temporary, meaning technology must be re-introduced and re-justified for every new project. The risk of failure falls on the individual project rather than being absorbed across a portfolio, creating a situation where the downside of adopting unproven technology is immediate and personal while the potential gains are long-term and organisational. Hannan and Freeman (1984) describe how inertia is reinforced

by established routines, and in construction this manifests as a persistent preference for proven manual methods, particularly under the time and margin pressure of individual projects. The cultural dimension reinforces this. C1 describes a culture where older workers in established positions make it difficult for younger employees to drive change, combined with a shareholder-driven focus on short-term profit delivery.

The physical environment adds further complexity. Construction environments are highly dynamic, with plans changing mid-project and layouts shifting, making it significantly harder to deploy autonomous systems that rely on pre-mapped routes. C2 notes that the more repetitive and predictable the task, the more tractable the automation problem becomes, which is why road construction is closer to adoption than building construction.

For Layer 3, C2 confirms GNSS is unavailable in tunnels, and CM1 adds that quarries can also experience radio shadow near rock walls, extending the GNSS-denial use case beyond tunnels and validating signal-independent navigation as a functional requirement rather than an optional feature in those specific contexts. The technical demands vary across the construction use cases identified. Tunnel environments are the most tractable, requiring navigation and transport in a GNSS-denied but relatively structured corridor, which aligns with Eira Systems core capability. Earthmoving and trenching use cases would require specialised mechanical attachments that go beyond Eira Systems current platform.
Assessment: *High for Layer 1 / High for Layer 2 / High for Layer 3*

Time to Revenue
C2 notes that progress has moved significantly more slowly than expected over the past ten to fifteen years, with SPOT pilots that went reasonably well technically but failed to progress to wider adoption due to insufficient organisational will. This is a textbook illustration of Moore (2014) chasm; visionary adoption that did not cross to pragmatist customers who will not commit until technology is fully proven and risk-free.

For Layer 2, road construction and earthmoving represent the most credible near-term opportunity. The fact that companies are already working on autonomous trenching solutions suggests that customer awareness and demand is beginning to emerge, which in principle shortens Eira's path to initial revenue. However the project-based adoption dynamic means each project still represents a fresh adoption decision, slowing diffusion even when technical readiness exists.

For Layer 3, the tunnel context presents a longer time horizon. While C2 confirms GNSS-denial as a real operational condition, tunnel projects make up a small subset of the broader construction market and the high cost of failure in underground environments means customers will require extensive validation before committing. The gap between operational need and procurement readiness is meaningful.
Assessment: *Mid for Layer 1 / Mid for Layer 2 / High for Layer 3*

External Risks
The regulatory environment in construction lags behind technical capability. C2 notes that mixing humans and autonomous machines on construction sites creates significant safety regulation challenges, and CM1 confirms that safety requirements for autonomous solutions are often interpreted more strictly than for equivalent manual operations. China and Japan have demonstrated fully autonomous road construction, and CM1 respondent describes European regulatory rule-setting as putting the sector behind. This creates both a risk and an opportunity for Eira Systems, if European customers wait for proven international solutions before adopting domestically, the window for early market entry narrows, but if Eira Systems can establish itself as the credible domestic alternative it benefits from the same regulatory lag that slows international competitors.

Competitively, large machinery manufacturers supplying companies like C2's company are already moving toward selling capability rather than equipment, and autonomous solutions for the most accessible use cases are beginning to emerge. This suggests that the competition is starting to increase in the areas where Layer 2 is most credible, which could limit Eira Systems' window for early entry in road construction and earthmoving specifically.
Assessment: *Mid for Layer 1 / Mid for Layer 2 / Mid for Layer 3*

4.2.10 Industry Synthesis

Several patterns emerged from the industry analysis that explains why some industries have come longer and are more ready to adopt autonomous UGVs while others aren't, which will be discussed in detail in the discussion chapter. What becomes clear is that many industries score relatively high or mid on potential but not enough to overcome the high amount of challenges. Another contributing factor is that many industries require a lot of specialized equipment and modules to solve specific assignments, something that made them score lower for the case of Eira Systems but may increase the score for another startup or company with another focus area.

Figure 4.1 below summarizes the aggregated potential and challenge scores across all eight industries and three layers, providing the quantitative foundation for the application screening that follows. To enable systematic comparison across industries, each sub-dimension is assigned a numerical value from 1 to 4, where 1 corresponds to Low and 4 to Super-High. As the framework evaluates three sub-dimensions under each category, the overall potential and challenge scores are calculated as the sum of their respective three sub-dimensions, producing a maximum score of 12 for each.

Industry Attractiveness Scores by Layer

Industry	Potential			Challenge		
	L1	L2	L3	L1	L2	L3
Agriculture	3	9	7	5	9	9
Infrastructure	3	6	6	5	6	7
Power Grids	4	7	4	5	6	7
Fire & Rescue	7	7	8	3	6	5
Mining	7	8	11	8	6	8
Forestry	3	6	5	4	9	10
Nuclear	5	4	7	6	7	9
Construction	3	6	6	7	7	8

Potential: Low (3-4) Mid (5-7) High (8-10) Super High (11-12)

Challenge: Low (3-4) Mid (5-7) High (8-10) Super High (11-12)

Scores sum the three sub-dimensions per MON category. Low=1, Mid=2, High=3, Super-High=4.

Figure 4.1: Industry Attractiveness Scores by layer

What the table clearly shows is that mining Layer 3 stands out with the highest potential score in the entire study at 11, and also has relatively high potentials in the other layers. Fire and Rescue presents a different but complementary picture, where all layers demonstrate a favourable potential to challenge ratio, suggesting a more accessible near-term entry point. Together, mining and fire & rescue represent the clearest overall case for Eira Systems across the study, combining strong compelling reasons to buy with use cases that align directly with Eira Systems' core platform capability of robust transport in difficult and signal-denied environments.
Nuclear also warrants closer attention despite its more modest scores. While the customer base is small and challenge is high, the decommissioning logistics use case shares a high degree of capability relatedness with the mining transport use case which is why we don't neglect it yet, more of this will be described in the following section.

With these industry-level patterns established, the analysis now moves to the level of specific applications. The following section screens a shortlist of concrete use cases against Eira Systems' current platform characteristics and plots them on the Attractiveness Map.

4.3 Applications

Building on the industry-level analysis, the following section identifies four concrete applications representing the most viable entry points for Eira Systems. These applications are selected not only based on their industry-level attractiveness but on how well they can be addressed using Eira Systems' existing means. Following Sarasvathy (2001) effectuation logic, the screening starts from what Eira Systems' platform can already do rather than from the largest theoretical market, prioritizing applications where the core capability of robust off-road transport in GNSS-denied environments is directly applicable without fundamental redesign. Each application is plotted on the Attractiveness Map in Figure 4.2 across the layers.

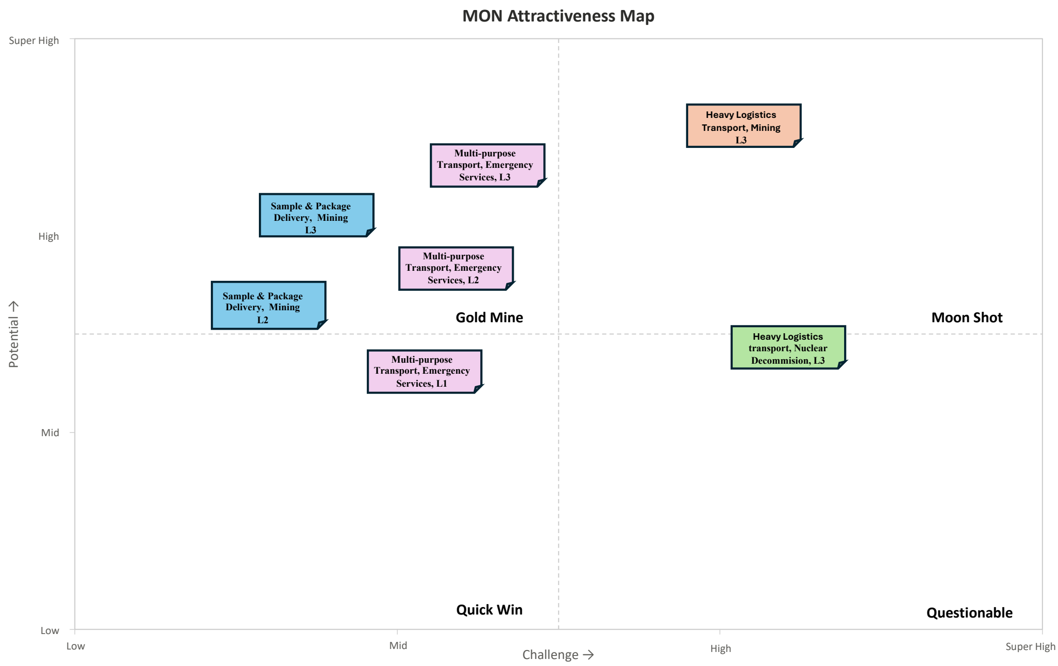

Figure 4.2: Attractiveness map of the four selected applications

4.3.1 Sample & Package Delivery, Mining

The most platform-compatible application identified in the study is internal transport of samples, tools and smaller goods within mining sites. M1 describes trials with smaller UGVs for precisely this purpose, noting that the impracticality of having personnel cover several kilometres on foot between work areas creates a concrete and recurring operational need. The application does not require fundamental platform redesign, as the primary requirements are terrain negotiability, sensor reliability in wet and dusty underground conditions, and GNSS-independent navigation. The platform operates as Layer 3 throughout, utilising GNSS as a complement when available in open pit contexts but never depending on it, which preserves full operational capability across both surface and underground environments within the same operational cycle. However Layer 2 could also be used, but would have to deliver to the edge of the different mines, due to its signal dependency, reducing potential significantly. CM1 notes that existing trials have struggled with the demanding terrain, representing precisely the environment Eira Systems is designed for. Relative to the Mining Layer 2 & 3 industry score, the high platform compatibility and low specificity of this application suggest a marginally lower challenge and stable potential, making it the most immediately realizable mining entry point.

4.3.2 Heavy Logistics Transport, Mining

M1 identifies the transport flow along the tunnel to the end face as the highest priority automation target in underground mining, accounting for the largest share of operational time and requiring the least human intervention of all underground tasks. The economic logic is the same as M1's autonomous trucks in open pit, low concentration ore can only be globally competitive through high throughput and low unit cost. This application is Layer 3 by definition, as underground environments have no GNSS coverage. Unlike previous applications, this use case would require a significantly larger and heavier platform than Eira Systems current prototype, as ore transport demands substantially greater payload capacity. The core navigation technology transfers directly but the platform investment is meaningful, placing this application further along the effectuation horizon. Relative to the Mining Layer 3 industry score, the lower platform compatibility raises challenges marginally while the strong compelling reason to buy sustains potential.

4.3.3 Multi-purpose Transport, Fire & Rescue Services

FR1 and FR2 are both explicit that multifunctionality is not merely desirable but a financial prerequisite for the investment to pay off. A platform limited to a single use case is used too rarely to justify the cost for wider adoption, while one that handles logistics, equipment transport and casualty transport across a range of operational contexts creates an acceptable investment calculation. The application therefore combines what could otherwise be separated into distinct use cases. Transporting water and equipment during forest fires and high alert as FR1 describes, and transporting injured personnel in difficult terrain where FR1 notes that medical treatment must be interrupted during manual carrying. In open and accessible terrain, Layer 2 is sufficient. In collapsed buildings, tunnels and GNSS-degraded environments, which FR2 explicitly identifies as the most critical scenarios, Layer 3 becomes operationally necessary. Layer 1 could also have use cases in specialized rescue missions. The multifunctionality requirement actually strengthens the application's position relative to the Fire and Rescue industry score, as it increases both willingness to pay and the breadth of the addressable market, suggesting a marginally higher potential than the industry score alone would indicate. Challenge remains moderate, driven primarily by the LoU procurement cycle and the cost barrier identified by FR2.

4.3.4 Decommissioning Logistics, Nuclear

N3 identifies semi-autonomous logistics moving loads of one to two tonnes between work areas as one of the two most promising automation targets in nuclear decommissioning. The environment is GNSS-denied by definition, making this a Layer 3 application throughout. Unlike the monitoring and scanning use cases in nuclear, which require specialised radiation instrumentation, the logistics use case primarily demands load capacity and reliable navigation in confined indoor spaces, making it the most platform-compatible nuclear application. The near-term opportunity at one plant, which N3 suggests could begin moving within approximately a year, provides a concrete entry point. Relative to the Nuclear Layer 3 industry score, the high platform compatibility for the transport-specific use case justifies a marginal reduction in challenge, while the narrow domestic customer base and site-by-site justification requirement keep potential constrained. The technology relatedness to application 2 in mining is strong on the navigation and transport dimension, though market relatedness is low given the entirely different customer, regulatory framework and procurement process.

4.4 Go to market strategy

The Agile Focus Dartboard in Figure 4.3 translates the attractiveness map findings into a concrete strategic prioritization across the four identified applications. Following Gruber and Tal (2017) framework, each application is assigned both a strategic role, either Primary Market, Growth Option or Backup Option, and a resource allocation decision, either Pursue Now, Keep Open or Place in Storage.

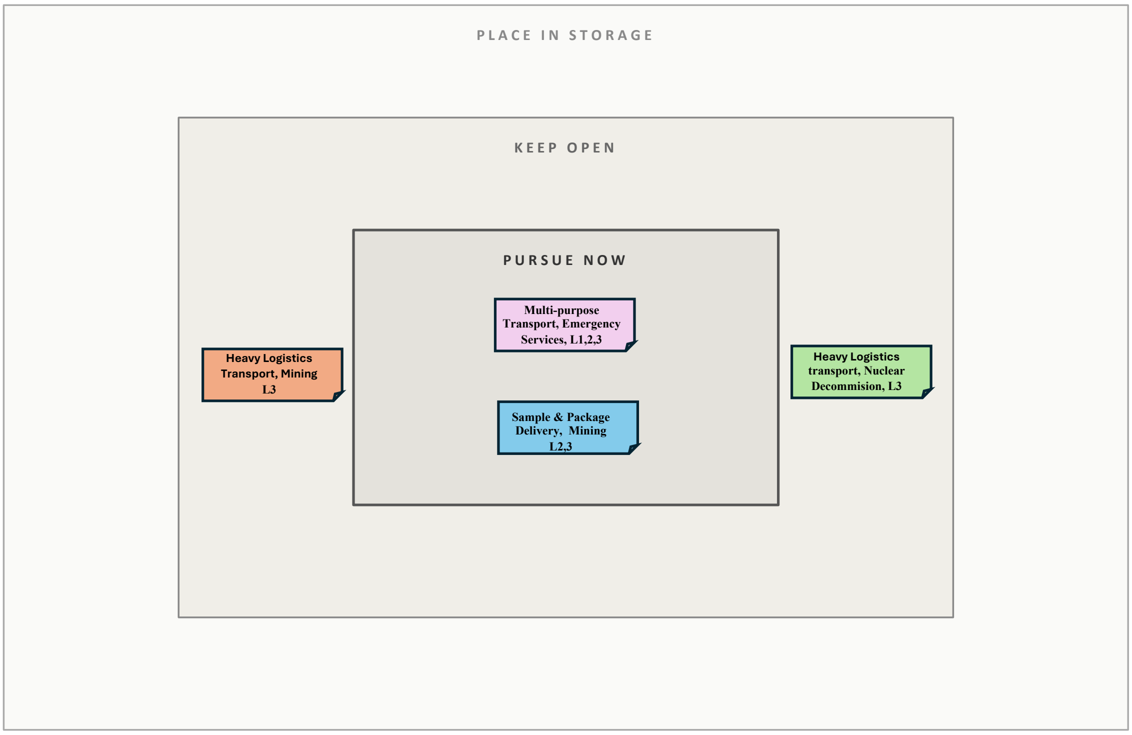

Figure 4.3: Agile focus dartboard

4.4.1 Pursue Now

Primary Market: Multi-purpose Transport, Fire & Rescue Services
Rescue Services are designated as the primary market for three converging reasons. First, the application maps directly onto Eira Systems' existing platform without fundamental redesign and the Layer 1 market is already commercially validated through Leo 1 and FR2, providing the earliest possible path to initial revenue. Second, the challenge score is the most favourable of the Pursue Now applications, driven by comparatively accessible regulation and a clearer procurement path than mining. Third, fire & rescue services align well with Eira Systems' broader vision. The company's core mission of enabling safe operations in environments where human presence carries unacceptable risk maps directly onto what rescue services need, and the operational profile of the application, navigating difficult terrain without GNSS in crisis environments, closely mirrors the military use cases that Eira Systems is simultaneously developing towards.

As described in section 4.2.3, the application spans all three layers, with Layer 1 providing the immediate entry point, Layer 2 addressing the logistics argument in open terrain and Layer 3 becoming operationally necessary in the most critical GNSS-denied scenarios. This layered progression embodies the dynamic strategizing that Gruber and Tal (2024) describe as one of the MON framework's most valuable functions for deep-tech ventures, by generating revenue and building market references at Layer 1 and 2 while simultaneously developing the technology toward the disruptive Layer 3 entry.

From a risk perspective, the primary market faces two major risks: municipal budget pressure and the LoU procurement cycle. Gruber and Tal (2017) emphasise that backup and growth options should not share the same major risks as the primary market, so that the venture can succeed even if the primary encounters serious obstacles. This risk profile therefore becomes the reference point against which all other applications are evaluated, and as discussed below, none of the three remaining applications share these primary failure modes.

Growth Option: Sample and Package Delivery, Mining
Sample and package delivery in mining is designated as a Growth Option to be pursued in parallel. Gruber and Tal (2017) describe Growth Options as opportunities that can increase value creation potential and should be as closely related to the primary opportunity as possible, so that pursuing both requires limited additional effort. On the product dimension this condition is clearly met. As described in section 4.2.3, the application shares all core technological requirements with fire & rescue services: GNSS-independent navigation, robust off-road terrain capability and autonomous transport without a dedicated operator. The same platform, sensor suite and navigation software serve both markets with limited additional development. Like the primary market, this application spans multiple layers, with Layer 2 viable in open pit environments and Layer 3 a functional requirement underground, allowing Eira Systems to commercialise incrementally while building toward full GNSS-independent capability.

On the market dimension, relatedness to the primary market is lower since mining organisations and fire & rescue services operate in entirely different procurement environments. However, there is one notable exception to this low market relatedness, FR3 explicitly describes mining companies as the primary decision-makers for mine rescue operations, meaning a reference case in fire & rescue services at a mining site creates a direct word-of-mouth pathway into mining procurement. A rescue service deploying Eira Systems' platform in a mine emergency validates the platform in the exact operational environment the mining customer cares most about, creating an unusually strong cross-market reference dynamic that partially compensates for the otherwise low market relatedness between the two sectors. Further, Gruber and Tal (2017) note that options with lower market relatedness offer weaker word-of-mouth benefits but stronger risk diversification, since they do not share the same major risks. The primary risk for this application is conservative adoption culture and long investment decision cycles in mining, which is independent from the LOU procurement pressure facing fire & rescue services.

4.4.2 Keep Open

Backup Option: Heavy Logistics Transport, Mining
Heavy logistics transport in underground mining is designated as a Backup Option. Gruber and Tal (2017) describe Backup Options as plans B that should be highly related to the primary opportunity while not sharing its major risks, enabling the venture to succeed with the backup even if the primary fails. On the product dimension, this application is moderately related to both Pursue Now applications, sharing the same GNSS-independent underground navigation requirement and off-road terrain capability as well as transportation as main assignment but does differ in terms of size and weight carrying capability. On the market dimension it is related to the sample delivery growth option, sharing the same mining customer base and procurement environment, which means references built in sample delivery directly support the path toward heavy transport adoption. The application does not share the primary market's major risks since its primary obstacles are the platform development investment required for greater payload capacity and the regulatory certification timeline M1 estimates around 2028/2029, both independent from LOU procurement pressure. As Gruber and Tal (2017) note on the attractiveness versus relatedness trade-off, this application scores highly on both dimensions, making it a natural candidate to be elevated toward Pursue Now as revenue from the current primary market creates the financial headroom for the heavier platform development, or if the pursue now options would fail.

Backup Option: Decommissioning Logistics, Nuclear
Decommissioning logistics at nuclear sites is also designated as a Backup Option. On the product dimension the technology relatedness to heavy mining transport is strong, as both require GNSS-independent heavy transport in structured underground corridors, and the relatedness to fire & rescue services is meaningful on the navigation dimension. On the market dimension, relatedness to the other applica-

tions is low since the customer base is entirely different, the procurement process is unique to the nuclear regulatory environment, and neither fire & rescue services nor mining organisations reference nuclear operators when making buying decisions. As Gruber and Tal (2017) note, options with lower market relatedness offer stronger risk balancing since they do not share the same major failure modes. The primary risks for this application are regulatory conservatism and data sovereignty obstacles, neither of which threatens the fire & rescue services or mining applications.

4.4.3 Place in Storage

No applications are formally placed in storage in this study. This reflects the deliberate scope of the application screening, which selected only the four most platform-compatible and commercially viable use cases from across the eight industries analysed. The broader industry analysis in stage 2 identified a significantly larger number of potential applications, many of which could plausibly be placed in storage as opportunities whose time has not yet come. Agriculture, forestry, infrastructure inspection and power grids all contain use cases that were deprioritised due to insufficient platform fit, high challenge or misalignment with Eira Systems' current means, and these represent the natural candidates for the storage zone in a more comprehensive application of the dartboard. As Gruber and Tal (2017) note, storing market opportunities does not mean discarding them but rather keeping them in the back of the mind for a future in which the technology, the market or Eira Systems' resources have evolved sufficiently to make them viable.

4.4.4 Portfolio coherence

Within Pursue Now, the two applications share not only the same core platform requirements but potentially the same physical machine. Both involve moderate payload transport in difficult terrain without GNSS dependency and neither requires heavy lifting or large-scale machinery. More concretely, a platform deployed for internal logistics in a mine is the same platform that could be used for rescue operations in that same mine when needed, as FR3 describes mine rescue as an environment where the two applications converge directly. This means a single deployment can build references in both markets simultaneously. The two backup options are similarly aligned with each other. Both heavy mining transport and nuclear decommissioning logistics require the same type of development beyond the current prototype: greater payload capacity and the ability to navigate reliably in confined, structured underground corridors with heavier loads. The technological development needed to pursue one is largely the same as what is needed to pursue the other. If the Pursue Now applications generate the commercial traction and financial headroom to invest in this next development step, both backup options become accessible through essentially the same platform evolution.

5
Discussion

This chapter discusses the findings of the study in relation to the two research questions. The first section addresses the cross-industry patterns that emerged from the industry analyses, examining which characteristics appear to drive or constrain UGV adoption across different sectors. The second section reflects on the application of the Market Opportunity Navigator in this context, discussing both its effectiveness and the adaptations that were found to strengthen its utility in a high-uncertainty deep-tech setting.

5.1 Cross-industry discussion

This chapter aims to answer the first research question:

Which general tendencies and characteristics drive or constrains the adoption of UGV technology across different industrial sectors?

5.1.1 Closed versus open environments as a driver of adoption pace

The regulatory environment in which the industry operates has emerged as one of the strongest indicators of how far UGV adoption has progressed. Looking across the industries, those that have come furthest are not necessarily those with the highest potential scores, but rather those where the effective challenge has been reduced through regulatory advantages. This becomes clear when looking at N1's company which has already deployed fully autonomous GNSS-independent vehicles in operation underground, and also why some mining companies have made progress with surface and underground tests even though certification is not yet fully in place. The fire & rescue services have another but related advantage in the right to legally close off a public area for operation, which creates a similar controlled space, albeit of a different nature. What unites these cases is that the actor can in practice advance earlier than the formal regulatory maturity would justify, which helps explain why they are able to act as early adopters (Rogers, 2003). Closed, controlled environments make it easier for the actors to test, validate and build experience within their own safety perimeter without exposing them to third-party risks or public certification requirements at every stage. It can also ease up barriers for operational use, due to a lower risk towards civilians. In contrast, industries operating in open public environments face regulatory lock-ins that individual actors cannot easily resolve on their own, slowing adoption even where potential is high and purchasing drivers are strong, as seen most clearly in agriculture as well as power-grid inspection and construction.

5.1.2 The dual effect of GNSS interference on UGV adoption

Regulatory factors in the previous chapter appeared as an obstacle throughout the study, but we now argue that the effect can become the opposite in the future.The external threat of GNSS-jamming moves towards worsening the conditions for GNSS-reliant autonomous systems while simultaneously strengthening the argument for choosing GNSS independent systems. In the future, as adoption of UGV's increase, so will the reliance on these systems, making several respondents believe that the system being able to navigate without a GNSS-signal might become a legal requirement which would push the adoption of GNSS-independent systems. In other words, while the legal aspects today constrain the adoption of UGVs in general, when the chasm has been breached (Moore, 2014), the speed of adoption for GNSS- independent systems may be driven by regulatory interventions.

It is also worth noting that regulatory shifts may not happen simultaneously over sectors, but rather that those who work with safety-critical systems and national preparedness likely will be leading the way. For example, in fire & rescue services FR2 assesses that some kind of formalization of requirements for signal-independent reserve capacity is likely relatively close in time, driven by national security policy pressure and already documented disturbances. Another example is agriculture, an industry that could become highly reliant on autonomous systems in the future (A2), where respondents emphasize that maintaining an uninterrupted food supply is vital for national preparedness and is therefore likely to be affected by those regulations.

5.1.3 The nature of purchasing drivers as an indicator of adoption pace

The primary purchasing arguments differ significantly between industries. In mining, fire & rescue services and nuclear, the primary value-driver is safety and operational necessity. In agriculture, forestry and construction, the primary purchasing argument is efficiency and cost reduction while in infrastructure and Power grids, the clearest motivator is quality of inspections. These results indicate that when safety or necessity to do certain tasks is the primary driver, adoption of the technology seems to go faster. This may reflect the fact that solutions requiring an increased cost compared to current alternatives are easier to justify internally when the value case extends beyond cost savings. In early stages of the adoption curve, where economic returns are uncertain and unproven (Rogers, 2003), non-economic arguments such as personnel safety may be able to carry the investment cases.

5.1.4 How adoption in adjacent contexts shapes industry receptiveness

A defining characteristic of the faster adoption rates observed in the rescue, mining, and nuclear sectors is the presence of highly visible opinion leaders who have actively bridged the chasm from visionary to pragmatic adoption. According to Rogers (2003), the overall speed of diffusion is dictated by how effectively an innovation's observability is demonstrated within near-peer networks. Those industries where visionaries already have acted on the technology seem to move faster towards the next step. For example, Leo 1, in Gothenburg's fire & rescue service, has led to discussion in other fire & rescue services across the country. The autonomous trucks in M1's open-pit-mine, which has proven to be economically viable, can be seen as legitimizing the case for the mining industry to take the same step underground, although additional interviews would be needed to confirm this. In the same way, N1's company's implementation of autonomous vehicles in their finutol storage may have strengthened the argument for other use cases within the nuclear sector.

An interesting anomaly within the logic of Rogers (2003) and Moore (2014) occurs in the agricultural sector. While the industry possesses a clear visionary pioneer in John Deere (as highlighted by A2), the lack of direct domestic collaboration with them means that this reference customer does not seem to have had a significant cross-country effect. Consequently, unlike the localized spillovers seen with Leo 1, this international visionary has not yet generated the near-peer observability required to accelerate cross-country adoption among regional contractors and pragmatists.

Another observation is that respondents across all industries expressed a positive attitude toward UGV potential. Several also noted current use of UAVs, often citing successful implementations. This may partly explain their receptiveness to UGVs as a comparable technology. While speculative, the authors believe that prior UAV adoption could lower barriers to UGV adoption, and given how far UAVs have progressed along the adoption curve, this familiarity may accelerate UGV uptake.

5.1.5 Organizational structure as a constraint on adoption

A further pattern that emerges across the industries is that organizational inertia appears to manifest differently depending on how each sector is structured around its core routines. Hannan and Freeman (1984) argue that inertia is strongest when changes threaten the technical core of an organization, defined as its established authority structures, core technology and operating procedures, while peripheral changes face considerably less resistance. This distinction is visible across the industries studied. In highly regulated sectors such as nuclear, power grids and railway maintenance, R&D units appear flexible enough to pilot autonomous systems for peripheral tasks, but scaling into daily operations generates considerably more friction. As I2 illustrates, automated findings still require physical verification by a certified inspector before any action can be taken, reflecting how deeply human accountability is embedded in the operational core of these sectors.

In more fragmented and cost-driven sectors such as construction, forestry and agriculture, organisational structure generates a distinct form of inertia. Rather than hierarchical accountability structures, these industries are characterised by decentralised and individually risk-bearing units, where the risk of technical failure falls on the individual operator, contractor or project rather than being absorbed across a larger organisation, creating what Christensen and Bower (1996) describe as a systematic bias toward proven solutions over disruptive alternatives.

These two types of inertia differ in where they block adoption. The first allows actors to advance through piloting before hitting resistance at the operational core, while the second blocks progress already at the testing phase. The second type therefore appears to represent the stronger overall constraint, which may partly explain why industries such as nuclear and mining have progressed further than construction and forestry despite similarly high challenge scores. However, as the technology move towards maturity, one could suspect that the opposite could apply.

5.2 MON Framework discussion

This chapter aims to answer the second research question:

How effective is the Market Opportunity Navigator as a strategic framework for deep-tech ventures in high-uncertainty sectors, and how can it be adapted to enhance its ability to support market selection and strategic decision-making?

The effectiveness of the market opportunity framework in this case can be discussed from both positive and negative perspectives. On the positive side, it provided a structured way to navigate a broad and uncertain commercial landscape, gave a clear overview of challenges and potential across the eight industries, and made it possible to compare fundamentally different sectors against the same dimensions. Without this structure, the breadth of the study would perhaps have been difficult to convert into a coherent strategic recommendation.

That said, it was not always a perfect fit for the Eira Systems case. Several issues emerged throughout the process. For example, the framework is designed to evaluate a small number of specific applications in depth, whereas our approach differed significantly, assessing a broad range of industries rather than conducting an in-depth analysis of individual applications. One could argue that a company should conduct a preliminary investigation of applications before selecting which ones to evaluate; however this study in itself serves that very purpose. For a company without this kind of prior evaluation, it is difficult to identify and select the right applications beforehand, which is why we argue that this broader exploratory approach was necessary.

Furthermore, having six evaluation criteria sometimes felt ineffective. While they provided structure, some criteria were grounded in hard facts and could be evaluated with relative confidence, while others relied on loose and speculative information. Yet both types receive a score in the same way, which risks obscuring the difference in reliability between them and making the overall rating appear more certain than it actually is. Introducing weighting to account for this could be a possible solution but would most likely be difficult in practice, as determining the level of reliability for each criterion is itself quite subjective and not always straightforward to identify. It would also require applying different weights across industries, since the availability of hard facts varies by context, which could in turn obscure comparisons between industries and undermine the consistency of the results.

Our process often had to deviate from the framework, but it was still valuable to have as a structural reference point. As Gruber and Tal (2017) noted, the framework functioned best when treated as a guide rather than a rigid manual. However, there are a few ways the framework could be adjusted to better suit the context of high-tech emerging markets, as presented in the following section.

5.2.1 The framework benefits from being applied iteratively

A central learning is that the application of the MON did not follow the linear sequence the framework prescribes. While Gruber and Tal (2024) acknowledge that the process can be iterative, this case suggests that this applies to a far greater extent than the framework indicates. The process proved deeply non-linear, with market potential frequently emerging as a hidden variable that could only be uncovered through direct dialogue with industry actors. Committing to specific applications too early may limit the researcher's ability to explore the technology's versatility. For example, applications such as sample delivery in mining and decommissioning logistics in nuclear were not raised in the workshops but only surfaced through subsequent interviews.

This non-linear nature gave rise to a central methodological tension regarding the appropriate level of analysis. The MON prescribes evaluation at the level of specific applications combined with customer groups, but this study conducted the primary evaluation at the industry level. This adaptation was motivated by the specific conditions of the study, a highly novel technology with undefined markets and an explicit ambition shared with Eira Systems to identify as broad a range of opportunities as possible. Defining specific applications before conducting the interviews would have required assumptions that could only be tested through direct market interaction, and approaching interviews from a predetermined application perspective may have caused the researcher to overlook potentially more valuable use cases that only emerge through open dialogue.

The industry-level adaptation generated genuine analytical value by enabling systematic comparison across sectors and allowing the most relevant applications to surface naturally through dialogue. It also helped uncover cross-industry patterns that can be used to generalise the findings across other markets that were not studied, helping future market discovery. However, its limitation becomes visible when examining the MON dimensions more closely. Several dimensions like compelling reasons to buy and implementation obstacles, are fundamentally application-specific. A single industry can contain applications with very different scores, as illustrated most clearly in the nuclear sector where the monitoring and logistics use cases differ substantially despite belonging to the same industry. Assigning a single industry-level score across such divergent applications tends to produce averaged assessments, suggesting that the MON may be most analytically powerful when applied at the application level, with industry-level application representing a practical but imprecise adaptation that trades depth for breadth.

5.2.2 Product fit may be better treated as a screening step rather than a part of the evaluation criteria

A further consideration concerns how the six MON dimensions should be weighted. Gruber and Tal (2017) note that practitioners can weigh dimensions differently depending on context. For an early-stage deep-tech venture such as Eira Systems, the effectuation logic of Sarasvathy (2001) suggests product fit may be particularly critical, since a small startup with limited resources cannot easily move away from its existing means without compromising its technological vision and competence. This consideration may apply more strongly in high-tech contexts where industries demand technically complex solutions, while ventures developing simpler products may have greater flexibility to adapt their offering to fit a given market. In this study, product fit was not applied as a formal weighting of any single MON dimension, but as a separate screening step at the transition from industry to application selection. This was because product fit influences several MON dimensions simultaneously, including implementation obstacles, time to revenue and economic viability. Treating it as a screening filter rather than a weighting allowed it to shape the application shortlist without distorting the comparability of the underlying scores.

5.2.3 A multi-layer dimension may add value where clear technological progression exists

Adding the multi-layer dimension to the analysis brought both benefits and challenges. On the challenge side, analysing industries across three autonomy levels was difficult in sectors where the technology has barely entered the market yet. In those interviews some layers were barely mentioned for several contexts, making evaluation of those factors difficult. Value drivers and challenges often looked similar across layers, and in many cases it was hard to tell the layers apart, especially when respondents were uncertain about the implications of higher autonomy levels. The added detail sometimes created more noise than clarity. On the positive side, the layered analysis helped identify markets where Layer 1, Layer 2 and Layer 3 each added different value, which was especially useful when deciding what to pursue now. By treating the layers as a step-by-step progression, the analysis enabled dynamic strategizing, where Eira Systems can enter the market with simpler versions of the technology while continuing to develop more advanced capabilities in parallel, making it possible to identify stepping stone applications that generate near-term revenue while building toward the more advanced Layer 3 entry that represents Eira Systems' long-term differentiation. For example, by entering the fire & rescue industry already at layer 1, it creates an early revenue while also strengthening the probability of selling the more advanced technologies later on.

6
Conclusion

The study identifies several characteristics that shape UGV adoption across industries. Safety and operational necessity as purchasing drivers appear to accelerate adoption more than efficiency arguments. Closed operational environments reduce the regulatory challenge by enabling testing within a controlled perimeter, explaining why industries such as mining and nuclear have progressed further than the likes of agriculture and construction despite similarly high challenge scores. Organizational inertia manifests in two distinct ways, blocking at the scaling phase in regulated sectors and at the testing phase in fragmented sectors, with the latter representing the stronger overall constraint. Near-peer reference customers accelerate diffusion, though the effect appears stronger when the reference is local rather than international. GNSS jamming creates an asymmetric pressure that worsens conditions for GNSS-reliant systems while strengthening the case for signal-independent alternatives, with regulatory formalisation expected first in safety-critical sectors.

The Market Opportunity Navigator proved relatively effective as a strategic foundation but may require several adaptations to function well in this high-uncertainty deep-tech context, including iterative application, industry-level first-pass filtering and product fit screening. Where a clear technological progression exists, the framework may also benefit from integrating technological sophistication as a strategic variable, enabling dynamic strategizing where near-term stepping stone markets can be pursued while more advanced capabilities continue to develop. This adaptation added analytical value but also increased the complexity of the evaluation considerably.

6.1 Recommendations for Eira Systems

For Eira Systems specifically, the study recommends pursuing multi-purpose transport in fire & rescue services as the primary market with sample delivery in mining as a parallel growth option, while keeping heavy mining transport and nuclear decommissioning logistics open as backup options. However the authors emphasize that the recommendations should be treated as a starting point rather than a definitive roadmap. Deeper research within the recommended markets, with a higher number of interviews targeting the specific applications and customer groups identified, would be needed to validate and refine the strategic direction before acting on it with full confidence.

6.2 Generalizability and Further Research

As this study is based on a single case with a limited number of interviews per industry, the findings should be treated as indicative rather than conclusive. The cross-industry patterns identified may point to broader tendencies, but the authors caution against drawing strong generalizations since the number of respondents does not fully represent the industry as a whole. The framework adaptations proposed are best understood as a starting point for further empirical testing rather than established recommendations, and their transferability to other deep-tech ventures will depend on how closely the conditions of high technological novelty, undefined markets and versatile core technology resemble those of this study.

Several directions for future research emerge from the findings. The cross-industry patterns identified under RQ1, such as the role of purchasing drivers, operational environment and organizational inertia, could be tested across a broader set of industries and geographies to assess whether they hold beyond the Swedish and Nordic context. The two distinct types of organizational inertia identified in this study, one blocking at the scaling phase and one at the testing phase, warrant more systematic theoretical development and empirical testing. The cross-market reference dynamic observed between fire and rescue services and mining, where a single deployment can simultaneously validate the technology in both markets, represents an underexplored dimension of market relatedness. This dimension is not currently accounted for in the MON framework and warrants closer examination in future research. Finally, the framework adaptations proposed here, including iterative application, industry-level first-pass filtering and the integration of technological sophistication as a strategic variable, should be tested across other deep-tech ventures in different technological domains to assess their broader applicability.

6.3 Scientific and Managerial Contribution

The study contributes a specialization of the MON Framework that integrates technological sophistication as a strategic variable, and identifies a set of adaptations that may strengthen the framework's applicability in nascent deep-tech contexts. Practically, it provides Eira Systems with a structured go-to-market strategy grounded in empirical data from twenty interviews across eight industries. Beyond the specific case of Eira Systems, several managerial implications may be applicable to other deep-tech ventures navigating similar conditions of high uncertainty and versatile core technology. First, prioritizing industries where safety or operational necessity drives the purchasing argument appears to accelerate early adoption more than efficiency-driven markets, reducing the burden of proof for an unproven technology. Second, seeking closed or controlled operational environments as initial entry points lowers the effective regulatory challenge and enables ventures to build reference cases before formal certification is required. Third, treating market exploration as an iterative process driven by close interaction with industry actors, rather than committing to specific applications early, reduces the risk of premature lock-in and increases the likelihood of identifying the most valuable use cases. Fourth, where the technology has a clear progression of sophistication, evaluating markets across multiple autonomy or capability levels enables dynamic strategizing, allowing the venture to generate near-term revenue through stepping stone applications while continuing to develop toward its most disruptive capability.

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A
Workshop Results

A.1 Table

Table A.1: Workshop Results

Workshop 1		
Stage	**Category**	**Capability**
Capabilities	Sensor systems	LIDAR
		RADAR
		Sensors
		Cameras
	Technical Abilities	GPS-independent
		Autonomy
		Fleet-control
	Mobility	Off-road driveability
		Negotiability
		Continuous operation
		Reliable
		E-Powered
	Form	Mid-sized
		Lifting arm
		Modularity
		Solar cells
		Wheel / band-based
	Physical Abilities	Heavy lifting
		Resilient
		Waterproof
		Strong drive
Stage	**Category**	**Application**
General Applica-tions	Transport	Autonomous trucks
		Buses
		Transport injured / sick
		Transport of people

		Transport of necessities	
		Food delivery	
	Rescue	General rescue	
		Rescue in wetlands	
		Mountain rescue	
		Forest fires	
	Nature / Environment	Nature / animal research	
		Measurements / sampling continuously	
		Forest surveying	
	Agriculture	Agriculture	
		Farming	
	Dangerous Goods	Handling of hazardous goods	
		Nuclear decommissioning	
		Nuclear powerplants	
	Construction	Construction work	
		Mounting / assembly	
	Hunting	Support (carry, lift)	
	Snowcat	Autonomous snowcat	
		Skilift	
Stage	**Category**	**Customer**	**Application**
Customers	Transport	Bus companies	Autonomous buses
			“Flexlinje” off-road
		Public Transport	“Flexlinje” off-road
			Food delivery
		Food delivery companies	Deliver food from restaurant to customer (autonomous)
			Deliver goods from wholesaler to customer (autonomous)
		Airport	Transportation of baggage between airport and plane
			Shuttle bus autonomous
		General	Transport of soil, materials, gravel, stone, etc.
		Hospitals	Transport emergency cases
	Rescue	Mountain rescue	Search for missing people
			Transportation of distressed in hard to reach terrain (autonomous/remote)
			Avalanche measures / sampling, trigger, assess
		Police	Task force in high risk situation, e.g. Bombs
			Thief scanning / bait

		Räddningstjänsten	Urban search / rescue in rubble / ruins
			Autonomous fire extinguishing forest fires
			Transport of gear at forest fires / flooding
			Fire robot in inaccessible environments
			Rescue in collapsed building / rubbles / landslides
	Nature / Environmental Research	Research Institutes	Geology sampling over large areas
			Study animals
			Environmental measuring / sampling (toxicity, gases)
			Continuous measures / sampling in sensitive areas
		Government authorities	Measure forest health, tree density, soil damage
			Environmental measuring / sampling
			Continuous measures / sampling in sensitive areas
	Inspection / Surveillance / Maintenance	Trafikverket	Inspection when planning roads / tunnels / bridges
			Fixing roads
			Autonomous inspection of railway / rail health
			Inspection of tunnels and bridges
		Agriculture	Search for diseases or pest
			Soil analysis, pH-levels, optimize fertilizing
			Measure moisture-levels
		Police / Security	Guard borders / airports / military bases
			Surveillance of suspects
			Patrol particularly vulnerable areas
		Energy companies	Transport sensors / fire extinguishing gear to powerplants in crises
			Inspection of power lines
			Maintenance / surveillance (power lines, power station)

			Measure dangerous substances
			Repair from distance
		Forest owners	Maintenance / clear roads / accessibility
			Forest inspections: diseases, fallen trees, control from distance
		Infrastructure companies	Inspection of tunnels and bridges
	Agriculture	Farmers	Spray pesticide
			Feed animals
			Fertilize
			Transport animals, food, tools
	Mining / Blasting Work	Mining companies	Monitor air quality
			Transport ore, gear, personnel
			Move gear / personnel between tunnels
			Handle blasting work
			Drill
		Infrastructure companies	Transport material
			Blasting work
		Construction	Drilling, screwing, welding
			Autonomous excavator
			Reinforcement robot
			Clean workspace
			Measurement
	Handling of Dangerous Goods	Nuclear Powerplants	Move demolition waste when decommissioning
			Move radioactive material
		Nuclear waste handling	Move radioactive material
		Battery producers	Transport damaged batteries
		Recycling centers	Move containers with dangerous goods
	Snowcats	XC-Ski clubs	Piste
		Skistar (etc)	Autonomous piste
			Skilifts to offpiste terrain
	Hunting	Hunters	Carry animals
	Charging	Forest owners	Act as hub for cooking, heat, electricity, internet
			Powerbank
		Mining	Charge machines in end of mines

		Logistics terminals / ports	Charge vehicles waiting for cargo
Workshop 2			
Stage	**Category**	**Capability**	
Capabilities	Negotiability (Real)	Off-road navigation	
		Range	
		Drivability / Negotiability	
	Automation (Real)	Automation	
		Communication	
		Sensors	
		GPS-independent	
	Layout (Real)	Cargo space	
		Driver Space	
		Negotiability	
	Negotiability (Imagined)	Drive on water	
		Air-drop	
	Automation (Imagined)	Fleet-capability	
		Complete Automation	
	Layout (Imagined)	Rolling powerbank	
		Heating cabin	
		Health center	
		Lifting device	
Stage	**Category**	**Application**	
General Applications	Transport	Mountain Taxi	
		Food delivery	
		Supplier forest fires	
		Forestry	
		Public transport (glesbygd, on-demand)	
	Support	Ability enhancing machine on wheels (connect more modules)	
		Modular unit (healthcare, energy, heat)	
	Amphibious	Drowning accidents / accidents close to shore	
		Driveability / Negotiability in wet areas	
	Rescue	Mountain Rescue	
		Evacuation emergencies	
Stage	**Category**	**Customer**	**Application**
Customers	Rescue	Naturetourism	Rescue in nature

		The Swedish Armed Forces	Evacuation of injured people
		Fire & Rescue Service	VMA
		Tourist associations	Mountain Evacuation
			Sightseeing
	Transport	Land Surveying	Cadastral surveying / Property boundary verification
		Post/delivery companies	Last mile delivery remote
			Deliver packages to current position
		Mining Industry	Transport excavation materials
		Forestry	Transport timber
		Transportation Industry	Västtrafik
		Mountainstations	Deliver necessities and people
		Naturvårdsverket / Länsstyrelsen	Planting / Release Animals
		Nature tourism	Transport tourist even further out
		Security Companies	Monitor protected objects (skyddsobjekt)
		MSB	—
		Lantbruk / Skogsbruk	Transport materials and personnel
		Elnätsbolag	—
		Provision MSB	—
		Telecom	Receiver and transmission in areas with poor coverage
		Mechanics / Service	Deliver tools + spare parts (forestry, agriculture)
		Agriculture / Forestry	Fertilize, spray, harvest. Refueling, tools, spare parts
	Health care	Fire & Rescue Services	Emergency care
		The Swedish Armed Forces	Combat Casualty Care
	Intelligence	Research organizations	Information gathering in dangerous environments
			Record / measurements in nature
		Fire & Rescue Services / Police	Surveillance
	Amphibious	Public Transport	School transport
			Transport people over land and water

		Oil riggs	Transport of personnel and material
		Sailing associations	Rescue accidents
		Municipalities / cities	Home care, Reed clearing, weeding, litter cleanup
			Sea Rescue

A.2 Images

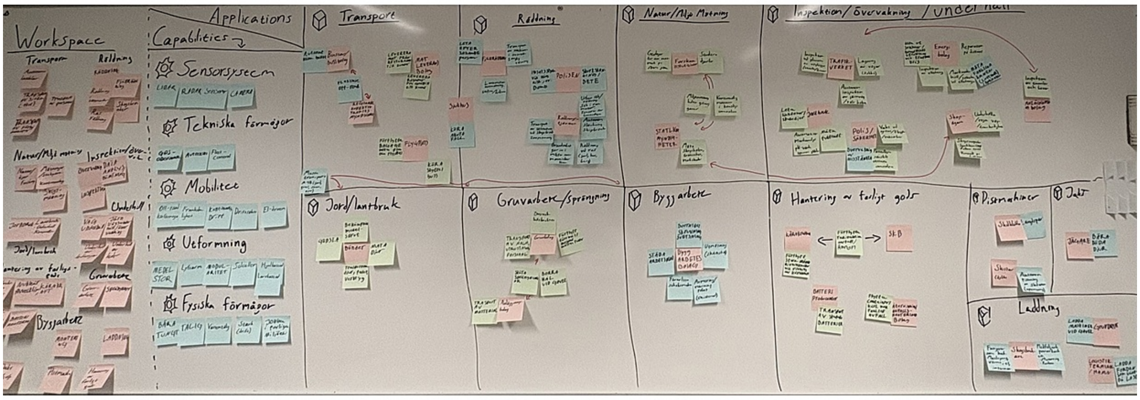

Figure A.1: Workshop 1

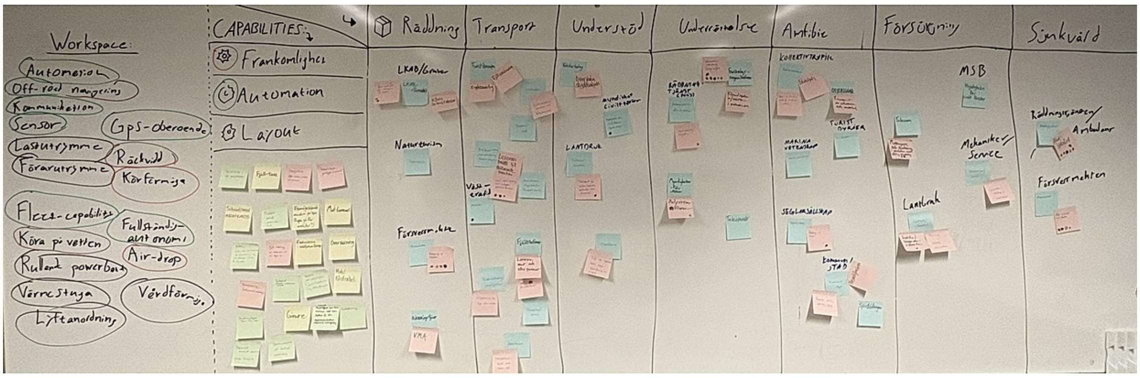

Figure A.2: Workshop 2

B

Current use and development of Autonomous Vehicles by Industry

B.1 Agriculture

Autonomy has quietly entered the agricultural sector through two distinct entry points. In the air, camera-equipped aerial drones are already being used for variable rate pesticide application, detecting variation across fields and adjusting dosage accordingly. In Denmark this has been actively driven by government funding aimed at reducing chemical input, though notably the technology is typically operated by agricultural advisors rather than the farmers themselves, creating coordination challenges when multiple fields need attention simultaneously before the optimal spraying window closes. On the ground, the more understated reality is that tractors are already largely driving themselves. GNSS-guided auto-steering has become so standard that drivers barely need to touch the wheel during field operations. Among vegetable growers, weeding robots equipped with cameras and sensors are beginning to replace chemical herbicides, though they are relatively new systems still in an early adoption phase with some running-in period before they become fully established. Milking robots represent an established example of automation in livestock farming. At the frontier of field-scale ground autonomy, AgXeed stands as the only company currently certified for fully autonomous large vehicle operation in the Nordic context, with the requirement that a certified operator sets up the safety zones before the machine is left to work independently. Among the major machinery manufacturers, John Deere is thought to have progressed furthest in autonomous systems development, including entirely autonomous solutions for tractors as well as the possibility of adding sensor systems onto current vehicles. However Claas has also invested in a company developing a driverless tractor capable of sowing, hauling, lifting, harrowing and general soil cultivation.

B.2 Infrastructure Inspection and Maintenance

Railway infrastructure inspection in Sweden operates on a roughly eight to ten week cycle, carried out by dedicated camera-equipped vehicles that run along the track filming the infrastructure in high resolution. These vehicles are operated conventionally, but the footage they collect is processed through image analysis software that flags anomalies ranging from weld defects to loose fastenings. A human inspector still needs to physically verify any finding before action can be taken, and the regulatory framework may need approximately two more years before camera-based findings are accepted without requiring physical verification. In high-traffic urban areas where daytime ground inspection is impossible due to train conflicts, aerial drones have become a practical solution, operating independently of train timetables and enabling inspection during daylight hours. Some measurement equipment has also been piloted on ordinary passenger trains, though the respondent describes coordination as the primary obstacle rather than technical feasibility. On the road side, vehicles are already collecting real-time road condition data including pothole detection. The Digital Vinter project in Gothenburg takes this further, using cars to collect slippery road data which is then combined with weather forecasts to guide winter maintenance crews on when and where to deploy, replacing what was previously a contractor looking out the window to decide whether to plow. These systems are already operational and led to fewer public complaints in the year it ran smoothly.

B.3 Nuclear Power and Nuclear Waste Management

Of all the industries covered in this study, nuclear is where autonomous systems have been deployed in the most demanding and carefully controlled conditions. At one of the large Swedish state-owned energy companies, radiation-hardened inspection aerial drones visit turbine halls where dose levels are too high for personnel during operation, equipped with thermal cameras, standard cameras and radiation point measurement equipment. Outdoors, an autonomous drone-in-a-box system patrols the perimeter, capturing still images at fixed locations for security monitoring. Remote-controlled demolition robots handle radioactive solid waste, cut tanks and process concrete around reactor structures, both in active operations and in ongoing decommissioning work, with multiple units already deployed. One of the decommissioning respondents describes current dismantling as approximately 90% manual, with robots deployed specifically for the highest risk and most physically demanding tasks. An autonomous quadruped robot has been successfully piloted for autonomous measurement tasks within the plant. At the Swedish nuclear waste management organisation, the picture is more advanced still: fully autonomous mobile robots are already in operational deployment underground, navigating a GNSS-denied environment through SLAM-based onboard mapping. The same modular platform serves as a transport vehicle, an autonomous mobile robot or a crane unit for nuclear fuel buffer placement depending on which module is attached, with a fleet control system managing multiple vehicles simultaneously under remote human supervision. This technology has been commercialised through preferred partner companies and is used by over 100 organisations globally, making this organisation one of the most advanced real-world deployments of GNSS-independent autonomous UGVs encountered in this study.

B.4 Construction and Civil Engineering

Compared to mining or nuclear, construction is a sector where autonomous technology has been talked about considerably more than it has been deployed. The clearest established applications are at the simpler end of the spectrum: aerial drones for site photography and documentation are described as fully automated and in widespread use, while autonomous lawnmowers handle grass cutting contracts with municipalities in a verified and growing application. In prefab concrete manufacturing, largely automated production through technology purchased from German manufacturers represents the sector's most mature autonomous process. On construction sites themselves, GNSS-guided asphalt laying and compaction equipment operates with a degree of semi-autonomy in road construction, with fully autonomous operation having been demonstrated in China and Japan though requiring complete area lockdown. An autonomous quadruped robot has been tested across multiple projects at one of the large Swedish construction contractors for data collection and progress tracking, analysing material quantities and monitoring construction progress, with technically positive results though the respondent describes insufficient organisational demand and will to push further. A small self-driving robot tested in Norway could mark out road alignments by spraying paint based on inputted drawings, a technology that has existed for fifteen years according to one respondent but remains far from widespread. The overall picture is one of a sector with pockets of genuine innovation but where the gap between what has been piloted and what has been scaled remains stubbornly wide.

B.5 Fire & Rescue Services

Within the Swedish fire and rescue services, the use of UGVs, aerial drones and autonomous technology is in an early but active development phase. One of the larger metropolitan fire and rescue services in Sweden is among the most advanced actors and has been working since 2021 to introduce a ground-based firefighting robot primarily intended for firefighting and reconnaissance in environments where it is considered too risky to send personnel, such as tunnels, parking garages and buildings with weakened structures. The robot is transported with a dedicated unit consisting of two robot operators and a squad leader, and is equipped with an infrared thermal camera to identify heat development in structures. It has so far been used on two occasions in critical situations: during an industrial fire to scan for structural fires, and during a tunnel construction project where the robot was driven in approximately 400 meters to check the situation after a fire broke out. The robot is remotely controlled and operates without GNSS dependence, which has proven to work well in underground environments, albeit with some known limitations regarding signal strength in the case of obstacles and reinforcement. Another rescue service has made a purchase of a similar robot and has followed the first organisation's implementation closely, with the same basic idea of operating in dangerous environments without exposing personnel to unnecessary risk.

In parallel with ground-based robots, several rescue services have been actively working with aerial drones for several years, and these today constitute a more established tool for situational awareness and reconnaissance. There are also ongoing discussions about combining ground-based and airborne systems, where the aerial drone quickly provides an overview and the UGV supplements it with information at ground level. When it comes to mine rescue, no robotics are currently used operationally. The efforts are based on manual smoke diving with the support of an electric cart that rolls out a radio cable and safety line, thermal cameras and signposts with local knowledge. However, autonomous vehicles are already used in mining operations in general, and the mining companies' technical departments are actively working to explore whether similar technology can also be applied to rescue operations, with a controlled trial with a remote-controlled vehicle for fire extinguishing at one underground mine planned. Overall, the current situation is characterised by the technology existing and being tested, but scaled-up implementation being slowed down by municipal budget limits, a lack of trained personnel and a lack of established cooperation structures between rescue services and other actors.

B.6 Mining Industry

The most concrete implementation is found at one of the large Nordic mining and smelting corporations, where a fleet of autonomous trucks operate in an open pit mine monitored by a few operators. Underground, the same company is testing a sensor-controlled traverse system at its smelters, a solution described as cost-effective and quick to install, which has proven to work well across different environments, both extremely hot above ground and more stable underground. The company has also tested smaller ground-based robots for internal logistics, specifically for transporting samples and small goods between units on large sites. For underground transport, a collaboration is underway with a major truck manufacturer on an all-electric truck in a limestone mine, where the aim is to map how an all-electric setup affects production. All of the company's mines are equipped with 5G, and sensor-based navigation is used underground because GNSS is not available, while Arctic mines above ground remain GNSS-dependent. The underground transport flow, where machines drive along the site to the end face, is identified as the highest priority area for future automation as it takes the most time and requires the least human intervention. For work at the end face, a collaboration is underway with a major mining equipment supplier to develop remotely controlled machines, but neither the technology nor the control room environments are considered fully developed yet. Certification of autonomous vehicles underground and at smelters is considered possible around 2028/2029, with EU regulatory requirements regarding specific components and reaction speeds being the remaining obstacle.

A smaller gold mining operation currently lacks any form of autonomous or remotely controlled equipment and is building out its first underground wireless network as a first step. Remote blasting is already handled remotely, and a planned next phase is described as a hybrid system where a driver takes the machine to the workplace, after which it autonomously returns and retrieves more material, though this has not yet been implemented. From the supplier side, one of the major construction and mining equipment manufacturers confirms that commercial trucks are currently being driven autonomously in mining environments on well-defined gravel roads, with GNSS as the primary navigation tool supplemented by cameras and sensors for obstacle detection. The same manufacturer has also tested a smaller load carrier fully autonomously using an internal prototype system, and piloted remote control of the load carrier via a separate wheeled excavator, allowing one operator to control both machines simultaneously.

B.7 Power Grids and Cables

In the electricity grid sector, aerial drones are the most established form of autonomous and remotely controlled technology. One of the larger Swedish electricity distribution companies has lidar-scanned its entire power grid to obtain precise pole positions with an accuracy of plus or minus three centimetres. This data is used to control aerial drones autonomously along the lines, where the drones are positioned via GNSS based on the loaded lidar model and take images from exactly the same position year after year to enable comparison over time. The inspections are carried out at least once a year and replace previous helicopter inspections, which gave poorer image quality and entailed greater personal risks in the vicinity of live power lines. A drone pilot actively monitors the flights. A municipal energy company has similarly purchased drone functionality for preventive maintenance of overhead power grids. A state-owned energy company's R&D department has conducted rigorous tests with both ground-based quadruped robots and flying systems in transformer stations, environments characterised by high voltage and limited personnel presence. In hydropower, the same company has flown autonomous aerial drones inside inlet tunnels equipped with laser scanners, operating in a self-exploring mode where a target point is specified and the drone navigates autonomously, with a current range of up to one kilometre in a tunnel. In a separate tunnel inspection, a radio-controlled ground vehicle with a laser scanner and fibre link was used for communication in a tube of approximately one kilometre, where operators were located at the entrance without having to follow along the entire length. The same R&D department is also testing ground-based robots with radiological measurement equipment and sound mapping equipment in nuclear power environments, and evaluating autonomous underwater inspections of water-filled tunnels, where work is focused on identifying suitable suppliers and resolving issues around battery life and communication via fibre line. Another electricity distribution company is investigating the use of ground-based solutions for patrolling fenced regional grid stations, where the regulatory situation is considered more favourable than for aerial drones, and colleagues in the industry have tested quadruped robots at switchyards. Line inspection services are also offered commercially by some actors in the sector, though this business is described as highly competitive.

B.8 Forestry

In forestry, partial autonomy has come the furthest and is today the dominant implemented area. Since the 1980s, the crane systems of harvesters have been automated step by step, and modern harvesters today handle several steps automatically, including automatic crane return and sorting of assortment. A Swedish forestry research institute runs a forest technology lab where a full-size forwarder is used in active research projects, adapted for both remote control and autonomous operation. The same lab is also developing a clearing robot in collaboration with a Finnish player, intended to independently clear undergrowth. On the aerial drone side, a startup has been working with aerial drones for thinning trees from the air since 2020 and is now said to be approaching pre-series production. Autonomous soil preparation and planting was demonstrated by the same research institute already in 2022, but still takes place with one person on site with emergency stops and is not yet commercially viable, partly because the technology is too costly in relation to the low margins of the measures. Two Swedish universities have jointly demonstrated autonomous forwarding with a smaller machine, and a Finnish project has shown a small autonomous harvester, but neither of these is close to commercial operation. On the transport logistics side, a concept inspired by the Canadian truck industry is pointed out as one of the more promising next steps, where a driver-driven main vehicle is followed by an autonomous shuttle trailer that transports timber to the cutting site, enabling double the load capacity per turn without an additional operator. Digital decision support is already partially implemented, with the harvester's real-time work data visible in the forwarder's cabin. GNSS is widely used in forestry for positioning and monitoring, but increasing interference and lack of coverage of logging areas make the system vulnerable, which is driving interest in local positioning solutions without satellite communication, an approach that has been explored at a research level in Canada among other places.

C

Market Opportunities Identified but Not Pursued Due to Limited Respondent Access

Autonomous ski-lifts and snowcats emerged from the workshops as potential applications given the demanding terrain and weather conditions in which they operate, combined with the seasonal labor challenges faced by mountain resorts. Several respondents across other industries also noted snow and winter conditions as an operational challenge for their current autonomous systems, suggesting a broader relevance of robust all-weather capability that this application would also demand. However no relevant respondents within the ski and mountain resort sector could be identified within the scope of the study.

Sewage and drainage inspection was identified as a potential application given the GNSS-denied underground environment and the recurring need to inspect infrastructure that is difficult and unpleasant for human operators to access. The application shares meaningful capability overlap with other underground transport and inspection use cases identified in the study.

Recycling and waste handling was mentioned by several respondents, including from the construction and manufacturing sectors, as an environment where repetitive and physically demanding transport tasks could be automated.

Combined UAV and UGV bridge and infrastructure inspection was identified as a promising complementary application, where aerial systems provide overview and the ground vehicle supplements with close-range inspection at ground level. This was touched upon in the infrastructure interviews but not pursued further due to limited respondent access.

Police surveillance and tactical support was raised in the workshops as a potential application given the overlap with the military use cases Eira systems is already developing toward. The operational profile, navigating difficult terrain in signal-denied or signal-suppressed environments, maps closely onto Eira's core capability, but the procurement complexity and sensitivity of the sector made it difficult to access relevant respondents within the scope of this study.

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