TECHNOLOGY READINESS ASSESSMENT & COMMERCIALISE FRAMEWORK

PROGRAMME	Longevity of Current Mines (LoCM)	**WORK PACKAGE**	LoCM24WP4 Technology Readiness Assessment & Commercialisation Framework

FINAL REPORT

PROGRAMME MANAGER	Martin Pretorius	**DATE**	02 December 2024
RESEARCH AGENCY	The Research Institute for Innovation and Sustainability (RIIS)		
PROJECT LEAD	V Mahadeo	**PROJECT TEAM**	T Mhlanga (RIIS)
			C Cook (RIIS)
			Z Ndlela (RIIS)
			B Greef (CSIR)

REF NO:	2024_LoCM_WP4_FR

MANDELA MINING PRECINCT
MINDS FOR MINES

Contents

1 EXECUTIVE SUMMARY

The Longevity of Current Mines (LoCM) program, led by the Mandela Mining Precinct (MMP), aims to enhance efficiency, safety, and sustainability in South Africa's mining operations. Within this initiative, the "Product development process from TRL6 to TRL9" work package focuses on streamlining the commercialisation of mining technologies. Recent regulatory changes have heightened OEM compliance responsibilities, emphasising the need for a robust TRL6 to TRL9 product development process. This study engages stakeholders to build a TRL6 - TRL9 resource base, develop a validated commercialisation framework, and establish an information-sharing platform, addressing these milestones through phased efforts.

The study focuses on technology development and commercialisation of the mineral extraction phase technologies of the mining value chain, prioritising safety, cost-efficiency, and environmental compliance. Throughout the stakeholder engagement, the critical gaps in the mining innovation ecosystem, including limited investment from mining companies and delayed government funding, were identified to place financial risks on Original Equipment Manufacturers (OEMs) and Small and Medium Enterprises (SMEs). Other factors include cultural and organisational factors (e.g. cultural and user resistance and high risk to the organisation), regulatory challenges and uncertainty, technological readiness, operational integration and interoperability, limited collaboration from the key players across the ecosystem, and market demand. These challenges hinder SMEs from overcoming the "Valley of Death" in commercialising technologies. A robust commercialisation framework must address these issues by offering timely financial and strategic support to SMEs, key drivers of mining innovation. The stakeholder insights were benchmarked against existing frameworks, informing key assumptions in addressing commercialisation barriers.

Stakeholder insights and research guided the design of the business framework. This comprehensive framework provides a structured approach to analysing, planning, and executing strategies for product commercialisation, leveraging industry standards such as the System Engineering Process ISO 15288, Technology Readiness Levels (TRL), and the Commercial Readiness Index (CRI). It ensures alignment across technology, business, and stakeholders, with checkpoints to integrate activities across critical organisational functions, reduce setbacks and increase commercial success.

The commercialisation (i.e., Business Framework) is not meant to be prescriptive to provide guidance. Depending on which phase the stakeholders have interest to the product development, they can prepare and plan for the requirements of the next phase or reflect on their success in previous phases to determine if rethinking and redoing is required. It is, therefore, the responsibility of the relevant stakeholder to take ownership of each phase, along with the associated requirements, to determine what is relevant and necessary for their journey.

Innovation thrives within a supportive ecosystem, and an information-sharing platform is crucial in fostering this ecosystem, particularly within the mining sector. Such a platform can support the commercialisation framework, helping bridge gaps in knowledge and resources.

2 AIM OF MILESTONE DELIVERABLE

The study aims to describe the product development and commercialisation process for mining technologies, focusing on advancing from Technology Readiness Level (TRL) 6 to TRL 9. This involves ensuring a seamless transition from technology demonstration in an operational mining environment

to a fully integrated system validated through testing, assessments and demonstration, ultimately paving the way for commercialisation. To achieve this understanding, industry insights are crucial for addressing challenges in the innovation process and understanding the different roles of the stakeholders involved.

This final report entails the work package deliverables based on the various phases of the different milestone deliverables. These include:

- **Establish a stakeholder resource base**- This phase was pivotal in mapping and identifying the key stakeholder's integral to the technology development and commercialisation value chain within the mineral extraction phase in the mining sector. Priority was given to engaging mining houses, original equipment manufacturers (OEMs), funding agencies, industry associations, and accredited validation firms, as these entities play critical roles in the ecosystem. Relationships with prominent industry associations, such as the Mandela Mining Precinct (MMP), Minerals Council South Africa (MCSA) members, and Mining Equipment Manufacturers of South Africa (MEMSA), were strategically leveraged to gain access to these crucial stakeholders. This collaborative approach ensured a comprehensive sector understanding and facilitated meaningful engagement.
- **Development of a commercialisation framework-** A detailed "Business Framework" was developed, referencing the Systems Engineering Process, Technology Readiness Levels (TRL), and the Commercial Readiness Index (CRI) frameworks. This framework serves as a comprehensive journey map for technology developers, a business framework to facilitate a structured and systematic transition from concept development to market adoption. By addressing the critical technical, operational, and commercial aspects at each stage of the development process, the framework ensures that technology developers can navigate the complexities of innovation effectively.
- **Creating an information-sharing framework-** To foster an environment where innovation can thrive, the Value Proposition Canvas model was utilised to synthesise insights from relevant stakeholders. This process enabled the conceptualisation of key aspects for an information-sharing platform designed to support the advancement of problem-solution matching and catalysing of innovation across the mine ecosystem. The platform aims to connect and empower relevant stakeholders, facilitating collaboration and knowledge exchange critical to advancing technology development and commercialisation efforts. This ecosystem is envisioned to complement the structured approach provided by the commercialisation framework and ensure that innovation efforts are supported from ideation to market readiness.

3 METHODOLOGY

This work package represents the entire project process, from establishing a resource base to adapting an information-sharing platform, as depicted in **Figure 1**.

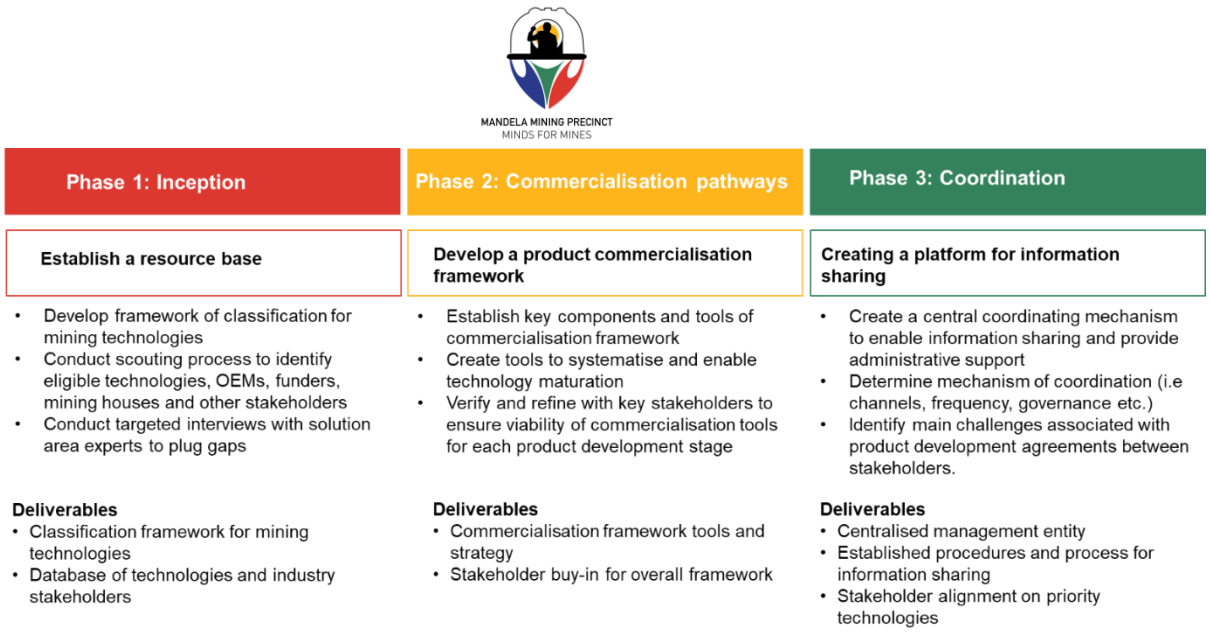


Figure 1: Overview of project approach

The phased approach facilitated the effective delivery of milestones, ensuring each deliverable received the necessary focus and attention. Stakeholders were engaged through various channels tailored to the specific phase of the project.

During the consultative Phase 2, outreach efforts targeted diverse stakeholders, leveraging connections with industry associations such as MEMSA and the MMP. This strategy proved effective in streamlining access to key stakeholders, highlighting the critical role that industry associations play in uniting participants around shared objectives. **Figure 2** illustrates the outline of the stakeholder engagement during this phase.

In Phase 3, the AOK/MMP event provided a strategic opportunity to engage directly with stakeholders. Attendees were invited to participate in a survey focused on an information-sharing platform, maximising the benefits of a gathering that brought together a wide array of industry representatives. This approach underscored the importance of leveraging existing events to collect valuable stakeholder input and drive collaborative progress.

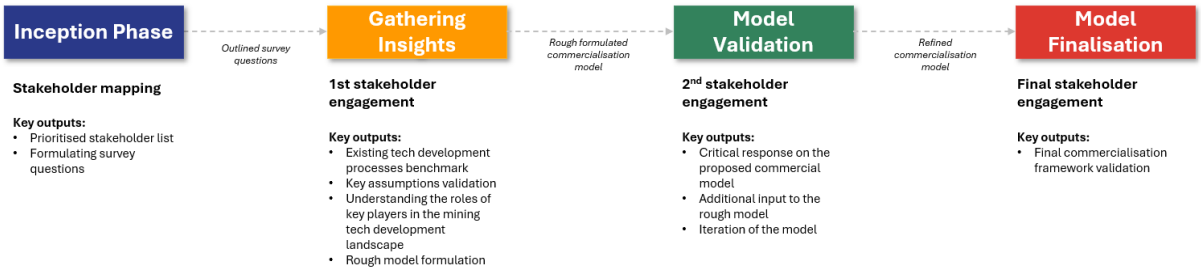


*Figure 2: **Overview of project stakeholder engagement approach***

This methodology was effective in ensuring a balanced approach to the conceptualisation of the "Business Framework" as insights gained from desktop research were validated and expanded on by a range of key stakeholders across the mining ecosystem. The synthesis of perspectives from academia, government, OEMs, funders, and the mining industry ensured that the challenges and successes were understood. The deductive nature of the framework development meant that

the initial research was exploratory and based on the initial assumptions held by the project team. The journey map of the commercialisation framework is therefore the first step in streamlining the entire commercialisation process of technology development and industry adoption. Additional effort is needed to assess where and how key industry players can intervene to provide additional support for technology developers. Furthermore, deeper insight into the success factors of OEMs and technology developers that have successfully introduced mining hardware into the industry is needed to refine the commercialisation framework.

4 RESULTS

4.1 Results Summary

The phased approach provided a structured and methodical pathway to achieve the study's objectives, culminating in phased outcomes. The first significant outcome was refining the study's focus, guided by the mining value chain, specifically emphasising technology development and commercialisation within the mineral extraction phase. This targeted focus facilitated the mapping of key stakeholders critical to supporting the technology development and commercialisation in the mineral extraction phase, establishing a resource base to advance subsequent milestones in later phases.

To date, the implementation team has successfully engaged with 21 key stakeholders as illustrated in **Figure 3**. Most contributors were technology developers, including OEMs spanning SMMEs to multinational corporations, alongside funding agencies such as the DTIC and IDC. These engagements provided valuable insights and contributions that have been instrumental in shaping the design of the commercialisation framework. Some of the key weaknesses and threats hindering the commercialisation process in the mining sector were market penetration issues due to problem-solution mismatch, change management, and funding limitations. The proposed business framework provides technology developers with a structured approach to integrating technology development with business activities. This approach allows them to evaluate whether their proposed solution effectively addresses industry pain points, develop a multilevel stakeholder engagement plan to address change management issues and prepare funding applications while the technology progresses at TRL 7, accommodating the waiting period.

Additionally, 37 stakeholders from across the mining industry participated in the survey on the proposed information-sharing platform, offering valuable insights into its design and adoption. Participants highlighted key benefits of the platform, including access to expert networks (21%), opportunities for fostering innovation (16%), and improved business outcomes (15%). However, stakeholders also identified significant challenges to adoption, such as concerns around confidentiality (25%), potential reputational risks (16%), and compliance with regulatory requirements (11%).

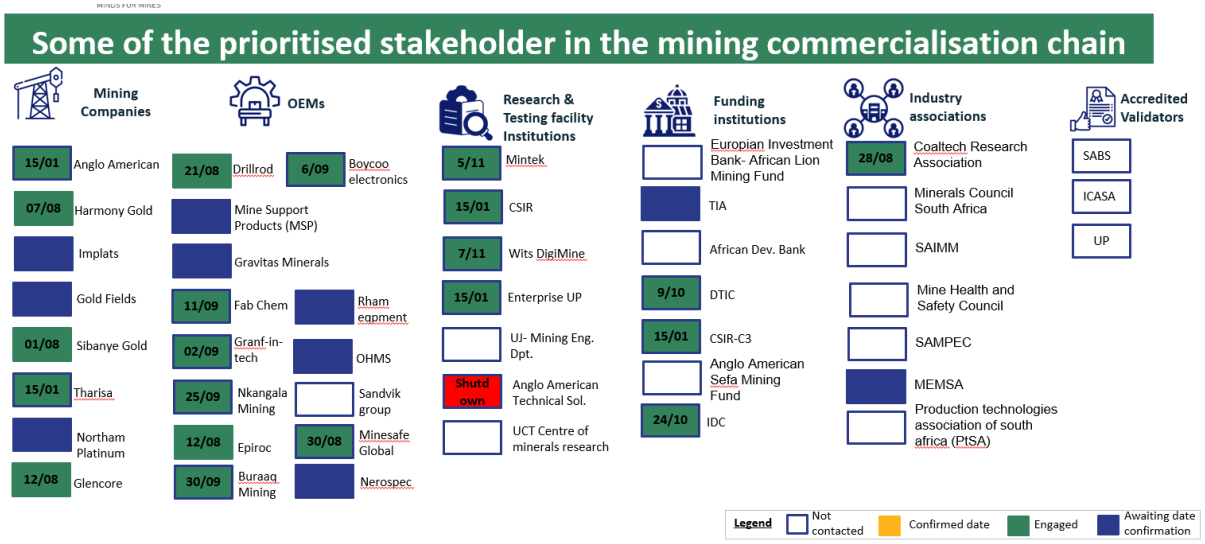


Figure 3: Prioritised stakeholder list and engagement update

5 RESEARCH FINDINGS

5.1 Research Outcome 1: Value chain map and core focus

The mining value chain encompasses multiple phases, starting with the exploration of a given area's geological composition to determine its potential for resource extraction. This is followed by assessing the site's economic feasibility and designing the mine layout to optimise operations. Once these evaluations are complete, the process moves on to securing the necessary licenses to commence mining activities and initiate mine construction.

The operational phase marks the beginning of the mine's active lifecycle, involving the extraction and processing of resources. Eventually, the lifecycle concludes with mine closure and rehabilitation, a critical phase focused on restoring the site to a safe and sustainable condition. This progression from discovery to rehabilitation is depicted in **Figure 4**.

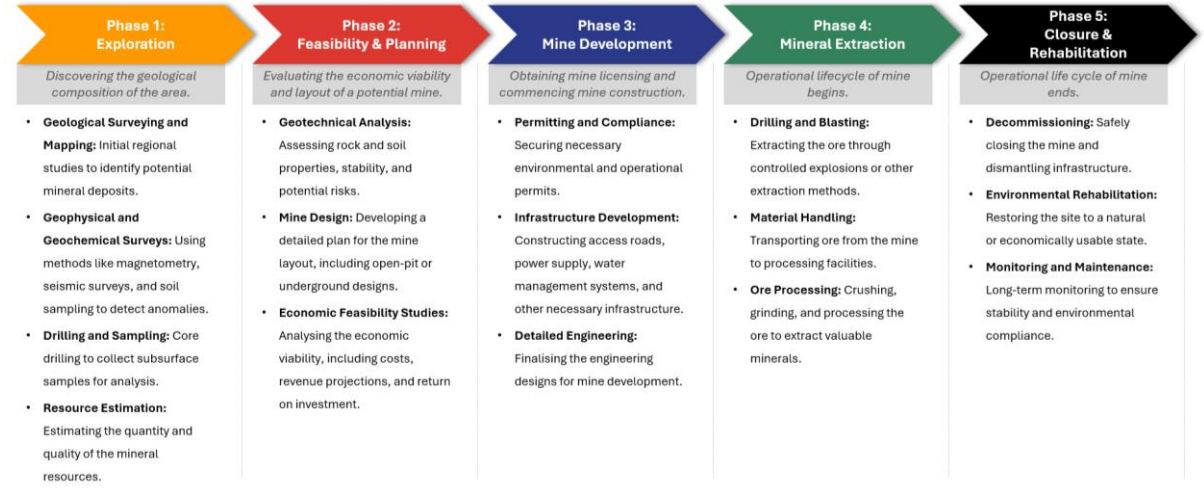


Figure 4: Mining value chain adopted from MMP

This study focused on the operational lifecycle of mines, where technology interventions are essential to optimise the value chain for competitive advantage. Mining operations face challenges such as equipment stress due to variable and unpredictable resource conditions. Adopting standard IT solutions, remote monitoring, and automated information gathering can mitigate variability, reduce costs, and extend equipment life.

In Phase 4 of the mining value chain, mechanical extraction and blasting are common techniques. Blasting is cost-effective, environmentally friendly, and critical for breaking rocks into specific fragmentations while meeting safety and compliance requirements. As illustrated in **Figure 5,** the mine's lifecycle includes interconnected activities like raw material extraction, transportation to processing facilities, and inventory management for export.

Figure 5: Drilling and Blasting of the mineral extraction process (Bhandari et al., 2017)

The support requirements in Table 1 are consistent with the stakeholder insights and align with the core questions outlined in the business framework as the technology developer progresses through the technology and business development journey towards the commercialisation of new technologies.

Table 1: Support requirements in transitioning from TRL 6 – TRL 9 (USA. Department of Defence, 2003)

Support requirements from TRL 6 – TRL 9				
	Technical	**Financial**	**Operational**	**Regulatory & Compliance**
TRL6 - TRL7	For prototype development, tech integration with mining operations and equipment, simulation and modelling tools.	Funding for extensive field testing and prototype deployment to operational mines. Grant and subsidy programs.	Access to operational mines and logistic support tech deployment to site.	Safety certification and environmental compliance for testing phases in operational environments.

TRL7 - TRL8	Systems and expertise to monitor and analyse performance, engineering support for iterations, and comprehensive testing for harsh mining conditions.	Investment for scaling and cost management for testing and prototype improvement.	Training programme development for mining staff and onsite technical staff for deployment.	Technology compliance with relevant mining and safety regulations; detailed documents to support regulatory submission and demonstrate compliance.
TRL8 - TRL9	Engineering support to incorporate feedback and finalise design with full integration with operations systems and workflows.	Commercialisation funding: Investment support for large-scale production, marketing and distribution in consideration of revenue models for development.	Market launch strategies and support for entering the market; customer support infrastructure. Continuous monitoring of technology performance and data gathering for continuous improvement.	Ongoing compliance aligns with evolving regulations and industry standards while maintaining and updating necessary certifications per regulatory bodies.

5.2 Research Outcome 2: Stakeholder validation of research

The barriers and success factors to commercialisation identified by LaTourrette (2022) and Gruenhagen (2022) were thoroughly validated during the stakeholder engagement process. Key barriers and success factors, highlighted in bold, emerged consistently across these discussions. The final column of **Table 2** provides a detailed summary of the feedback stakeholders shared regarding these prominent factors, offering valuable insights into their perspectives and experiences.

Table 2: Summarised barriers to commercialisation comparing desktop research and stakeholder insights

Barriers to commercialisation		
Thematic Area	**Barriers based on research**	**Stakeholder insights**
Economic barriers	• **Insufficient demand** • Insufficient supply • **High capital requirements** • **Financial constraints**	• The stakeholders highlighted economic barriers: the high capital requirements for product development and limited financial resources. • The conservative mining sector is not embracing mechanisation, resulting in insufficient demand for new technologies.
Regulatory barriers	• Approval cost and duration • Prescriptiveness and outdated standards • **Regulatory challenges and uncertainty**	• Navigating the complex and evolving regulations that impact the readiness of technology and its relevancy in the mining sector.
Cultural and organisational barriers	• **Cultural resistance** • **High risk** and limited trust	• Change management was highlighted as one of the key challenges in technology adoption by end-user mining personnel, given the limited employee

	• Performance and recognition systems focused on efficiency • **Limited employee involvement** • Soft institutions and **organisational values**	involvement in problem statement definition and solution development. • Technology development is regarded as a high financial risk. Hence, mining houses buy off-shelve market-ready solutions. • Innovation culture is under development in some mining houses, forms part of organisational values and is incentivised in smaller OEMs.
Commercialisation Success Factors		
Technological advancements and readiness	• **Implementation of advanced technologies** • **Incremental Innovations** • **High TRL and CRI Levels** • Intellectual Property (IP) management	• Customisation of off-shelf technologies and absorption of TRL 9 technologies seems to be a mining formula for the mining houses and bigger OEMs that acquire smaller technology manufacturers with TRL 9 technologies. • Advanced technologies such as the missing person locator and safety improvement have seen successful implantation in some mining houses.
Market focus and demand	• Market conditions favouring commodity production • Ensuring market demand • **Customer challenges and productivity goals**	• Bigger OEMs focus on business case development and conduct a fair number of consultations between the customer and product development centres. Some OEMs adopt a customer-centric product development framework. • Technology priorities of mining houses are digitisation and production efficiency, as well as improving technologies and enhancing safety technologies.
Organisational support and collaboration	• **Support from senior management** • Effective collaboration with stakeholders • **Stakeholder engagement and transparency**	• Team buy-in and championship at various levels (senior-mid management) are critical in tech adoption at the mines. • The OEMs shared that building strong, long-lasting relationships with clients, OEMs, and mines is important for exploring new ventures and commercialisation opportunities. Leveraging the existing relationships streamlines the market introduction of the technology.
Operational integration and efficiency	• Ease of implementation and use • **Operational integration** • Continuous improvement and adaptation	• Diversified mining houses indicated that developing and implementing concepts applicable across the group is easy. • Complexity of technology usage in the implementation process is one of the tech adoption challenges. • On-site pilot testing informs the operational integration.
Regulatory environment	• Supportive and adaptive regulatory frameworks	

The stakeholder insights were further analysed. Stakeholder feedback and a SWOT analysis were used to identify key themes, trends, and strategic insights into mining technology development and commercialisation, as shown in **Figure 6**. These findings highlighted critical success factors, challenges, and growth opportunities, guiding the creation of a tailored commercialisation framework that addresses the mining sector's specific needs and complexities.

Figure 6: SWOT analysis from stakeholder engagement data synthesis

It is recommended that these factors be carefully evaluated, and a Threats, Weaknesses, Opportunities, and Strength analysis be carried out with key stakeholders to pinpoint critical focus areas. This exercise will help prioritise actions that leverage the identified strengths to mitigate the threats and, where feasible, transform these threats and strengths into opportunities. At the same time, the process should focus on utilising the identified opportunities to address weaknesses, particularly those related to the systemic challenges within the ecosystem that continue to hinder the commercialisation of new technologies. This strategic approach ensures a more collaborative, comprehensive and proactive response to the underlying issues.

5.3 Research Outcome 3: Commercialisation framework

The business framework adopts systems thinking across three individual models to represent the technology development and commercialisation journey that technology developers would follow to produce and commercialise a solution for a client. The framework's overall structure is rooted in the fundamentals of each phase across ISO15288, Technology Readiness Levels, and Commercial Readiness Index.

This framework aims to set up a mining industry guideline for OEMs and mining stakeholders to better understand the commercialisation process for new technology innovation. This includes identifying organisations/institutions/service providers who can assist with establishing various processes set out in the framework. This will eventually lead to establishing networking between these entities and OEMs in rendering services from concept to product adoption, following a properly channelled pipeline of the respective readiness level assessments, validation and certification requirements. The various funding mechanisms considered during each of these

processes, including the means of how to and when to apply, should also find its way through this framework.

The business framework is not an engineering process but rather a detailed journey map for technology developers to become aware of the challenges and risks associated with commercialising technologies. The framework's value is that it reduces the risk and the challenges businesses face along the commercialisation journey and encourages proactive solutions for tasks in the technology developer's environment of control. Each phase and checkpoint across the journey are intentionally designed to prompt the user to cover each of their fundamental bases before moving on to the next phase. Fully completion is encouraged to increase the probability of success in the subsequent phase.

The framework is not meant to dictate or be prescriptive but rather as guidance for businesses seeking to commercialise their technologies. Depending on which phase the user finds themselves in, they can prepare and plan for the requirements of the next phase. Users can also reflect on their success by referencing previous phases to determine if rethinking and redoing are required. It is, therefore, the responsibility of the user to take ownership of each phase, along with the associated requirements, to determine what is relevant and necessary for their journey.

In consideration of manufacturing readiness levels, this framework does not thoroughly delve into the process associated with MRLs. However, it should be considered as users reach **TRL 7**. During the pre-conceptual phase or ideation generation phase Du Preez et al. (2008), the technology developer focuses on **TRL 1 – TRL 3** from a technology development measure, while defining the value proposition and competition analysis from a business development perspective in alignment with CRI 1.

TRL 1

During this stage, the primary focus is on conducting in-depth research on the underlying scientific concepts and thoroughly investigating the problem to address a specific industry challenge, as illustrated by the questions outlined in **Figure 7**. This involves exploring foundational theories, understanding the technical aspects, and identifying the issue's root causes to develop a clear framework for potential solutions tailored to the industry's needs.

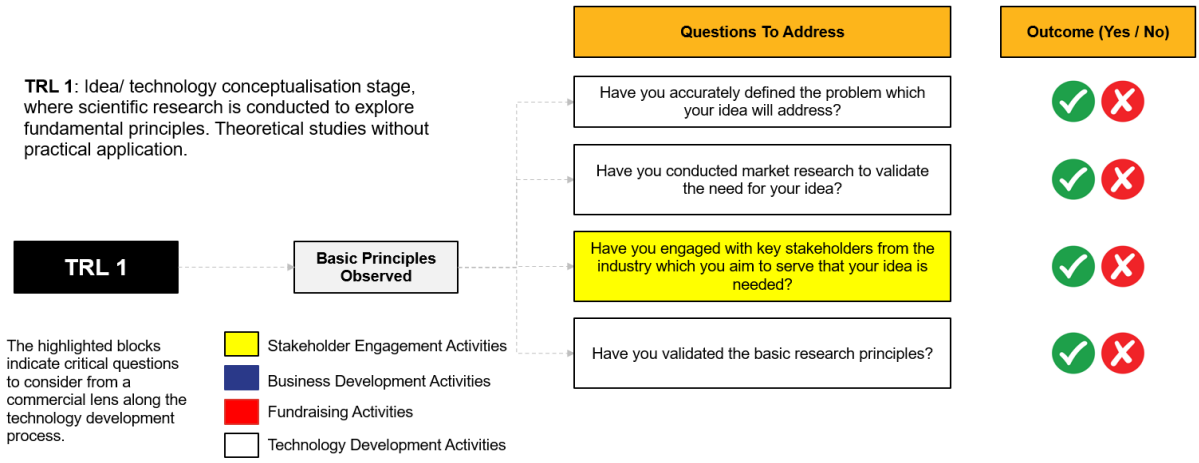


Figure 7: Highlights key questions to consider in progressing through TRL 1

TRL 2

At this stage, equal emphasis is placed on the technical and business development aspects, as detailed in the guiding questions presented in **Figure 8**. This balanced approach aligns with the CRI, which advocates incorporating commercial considerations as early as **TRL 2**. Doing so ensures that technical advancements are developed with a clear understanding of their market potential and business feasibility, fostering a seamless integration of innovation and commercialisation efforts.

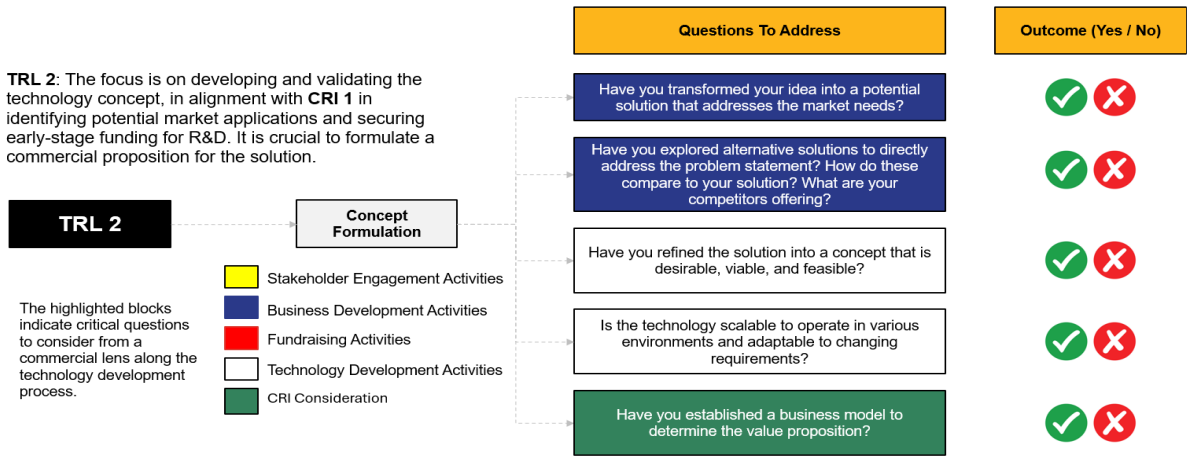


Figure 8: Highlights key questions to consider in progressing through TRL 2

TRL 3

At this stage of development, the stakeholder filter, as illustrated in **Figure 9**, is actively applied to ensure that the appropriate stakeholders are engaged early in the process. This early engagement is crucial for understanding the market needs, which helps refine the solution/idea to meet the market need and guide the technology development process. By involving relevant stakeholders at this stage, the process benefits from valuable insights, feedback, and potential partnerships that contribute to a more informed and intentional design to market needs.

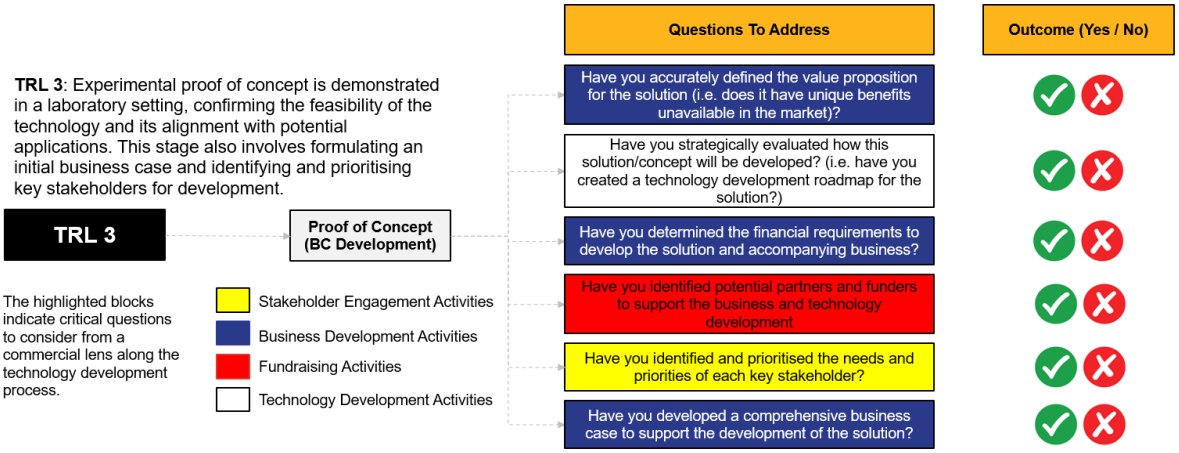


Figure 9: Highlights key questions to consider in progressing through TRL 3

In addition to the TRLs, there are critical checkpoints within the business framework. These checkpoints (CP) are designed to help the technology developer assess the progress made in advancing the technology while also evaluating key business development activities necessary for its successful commercialisation. By meeting the criteria established at each checkpoint, the technology developer demonstrates readiness to move forward to the next phase of the business journey, ensuring a balanced focus on both technical milestones and commercial viability. As such, checkpoint A (**CP A**) in **Figure 10** enables technology developers to assess and reflect on the progress achieved during **TRL 1 to TRL 3**, ensuring that both the technical feasibility and the commercial potential have been adequately addressed before advancing further into **TRL 4** illustrated in **Figure 11**.

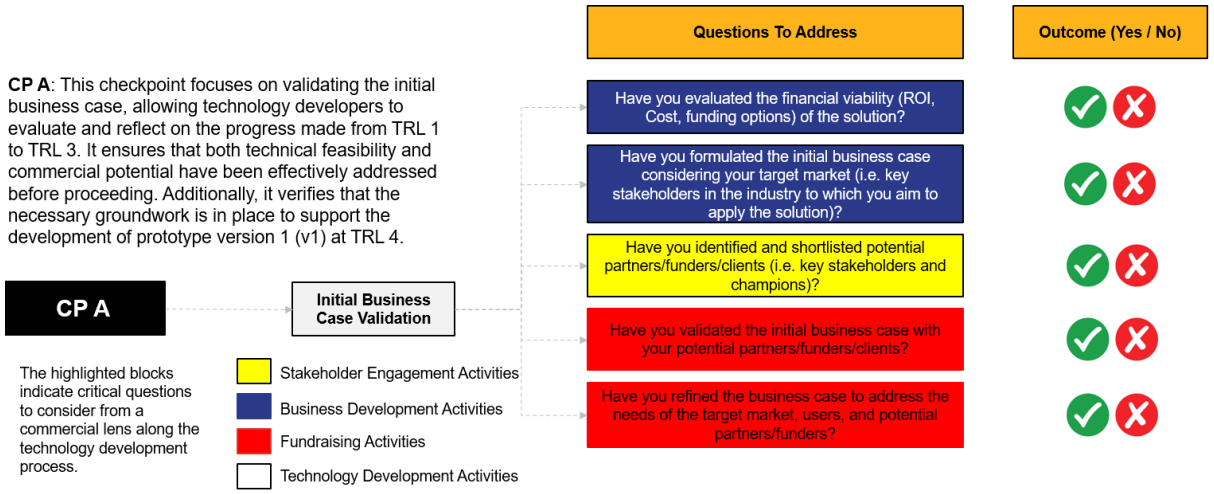


Figure 10: Highlights key questions to consider in progressing through DG A

The pre-conceptual stage is followed by concept refinement, which includes modelling a prototype to determine the feasibility of the concept, this phase requires stakeholder engagement in incorporating user insights while focusing on **TRL 4** of the technology development activities.

TRL 4

At **TRL 4**, identifying and engaging key stakeholders are crucial to gaining early buy-in from potential commercial clients and insight into the verification and validation needs of the operational environment to support the development of technology. This process involves analysing stakeholder engagement, alignment, and commitment to ensure that needs and expectations are considered during the development phase. Simultaneously, the initial prototype of the proof of concept, which began at **TRL 1**, is further developed and refined. This prototype is crucial for generating valuable insights that inform and strengthen the business case development. As illustrated in **Figure 11**, these interconnected activities ensure that both technical progress and market viability are advanced in parallel, setting the foundation for successful commercialisation.

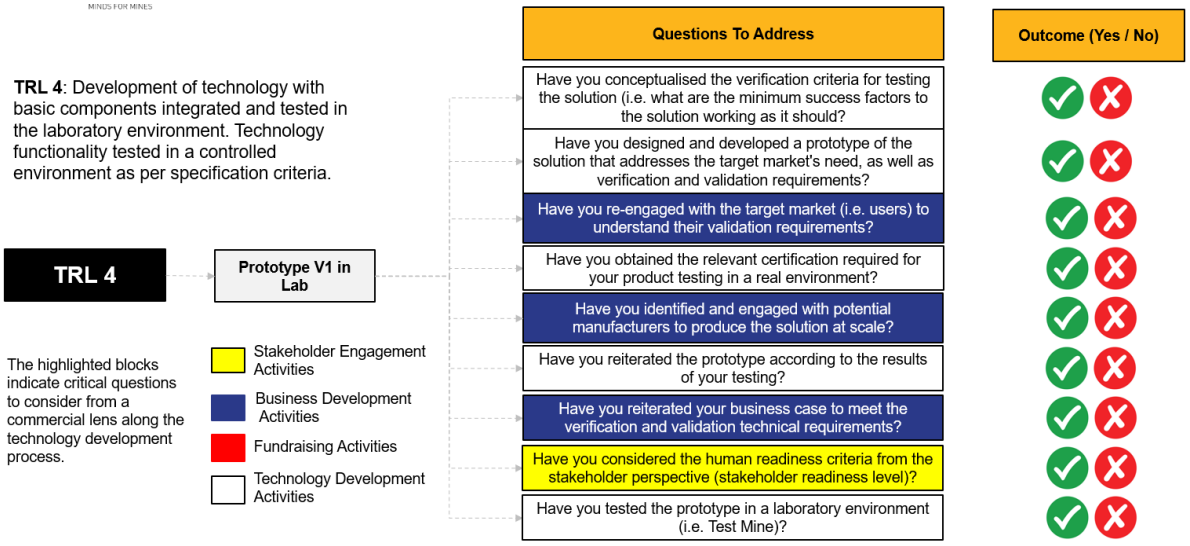


Figure 11: Highlights key questions to consider in progressing through TRL 4

CP B

This checkpoint emphasises critical questions about securing funding for advancing the prototype developed at **TRL 4** into subsequent development stages and supporting its eventual commercialisation. It addresses the strategic planning required to overcome the inherent challenges of the "Valley of Death," a phase where many technologies face significant resource gaps between development and market adoption. By focusing on fundraising strategies and resource mobilisation, this gate in **Figure 12** ensures that the technology is supported by the necessary financial and stakeholder investment to progress toward operational adoption.

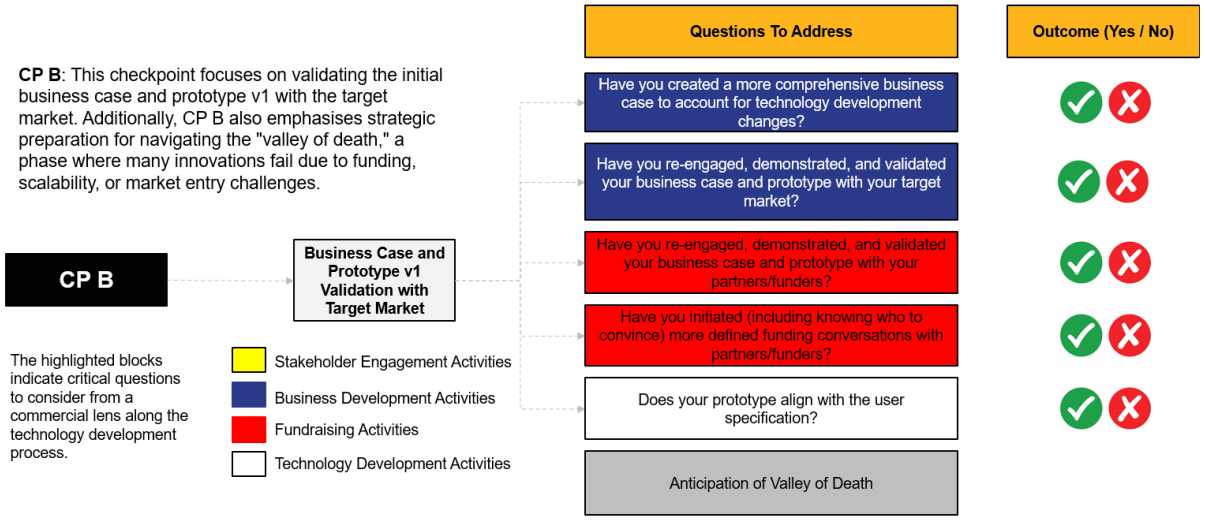


Figure 12: Highlights key questions to consider in progressing through CP B

Once the concept is refined and the first version of the prototype is developed, iterative improvements are made to create a minimum viable product (MVP) that meets the requirements of **TRL 5 to TRL 6**. During this technology development phase, the developer should address

key aspects of the Manufacturing Readiness Level (MRL) to understand the manufacturing requirements for future full-scale production. Additionally, fundraising activities become a critical focus, as the functional prototype can be a compelling medium to attract investors. This stage also marks the approach to the "Valley of Death," a pivotal point where securing and navigating the various challenges is vital to transitioning the technology from development to commercialisation.

TRL 5

At this stage of development, all essential components—including technology refinement, business development strategies, stakeholder engagement, and fundraising initiatives are necessary, as depicted in **Figure 13**. This phase ensures the technology is well-positioned for advancement by addressing technical milestones, aligning with market needs, fostering stakeholder collaboration, and securing the necessary financial resources. These efforts collectively prepare the groundwork for the subsequent stages of development, enabling a smoother transition toward commercialisation and market readiness.

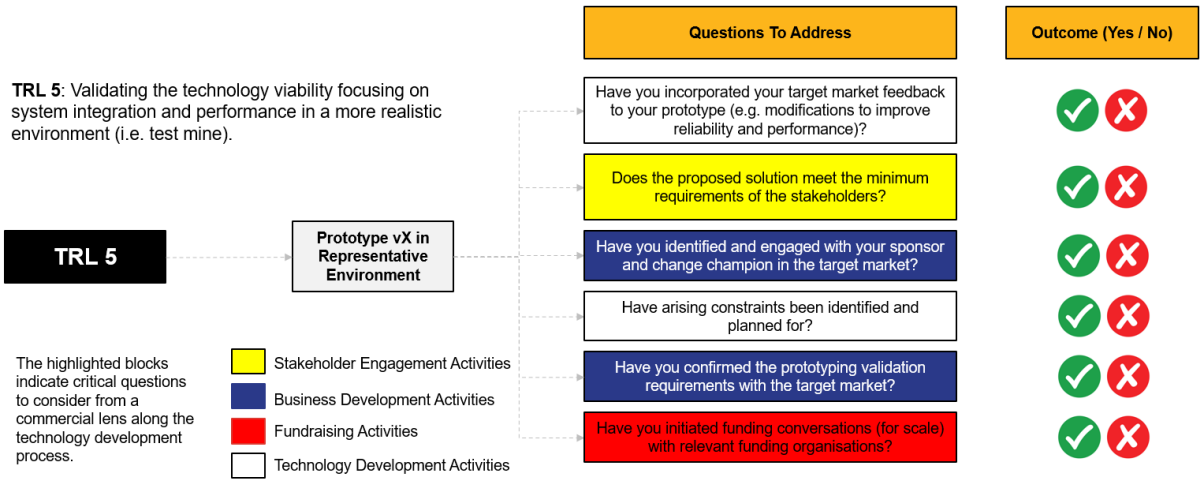


Figure 13: Highlights key questions to consider in progressing through TRL 5

TRL 6

At this stage, the primary focus is refining the prototype to address modifications identified following its initial testing at **TRL 5** in **Figure 17**. Based on real-world feedback and testing results, this refinement process enhances the prototype's functionality and reliability. Simultaneously, the impact of these iterations on the business development process is carefully assessed, as adjustments to the prototype may influence market strategies, cost considerations, and value propositions, as shown in **Figure 14**. Additionally, this stage considers the end-user's Human Readiness Level (HRL), evaluating their capacity and willingness to adopt the technology within its intended operational environment. This alignment with user readiness is critical as it lays the foundation for successful implementation at **TRL 9**, as illustrated in **Figure 19**.

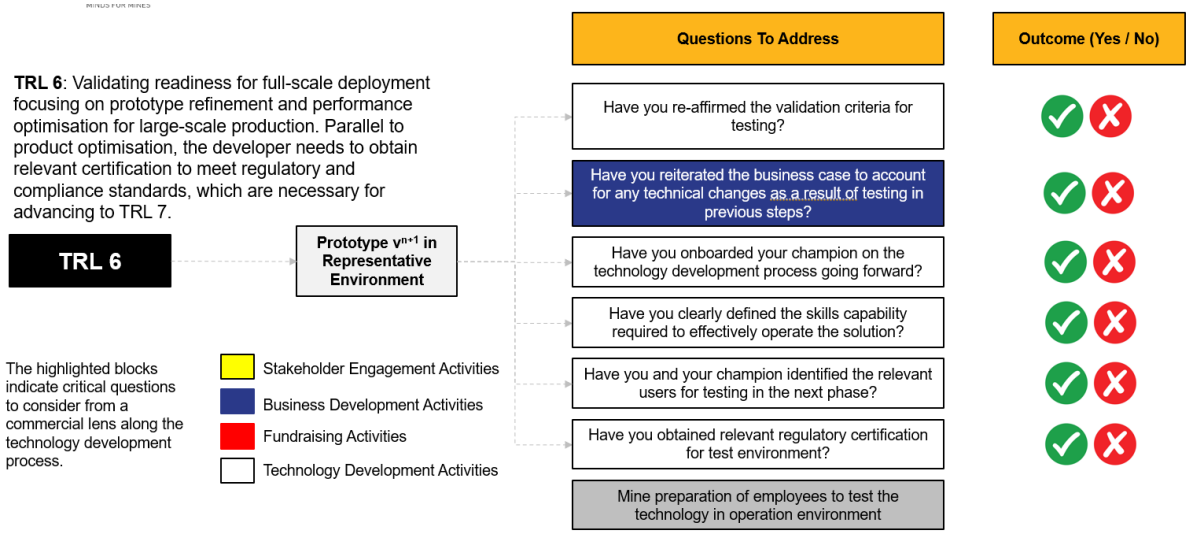


Figure 14: Highlights key questions to consider in progressing through TRL 6

CP C

Building on the refinements made to both the technology and the business case, which are informed by user feedback collected during **TRL 5** and **TRL 6** testing, **CP C** focuses on prioritising fundraising activities. As shown in **Figure 15**, these fundraising efforts are strategically aligned with the degree of business case validation achieved through the testing phase. The validation level determines the technology's readiness for further investment, making it a critical factor in securing the financial resources necessary to advance to the following stages of development and commercialisation.

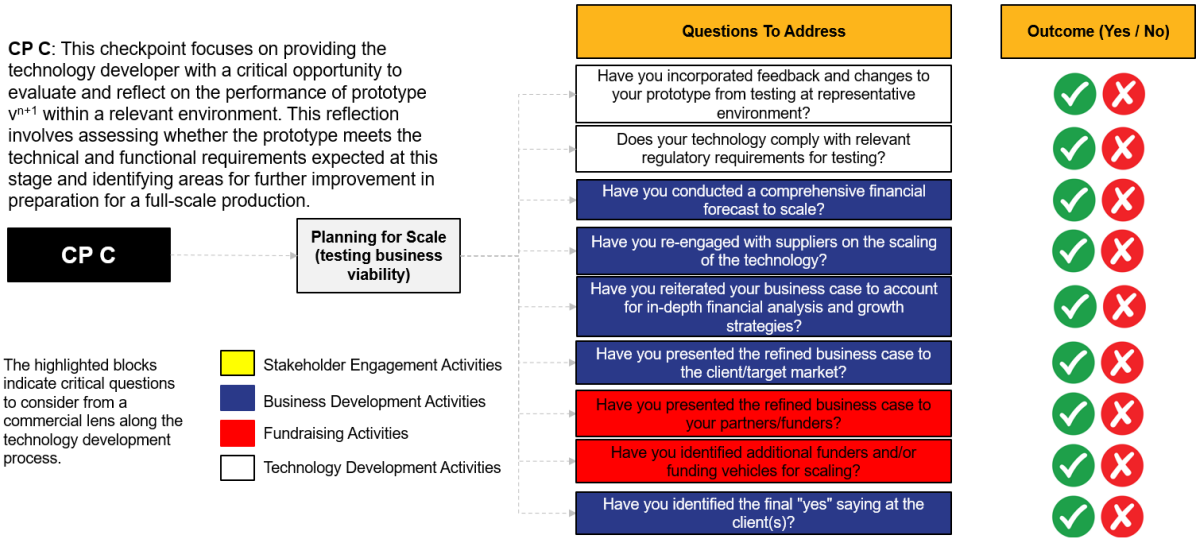


Figure 15: Highlights key questions to consider in progressing through CPC

During the system development and demonstration phase, the technology developer focuses on TRL 7 of the technology development activities, while **CP D** encourages the focus on business development and fundraising efforts.

TRL 7

Testing in the operational environment demands thorough technical refinements to ensure that the technology aligns with the specific operational requirements and accurately replicates the final product. As a result, the primary focus during this stage is refining the technology to ensure its readiness for real-world deployment. Most of the questions in this phase, as illustrated in **Figure 16**, are centred on the technical development activities, addressing factors such as performance, reliability, and scalability to ensure the technology functions as intended in the operational environment whilst meeting client needs and regulatory compliance standards.

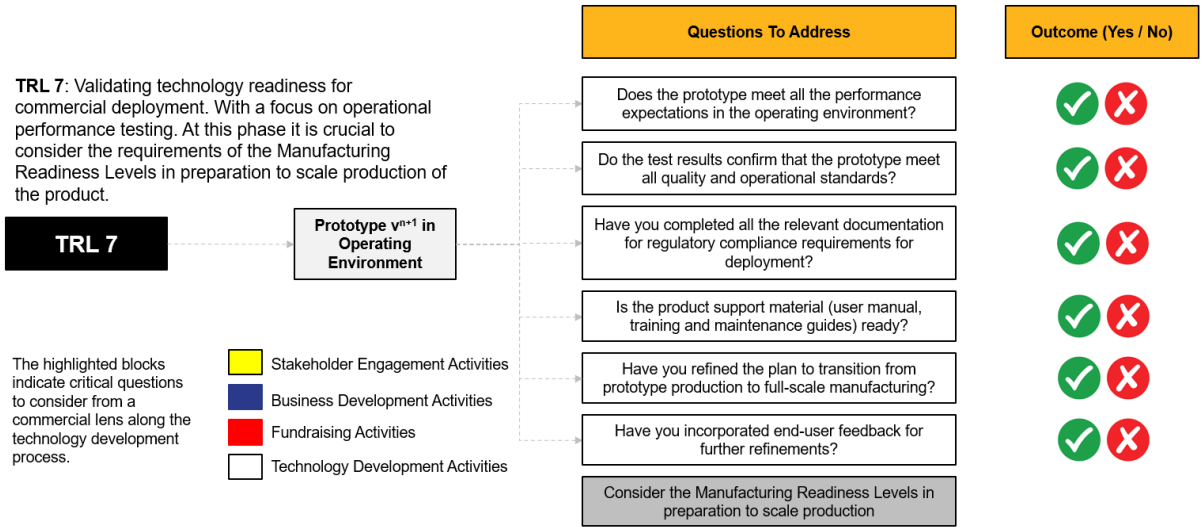


Figure 16: Highlights key questions to consider in progressing through TRL 7

CP D

While **TRL 7** emphasises technical improvements and technology refining, the **CP D** in **Figure 17** places greater focus on business development. This stage ensures that a commercial perspective is consistently applied, guiding the technology toward the final stages of its development. By prioritising business strategy, market fit, and scalability considerations, the goal is to align the technology's technical progress with the commercial objectives needed for successful market entry and adoption in the later stages of the development process.

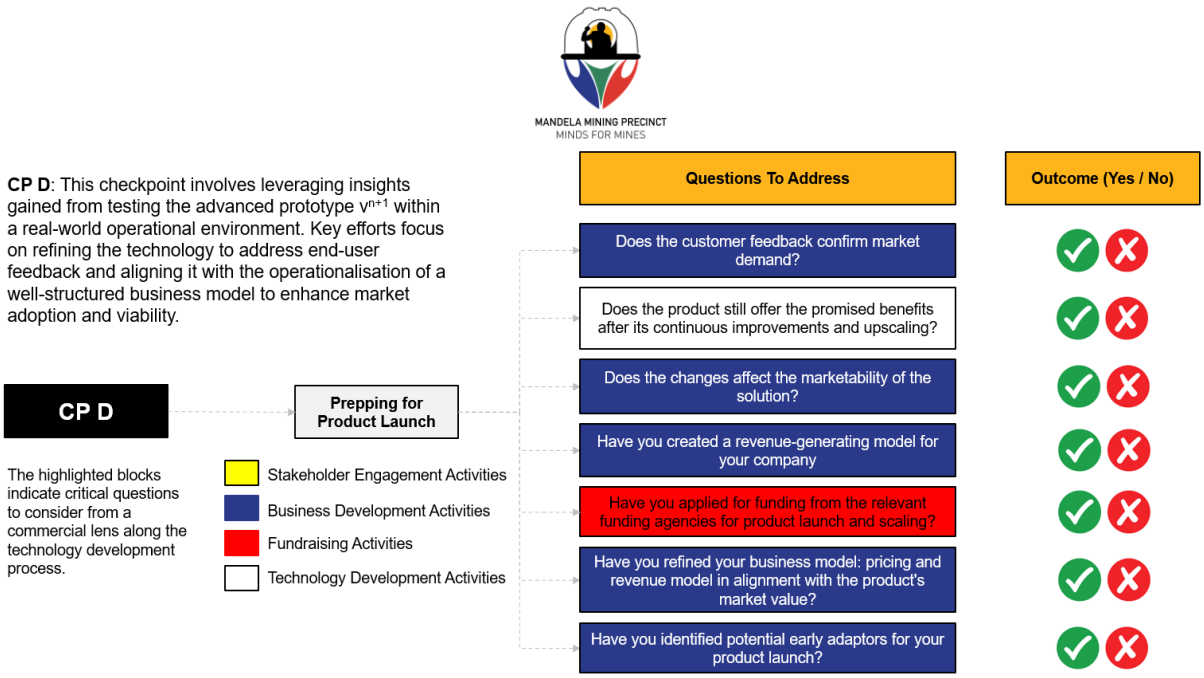


Figure 17: Highlights key questions to consider in progressing through DG D

During the production and deployment phase, the technology developer focuses on the **TRL 8** and **TRL 9** activities, which align with the product launch activities highlighted in **CP D**.

TRL 8

Another critical touchpoint with stakeholders occurs after **TRL 7**, ensuring that the necessary technological and operational support structures are established in preparation for deployment. This stage involves engaging stakeholders to confirm that all logistical, technical, and operational frameworks are ready to facilitate a smooth transition from prototype validation to full-scale technology development and deployment, as shown in **Figure 18**. Ensuring these support systems are in place is essential for addressing any challenges that may arise during the technology's operationalisation, ensuring sustained performance once deployed in the field.

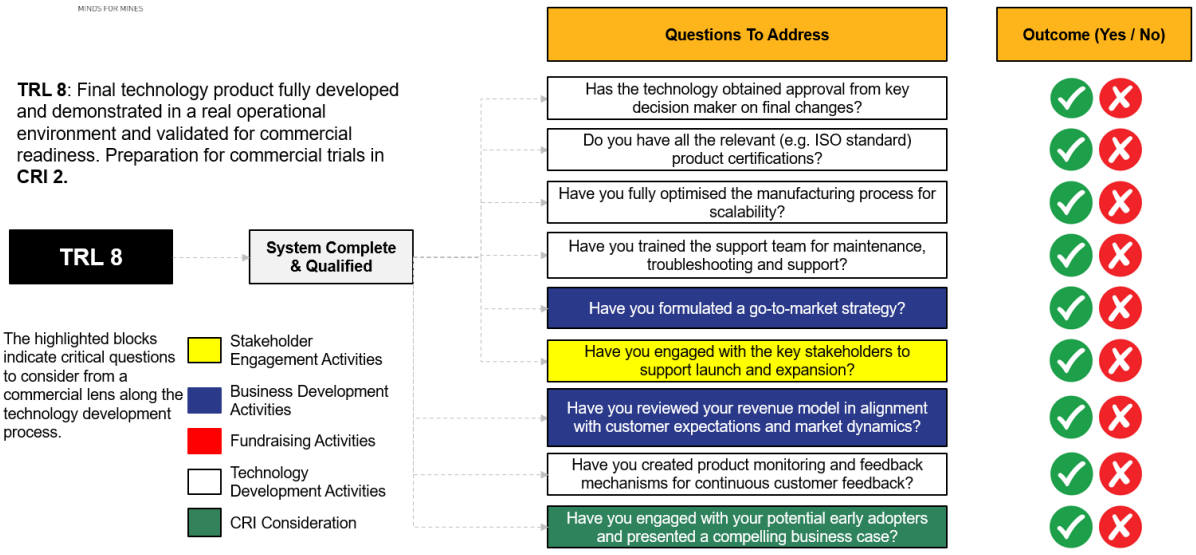


Figure 18: Highlights key questions to consider in progressing through TRL 8

TRL 9

While the primary focus at this stage is on optimising the technology's performance within the operational environment, equal attention is given to the business development aspects in preparation for the product launch, as illustrated in **Figure 19**. This involves refining market strategies, finalising commercial models, and ensuring that all business-related processes—such as sales, marketing, and distribution—are aligned with the technology's capabilities and market demands. The goal is to ensure that, alongside technological readiness, the business infrastructure is fully prepared to support a successful product launch into the market.

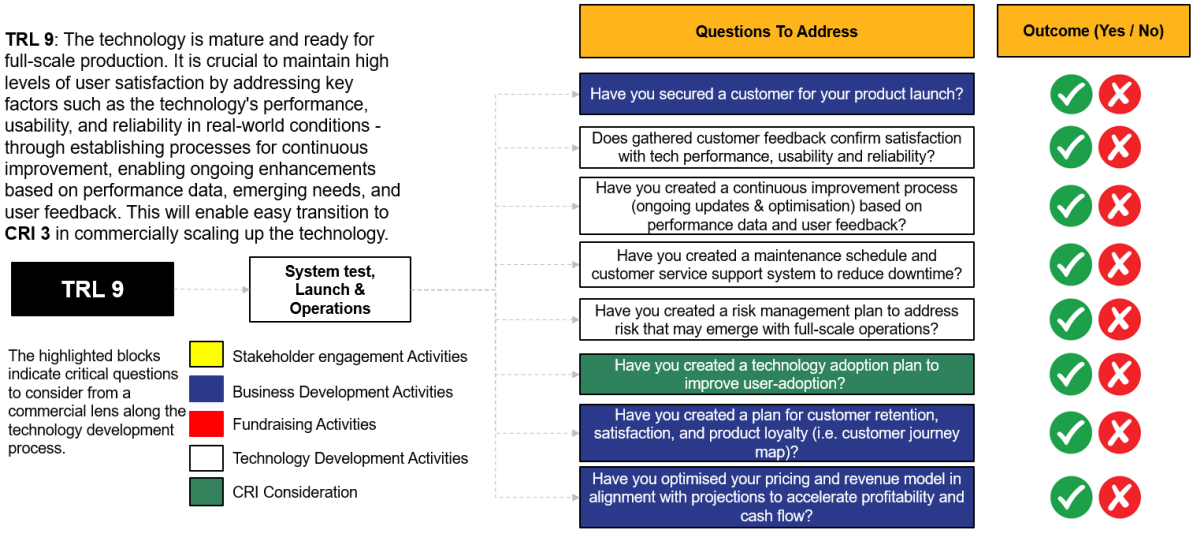


Figure 19: Highlights key questions to consider in progressing through TRL 9

CP E

TRL 9 offers valuable lessons in preparing for the product launch to the market. This checkpoint **E**, depicted in **Figure 20**, provides the technology developer with a pivotal opportunity to reflect on the full-scale product commercialisation by evaluating critical aspects of technical, business development, and fundraising efforts. It allows for a comprehensive review of the product's readiness for market introduction, ensuring that all components—from technology performance to business strategy and scalability—are optimised. Additionally, it helps assess the necessary funding to scale the product effectively, paving the way for a smooth transition to **TRL 10**, as depicted in **Figure 21**, where the technology is fully commercialised and introduced into the market.

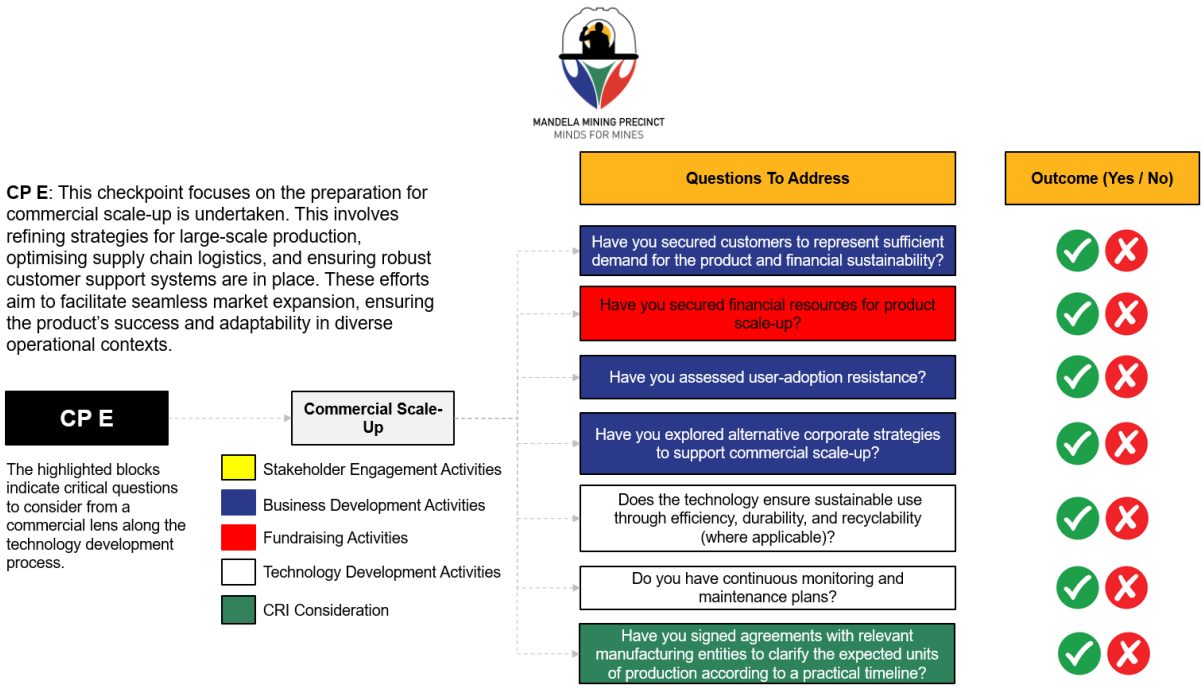


Figure 20: Highlights key questions to consider in progressing through CP E

Beyond **TRL 9**, the technology developer focuses on the long-term sustainability of the business, ensuring continuous improvement of their technology and commercialisation success.

TRL 10

At this level of development, the focus shifts toward enhancing business operations at the industry level and ensuring the long-term sustainability of the product's use following a successful launch at **TRL 9**. The emphasis is on continuously monitoring and improving the product to maintain and strengthen its competitive position in the market. This involves ongoing efforts to refine the product's performance, address emerging market needs, and incorporate user feedback to ensure the product remains relevant, efficient, and superior to competing offerings. The goal is to establish a robust market presence that supports sustained growth and long-term success.

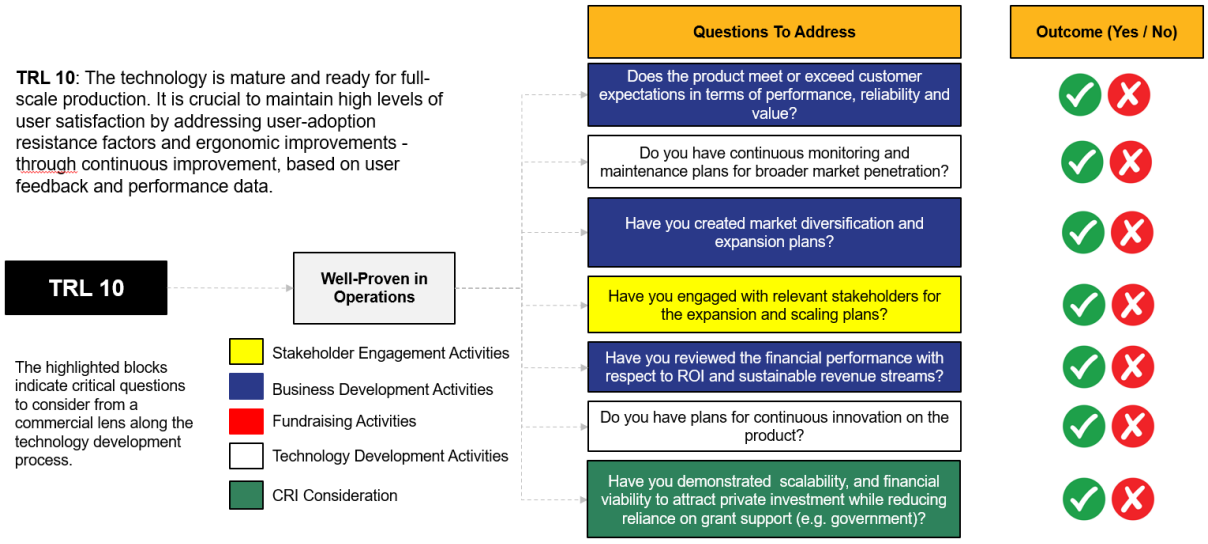


Figure 21: Highlights key questions to consider in progressing through TRL 10

As illustrated in **Table 3**, implementing the business framework can address key challenges that hinder the commercialisation process within the mining industry.

Table 3: Potential impact of the implementation of the business framework in addressing commercialisation challenges

Challenges inhibiting the commercialisation of the technology mining industry	Impact of the Business Framework in alleviating the experienced challenged
Problem-Solution Mismatch: Often, technologies developed by solution providers do not exactly meet the mine's specific requirements. Significant time and resources are invested in testing, validating, and adapting the technologies.	The business framework encourages problem identification as part of ideation, along with TRL 1 activities of observing basic principles.
High Risk and Low Risk Appetite: A great degree of investment risk is associated with adopting new technology from smaller solution providers. This is due to the significant resources required for testing, the solution provider's ability to deliver support, and the solution provider's organisational continuity across the lifespan of the mine.	Early stakeholder engagement and securing project champions during the technology development journey is crucial for mitigating new technologies' risks. The business framework emphasises the importance of stakeholder involvement starting from TRL 1 to ensure that the identified problem aligns with the potential users' pain points.
Access to Funding: The mining industry straddles three different government departments, which makes obtaining grant funding tricky. Mining companies' reluctance to invest in technology development shifts the burden onto OEMs and SMEs, who assume significant financial risks.	Government entities, such as TIA, provide funding for technology development at stages from TRL 4 to TRL 7. However, accessing this support requires the submission of specific business documents. The journey map serves as a guide to encourage the preparation of these documents early in the technology development process, starting at CP A.
Access to Key Decision Makers: Technology providers often do not have access to the ideal sponsors and change champions within the mine to advocate for adopting the new technology.	Industry associations such as MEMSA and MMP play a crucial role in bringing together diverse stakeholders within the industry, offering technology providers valuable opportunities to network and establish connections with key decision-makers. By conducting demonstrations and pilot projects to test their technologies in representative environments at TRL 6, technology developers can effectively showcase the value and impact of their solutions given their business case developed in CP B, building trust and confidence among decision-makers.
Skills Gap: The status quo conflicts with the legacy of SA mining, and the adoption of new technology is seen as a threat to employment.	A human-centred design approach considers the challenges of the end user from the onset. Idea conceptualisation with people-centric modernisation from idea generation to technology development can reduce adoption resistance in the operational environment. Early stakeholder engagement during TRL 1 is crucial, with ongoing collaboration through multi-level stakeholder interactions to ensure the matching of skills capability to technology usage

	needs. Early skill development interventions can then be initiated to reduce the skills gap.
Impact of the "Valley of Death": In the SA commercialisation space, the challenges experienced in the "Valley of Death" have significantly increased.	The business framework emphasises the importance of proactively addressing the "**Valley of Death"** at CP B. This involves guiding technology developers to anticipate and strategically prepare for the critical challenges that typically arise from TRL 6 onward, such as securing funding, scaling production, and navigating market entry barriers. By encouraging early planning and resource allocation, the framework helps mitigate risks and ensures a smoother transition through this high-risk phase of technology commercialisation.

5.4 Research Outcome 4: Stakeholder validation of commercialisation framework

The business framework, designed as a TRL 1 – TRL 10 technology development to commercialisation journey map with structured yes/no questions, was validated through a stakeholder workshop on the 15th of January 2025. Feedback from 16 industry experts emphasised its value in guiding technology providers through the commercialisation journey, addressing key concerns without over-complicating the process. Among the 19 industry experts, 58% were from academic institutions, 26% were from major and minor mining houses, 19% were OEMs, and 5% were from funding bodies. The validation session reinforced the framework's approach to simplifying commercialisation while aligning with existing industry practices.

Key Feedback and Recommendations:

- **Framework's Practicality**: Stakeholders appreciated that the framework avoids "reinventing the wheel" and instead offers actionable guidance for bridging the Valley of Death.
- **Incorporating Manufacturing Readiness Levels (MRL)**: The inclusion of MRL as an option for further refinement addressed a concern about its absence in the framework.
- **Competitor Analysis**: A stakeholder suggested performing competitor analysis earlier in the roadmap's commercialisation stages, which has been incorporated at TRL 3.
- **Checkpoint System**: To mitigate rigid progression challenges, the framework will integrate a checkpoint system rather than strict re-evaluation decision gate requirements.
- **Technology Readiness vs. Commercialisation Readiness Index**: A recommendation was made to explicitly address how TRL and CRI are merged, including why CRI (a more qualitative metric) was chosen over CRL for this framework. Due to the less technical nature of this framework, this recommendation will not be addressed but remains a good indicator for future work on the commercialisation framework.
- **Minimum Viable Product Integration**: Stakeholders recommended creating a Minimum Viable Product (MVP) framework to incorporate design thinking principles and enable practical validation of the commercialisation process.

- **Valley of Death Dynamics**: While the framework scope does not currently allow for a deep dive into technical and cultural aspects affecting the Valley of Death, stakeholders acknowledged this as a potential avenue for future research.

Overall, the framework received positive validation for its practicality and focus on providing clear, implementable steps for technology providers, particularly within the TRL 6 – TRL 9 range. It serves as a useful tool for reducing the negative impact of the Valley of Death and improving the probability of successful commercialisation. The stakeholders expressed their appreciation for the framework's attempt to establish a transparent approach to TRLs where technology providers can learn and grow as they navigate the commercialisation journey.

5.5 Research Outcome 5: Value proposition of an information-sharing platform

The conceptualised information-sharing platform for the mining industry addresses key operational challenges and is guided by the Value Proposition Canvas and industry insights. It aims to meet professionals' needs for discovering technologies, collaborating on funding, and improving efficiency while overcoming concerns about confidentiality, trust, and regulatory uncertainties, as shown in **Figure 22** and **Figure 23**.

Figure 22: Value proposition canvas with a focus on customer segment pains, gains and jobs insights

The platform provides pain relievers like robust security, anonymous posting, easy issue classification, and gain creators such as expert networks, collaboration opportunities, and updated

market insights. Functionally, it serves as a repository for challenges, regulations, and best practices, featuring Q&A, project sharing, and trusted supplier lists. The platform supports industry modernisation and innovation by addressing pains and delivering gains (refer to **Appendix A** for survey data).

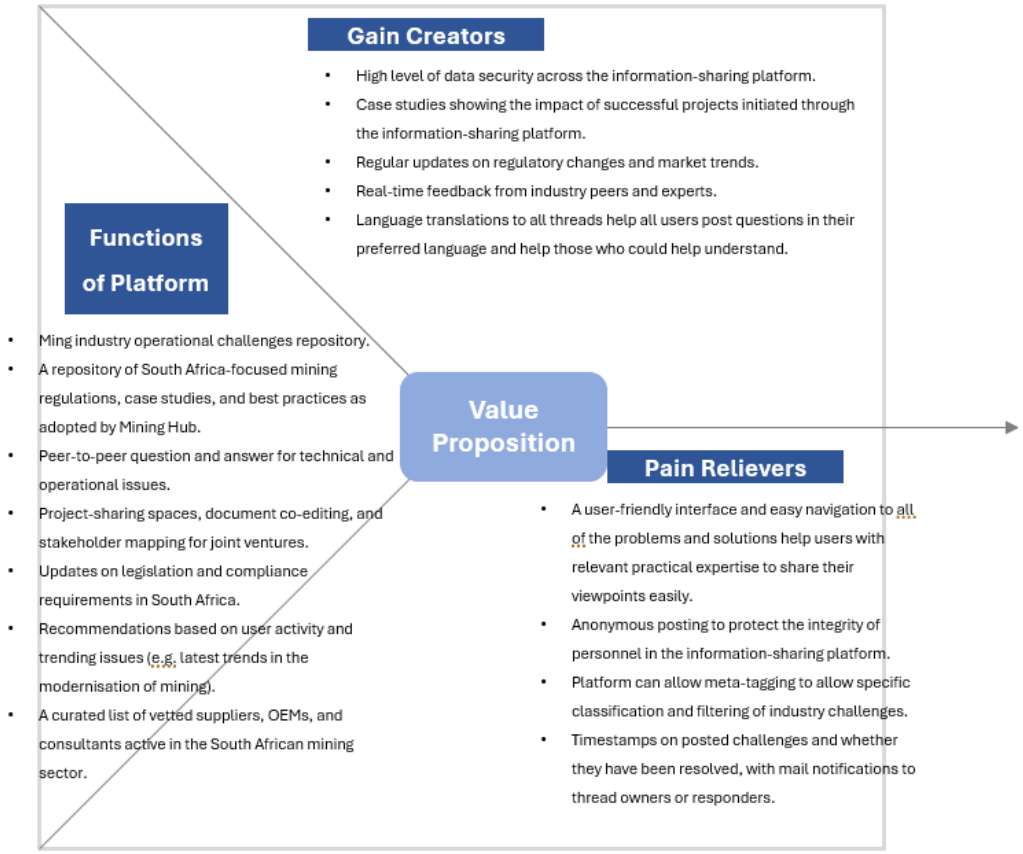


Figure 23: Value proposition canvas with a focus on pain relievers, gains creators and proposed platform functions

The information-sharing platform used simultaneously with the Business Framework ensures that technology developers address operational challenges and mine needs from the onset of solution development. The probability of commercial success lies in a product-market fit that aligns with market desirability, technology feasibility, and financial viability.

6 CONCLUSIONS

This report brings insights from key milestones to address significant gaps in the mining industry's innovation ecosystem, focusing on technology development and commercialisation. Milestone 1 laid the groundwork by establishing collaborative partnerships and building a theoretical foundation. Milestone 2 emphasised stakeholder and technology mapping, providing critical input for the commercialisation framework developed in Milestone 3. Milestone 4 underscored the importance of

fostering a supportive ecosystem to facilitate the technology development and commercialisation process effectively by creating the information-sharing platform.

Key challenges include mining companies' reluctance to invest in technology development and placing financial risks on OEMs and SMEs. These challenges are exacerbated by delayed government funding, undefined problem statements, regulatory complexities, and resistance to change. The "Valley of Death" remains a significant barrier as small OEMs struggle to advance technologies from prototype to market due to limited financial and infrastructural support.

A business framework, presented as a technology developer journey map, was created to alleviate these challenges, drawing from established industry standards. This well-defined approach offers technology developers a clear pathway to navigate the complexities of the commercialisation process, helping to minimise obstacles and enhance the likelihood of success. The framework underwent validation by key stakeholders to ensure it met industry requirements and was practical for real-world application. This initial proposed design of the business framework also set the stage for ongoing engagement and continuous improvement, ensuring its relevance and effectiveness over time.

Furthermore, a survey conducted among mining professionals revealed a strong demand for a secure platform for information sharing. This platform could alleviate confidentiality concerns while promoting collaboration, innovation, and knowledge exchange. Features like peer-to-peer Q&A, project sharing, and curated resources would support these goals. It could serve as a vital touchpoint for technology developers, offering them a direct avenue to engage with key decision-makers.

Addressing these challenges and leveraging these tools will enhance the mining sector’s capacity for technological innovation, focusing on areas like health and safety, productivity, and environmental sustainability.

In turn, all deliverables for milestone 5 were achieved.

7 RECOMMENDATIONS

This workstream has been instrumental in fostering discussions and promoting strategic thinking around technology development and commercialisation among key stakeholders involved in research, development, and innovation within the mining sector. It has highlighted significant barriers to technology commercialisation while also identifying strengths and opportunities that can be harnessed to collaboratively build a more supportive and innovation-friendly environment in the mining industry.

Based on insights gathered from stakeholder engagements, the following recommendations can be implemented to strengthen the mining sector's innovation ecosystem. Leveraging some of the industry’s strengths could overcome threats and turn them into opportunities that can remove some of the weaknesses:

Customer-centric approach

This multilevel stakeholder engagement approach will help refine the problem statement for all stakeholders to ensure a problem-solution match. It can also help address client expectations and change management challenges.

Market Fit

Client feedback should be encouraged and leveraged for marketing purposes to increase visibility for the OEMs to assist in market penetration.

Incentivised Innovation

An incentive mechanism should be developed to address market penetration issues to encourage mining houses to absorb technologies. This can be done through industry associations like the MMP.

Digital Transformation

The focus on digital transformation presents an opportunity for OEMs to focus more on developing technologies that can be adapted for market needs such as safety, productivity, and sustainability.

Tracking and Monitoring

The technology developers use tracking tools ranging from customer specifications to industry-standard TRLs. This presents an opportunity for the potential acceptance of a standardised industry commercialisation framework that various stakeholders can leverage to support the technology development efforts and commercialisation of these technologies.

These interventions will potentially work in a unified approach towards innovation through collaborative partnerships amongst the RDI stakeholders. To ensure that there are:

- **Improved Financial Support Mechanisms (refer to Appendix B):** Timely government funding, targeted grants, and incentives.
- **Infrastructure Support:** This is for rapid prototyping and testing spaces and facilitates access to expertise (champions, sponsors, and mentors).
- **Continuous Improvement:** Joint pilot projects to test the proposed business framework for adaptation and capacity building for technology developers regarding its application.
- **Development of An Information-Sharing Platform:** A centralised, web-based platform for the mine industry to share specific operational challenges that technology developers can address both individually and through collaborative efforts with other solution providers.

8 WAY FORWARD

Building on the successful activation of key stakeholders through this workstream, the MMP is well-positioned to assume a central role as a convenor and facilitator in advancing the development and commercialisation of mining technologies. By leveraging its established relationships with mining houses, OEMs, SMEs, funding agencies, and industry associations, the MMP can foster collaboration among these diverse actors.

This role would involve coordinating efforts to create a conducive ecosystem that supports the commercialisation process, including facilitating dialogue, aligning goals, and addressing barriers such as funding delays, regulatory challenges, and gaps in infrastructure. Additionally, the MMP can guide the development of frameworks, such as the business framework and the proposed information-sharing platform, to ensure they meet the sector's needs and drive impactful innovation. By serving

as a nexus for innovation, the MMP can enable the mining industry to overcome existing challenges and achieve sustainable technological advancement.

9 REFERENCES

9.1 References to Technology Readiness

Bhandari, S., Bhandari, A., Anchalia, N., Chotiya, L. (2017). *Improvement in Mining Operations by Data Collection and Analysis*. Available from https://www.mineexcellence.com/download.php?filename=%27YWRtaW4vYXJ0aWNsZXMvSW1wcm92aW5nLU1pbmUtUHJvZHVjdGl2aXR5LWJ5LWJldHRlci1BbmFseXNpcy1vZi1CbGFzdGluZy1kYXRhLnBkZg==%27

United States of America Department of Defence (2003). *Technology Readiness Assessment Deskbook*. Available from https://apps.dtic.mil/sti/pdfs/ADA418881.pdf

ARENA (2014). *Commercial readiness index for renewable energy sectors*. Available from https://arena.gov.au/assets/2014/02/Commercial-Readiness-Index.pdf

LaTourrette, T., Regan, L., & van Abel, K. (2023). Barriers to the Commercialization and Adoption of New Underground Coal Mining Technologies in the US. *Rand Corporation*. Available from https://www.rand.org/content/dam/rand/pubs/research_reports/RRA1500/RRA1575-1/RAND_RRA1575-1.pdf

Gruenhagen, J.H., Cox, S., & Parker, R. (2022). An actor-oriented perspective on innovation systems: Functional analysis of drivers and barriers to innovation and technology adoption in the mining sector. *Technology in Society*, 68: 10192

Beard, T.R., Ford, G.S., Koutsky, T.M., & Spiwak, L.J. (2009). A Valley of Death in the innovation sequence: an economic investigation. *Research Evaluation*, 18 (5): 343 – 356.

Documentation, T. P. S. (2007). *Systems and software engineering—Software life cycle processes*. Available from https://www.saiglobal.com/PDFTemp/Previews/OSH/iso/updates2007/wk40/DRAFT/ISO-IEC_FDIS_12207.PDF [Accessed 07 Nov 2024].

Du Preez, N. D., & Louw, L. (2008, July). A framework for managing the innovation process. In PICMET'08-2008 Portland International Conference on Management of Engineering & Technology (pp. 546-558). IEEE.

9.2 Reference to South African Funding Bodies for Mining Hardware

The most noticeable and prominent funding bodies in South Africa responsible for funding the hardware aspect of projects in the mining industry are distributed within the mining ecosystem, with various options for funding depending on the nature of the business and the capital requirements. The most notable organisations and programs in South Africa which provide funding and support for research and development in the mining sector, particularly focusing on hardware and technological innovations are:

- **Industrial Development Corporation (IDC):** Through its Basic Metals and Mining Fund, the IDC aims to support entrepreneurs investing in industrial capacity and job creation within the mining and metals sector. Most of the IDC funding during 2023/24 supported capacity expansions, startups, distressed businesses and working capital requirements.

  Link to the page: https://www.idc.co.za/mining-metals/

  Link to their application document: https://www.idc.co.za/wp-content/uploads/2023/08/Application-Form___.docx

- **Department of Mineral Resources and Energy (DMRE):** In collaboration with the IDC, the DMRE has launched a R400-million fund to boost new mining projects, particularly targeting junior miners and exploration activities. The initiative seeks to address the existing funding gap in mining exploration. The fund is expected to stimulate the discovery of new mineral resources, enhancing the nation's mining sector and contributing to economic growth.

  Link: https://www.news24.com/fin24/economy/govt-launches-r400-million-fund-to-boost-new-mines-20240206

- **Support Programme for Industrial Innovation (SPII):** Offered by the Department of Trade and Industry (DTI), SPII provides grants to South African registered enterprises engaged in pre-competitive development activities leading to the commercialisation of new products or processes. This program is particularly beneficial for companies involved in R&D within the mining hardware sector.

  Link: https://hsrc.ac.za/innovation-support-in-south-africa/

- **Mining Equipment Manufacturers of South Africa (MEMSA):** Established with funding from the Department of Trade and Industry, MEMSA serves as a development cluster to increase the capacity and capability of local mining equipment manufacturing. It supports R&D initiatives and facilitates access to funding for its members.

  Link: https://memsa.org.za/news/memsa-mission-serve-mining-manufacturing-comTmunity-sa-abroad

- **Technology Innovation Agency (TIA):** An initiative of the Department of Science and Technology, TIA's goal is to enable and support technological innovation across all sectors of the economy, including mining. It offers funding and support for developing and commercialising research outputs, providing resources for R&D activities in mining hardware. TIA has several development grants, such as the Technology Development Fund (TDF), which supports the progression from prototype development to technology demonstration (TRL 4-7) for Small, Medium and Micro Enterprises (SMMEs), Higher Education Institutions (HEIs), Science Councils (SCs), and start-up companies.

- **Fundable Activities:** The fundable activities include prototype development, demonstration and pilot projects, support for certification activities, piloting and techno-economic analysis projects.

  Link: https://www.tia.org.za/

Waiting Period:

Amount	Investment Decision Turnaround Time
Funding applications <R1m	4-weeks
Funding applications > R1m and <R15m	15-weeks
Funding applications >R15m	26-Weeks

- **Manufacturing Support Programme (MSP):** Managed by the DTIC, MSP offers a reimbursable grant of up to 20% for projects, with a maximum grant of R10 million over a two-year investment period. For projects that are 51% owned and controlled by women, youth, or persons with disabilities, the grant increases to 30%. This program supports competitiveness improvements and capital investment in the manufacturing sector.

  Link: https://www.thedtic.gov.za/financial-and-non-financial-support/incentives/manufacturing-support-programme-msp/

- **National Equipment Programme (NEP):** Coordinated by the National Research Foundation (NRF), NEP provides funding for acquiring or developing equipment to enhance research capabilities. The program encourages local design and development of next-generation research equipment in South Africa, supporting institutions in improving their research infrastructure.

  Link: https://www.nrf.ac.za/wp-content/uploads/2024/03/NEP_Framework-and-Funding-Guide_March-2024.pdf

- **Manufacturers Support Centre (MSC):** The MSC offers support for plant and equipment capacity in the manufacturing and mining sectors. Services include access to finance, productivity improvements, and assistance with equipment acquisition to enhance operational efficiencies.

  Link: https://www.mscec.co.za/support-offered/productivity-efficiencies/plant-equipment/

- **China-Africa Development Fund (CADFund):** While not exclusively South African, the CADFund invests in African projects, including those in South Africa, focusing on agriculture, manufacturing, and infrastructure. It supports Chinese enterprises engaged in economic and trade activities in Africa, facilitating investments contributing to local industrial development.

  Link: https://en.wikipedia.org/wiki/China-Africa_Development_Fund

- **Merchant West:** Merchant West is a private financial institution in South Africa offering innovative financing solutions to businesses. They specialise in asset finance, working capital, and bespoke financial products to meet specific business needs. Their offerings include equipment financing, debtor finance, and rental solutions, enabling businesses to access funding for operational growth or capital investments. Eligibility depends on the applicant's financial stability and ability to repay the financing, with requirements varying by product. Businesses can expect processing times to differ based on their request's complexity and their documentation's completeness.

  Link: https://merchantwestinvestments.co.za/

- **SEDA:** SEDA provides non-financial support to South African small, micro, and medium enterprises (SMMEs). Their services include business consultations, training, capacity building, and market access and business plan development assistance. SEDA enhances entrepreneurial success by equipping SMMEs with skills and tools to scale sustainably. Eligibility is restricted to South African-owned businesses operating locally. While exact waiting times depend on program demand, SEDA's network of local branches allows for accessible engagement and support for businesses nationwide.

  Link: https://www.seda.org.za/Programmes/Pages/EnterpriseDevelopment.aspx

- **Coaltech:** Coaltech is an energy solutions company focusing on upgrading coal technologies to enhance energy efficiency and reduce environmental impact. They provide innovative systems to improve coal quality, enabling users to meet regulatory standards and lower emissions. Coaltech collaborates with coal producers, industrial energy users, and energy companies aiming for cleaner energy solutions. Eligibility for their services depends on the scope of the client's coal-related challenges and their interest in implementing Coaltek's technologies. Project timelines and waiting periods are determined by the scale of the solution and the implementation process.

  Link: https://coaltech.co.za/

- **The Anglo-American SEFA Mining Fund:** The Anglo-American SEFA Mining Fund is a partnership between Anglo-Americans and the Small Enterprise Finance Agency (SEFA), aimed at supporting emerging black-owned mining businesses in South Africa. The fund provides financial and technical assistance to SMEs in the mining sector. Funding is available for pre-feasibility studies, feasibility studies, and project development, focusing on promoting sustainable mining ventures. Eligibility criteria include being a black-owned business operating in the mining sector, with projects demonstrating economic viability and alignment with industry regulations. Waiting times for funding approval depend on the complexity of the application and project scope, with thorough due diligence conducted to assess feasibility and impact.

  Link: https://southafrica.angloamerican.com/our-stories/the-anglo-american-sefa-mining-fund

- **Public Investment Corporation (PIC)**: Has had a recent collaboration with **International Resources Holding (IRH)** to demonstrate a growing interest in developing underperforming and undeveloped mining assets. This partnership focuses on traditional mining activities and critical minerals and renewable energy integration, ensuring alignment with global sustainability goals. Such investments open up opportunities for companies working on green mining technologies or transitioning to sustainable energy sources.

  Link: https://www.pic.gov.za/

- **Small Enterprise Finance Agency (SEFA):** SEFA supports small businesses and cooperatives across various industries, including those involved in technological innovation. Its primary focus is enabling startups and SMMEs to access financial resources, mainly when traditional funding options are unavailable. SEFA offers loans ranging from R50,000 to R15 million and emphasises job creation and enterprise sustainability, with funding decisions taking 4–12 weeks, depending on the application's complexity and the required documentation's

completeness. To be eligible for this fund, businesses must operate in South Africa, demonstrate sustainability potential, have a sound business plan, a valid South African ID, and proof of residence.

Link: https://www.sefa.org.za/

- **Development Bank of Southern Africa (DBSA):** The DBSA supports infrastructure development in South Africa and the region, focusing on energy, transportation, and technology projects with significant societal impact. While its focus is on large-scale projects, it also supports innovative technology commercialisation initiatives that align with its developmental mandate. To be eligible for funding, the proposed project must demonstrate clear developmental and economic impact and provide detailed project documentation, including feasibility studies and financial projections. Applications typically take 8–20 weeks for evaluation, depending on the size and complexity of the project. This is ideal for developers working on large-scale technologies requiring infrastructure or significant capital investment.

  Link: https://www.dbsa.org/

- **National Empowerment Fund (NEF):** The NEF supports black-owned businesses and projects promoting inclusive economic participation. It provides financial and non-financial support to businesses across sectors, including technology development. To be eligible for funding, the business must have at least 51% black ownership and adhere to B-BBEE level 1 status, with applicants demonstrating a commercially viable business model and a clear value proposition.

  Link: https://www.nefcorp.co.za/products-services/

Other Notable Funding Bodies for Mining Hardware

- **Breakthrough Energy Ventures:** Breakthrough Energy Ventures supports innovative technologies to combat climate change, including mining technologies that reduce emissions and enhance sustainability. They focus on startups with scalable solutions that have the potential for global impact, emphasising clean energy transitions and decarbonisation**.**

  Link: https://www.breakthroughenergy.org/

- **Helios Investment Partners:** Helios Investment Partners drives economic development in African industries, including mining and energy, by investing in businesses with high growth potential and a commitment to sustainable practices. They focus on companies operating in or serving African markets, supporting inclusive growth and long-term impact.

  Link: https://www.heliosinvestment.com/

- **EIT RawMaterials:** EIT RawMaterials is dedicated to strengthening Europe's raw materials sector through mining, recycling, and resource efficiency innovation. They support startups, SMEs, and consortia working on projects that enhance the raw materials value chain and promote a sustainable circular economy.

  Link: https://eitrawmaterials.eu/

- **Resource Capital Funds (RCF):** Resource Capital Funds invests globally in mining and natural resource projects, focusing on early-stage ventures, expansions, and companies in

exploration, development, or production phases. They aim to back technically and financially strong projects with significant growth potential.

Link: https://www.resourcecapitalfunds.com/

- **Venture Catalyst Space:** Venture Catalyst Space supports startups and SMEs developing innovative space-related technologies, including satellite applications for mining operations. Their focus is on commercially viable solutions that leverage space technologies to improve industries like mining, agriculture, and communications.

  Link: https://venturecatalyst.space/

- **Elemental Accelerator:** Elemental Accelerator funds projects focused on sustainability and energy transition, including clean energy technologies for mining operations. They target startups and projects with measurable social and environmental impacts, especially those in early growth stages aiming to address critical challenges.

  Link: https://elementalexcelerator.com/

- **Savannah Fund:** Savannah Fund provides seed funding to African-focused tech startups, including those offering innovative solutions for mining technology and resource management. They prioritise scalable startups with a clear path to revenue generation, fostering technology-driven growth across the continent.

  Link: https://savannah.vc/

10 APPENDICES

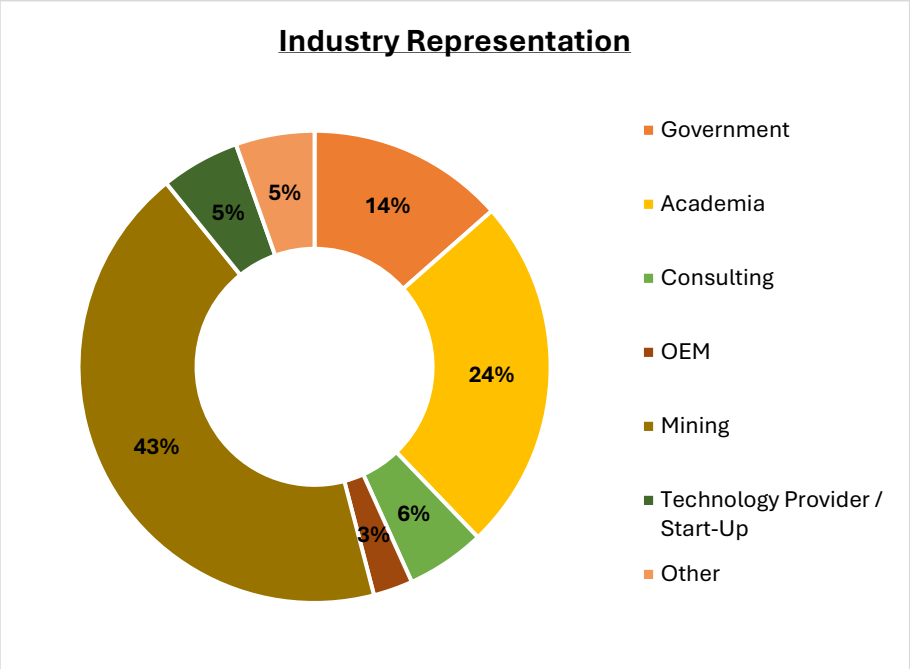
APPENDIX A - Stakeholder survey results

APPENDIX A: Stakeholder Survey Results

Stakeholder survey data informing the development of the information-sharing platform

Demographics of participants

Most participants (43%) completed the survey represented a mining house, as depicted below. This data point is significant as it represents a primary user of the potential information-sharing platform. Hence, the sentiments across the other questions represent core pain points and gain creators in conceptualising the value proposition.

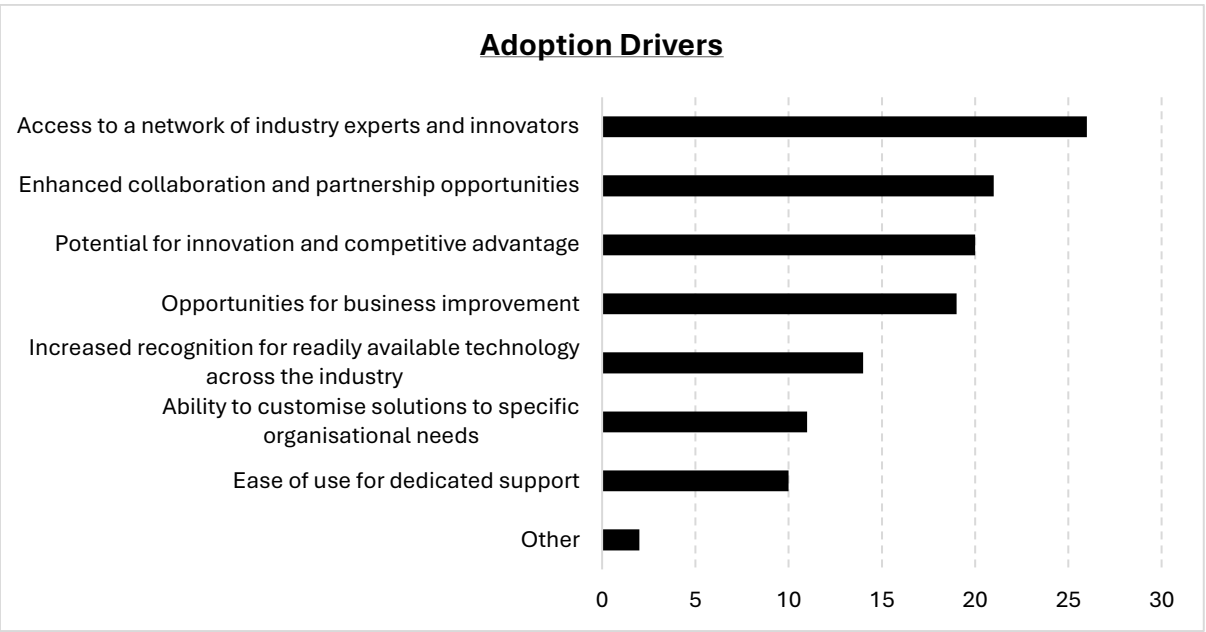


Key challenges

The major resistant factors causing hesitation to share specific operational challenges on a web-based, public, centralised platform were concerns about confidentiality and IP protection (25%), fear of reputational risk (16%), and potential regulatory compliance issues (11%). Notably, "unwillingness to share knowledge" was not a concern, indicating the industry's appetite for collaboration (or co-opetition). Several key considerations are crucial in ensuring the quality of solutions, maintaining competitive advantage, and data security.

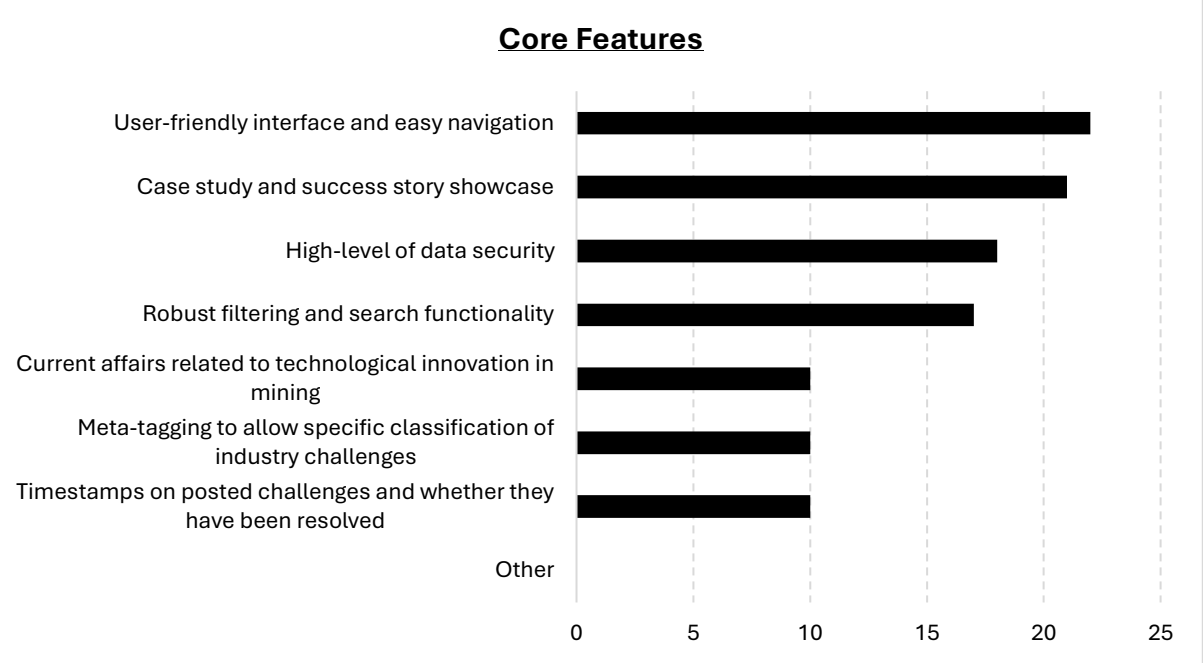
Adoption drivers

There are explicit attributes that would encourage using a centralised information-sharing platform. The top five include access to a network of industry experts and innovators (21%), enhanced collaboration and partnership opportunities (17%), potential for innovation and competitive advantage (16%), opportunities for business improvement (15%), and increased recognition for readily available technologies (9%). Similarly, these results indicate the industry's desire to form mutually beneficial relationships to drive operational excellence along the modernisation journey.



Priority features

The participants indicated three features are critical in ensuring an information-sharing platform's sustained use and adoption. These include a user-friendly interface and easy navigation (20%), case studies with success stories (19%), and a high level of data security (17%).



_____END_____