

Rio Tinto, the Organization Facing Aluminium Technological and Environmental Challenges

Sylvie Fraysse

General Manager, Aluminium Technology Solutions

Rio Tinto, Voreppe, France

Corresponding author: sylvie.fraysse@riotinto.com

<https://doi.org/10.71659/icsoba2024-kn004>

Abstract

In Rio Tinto's Aluminium R&D and Technology Group, our focus over recent decades has been on productivity (volume and cost) and health, safety and environment. Today, these areas remain critical and are complex to improve given the progress made. However, new objectives have been added, centred on finding better ways to provide the aluminium the world needs while reducing our carbon footprint and making net zero a reality. To meet these new objectives as quickly as possible, we must work differently. This means adapting our R&D and technology portfolio, moving faster, working with external parties and technologies, and being more ambitious and bolder.

Continuous improvement and innovation are part of our DNA at Rio Tinto. In response to this new context, Rio Tinto has established a global organization based on the strong existing know-how and skills of the R&D teams, combined with a more centralized support model to our product groups and assets. This model aims to be more efficient and impactful and will enable us to find and adopt technologies, to find the right partnerships (from labs to industrial companies), and to move quickly from idea to implementation at operational sites.

In Rio Tinto Aluminium, we have extensive experience in both research and development (R&D) and the industrialization process, bolstered by our robust technology sales history and strong ties with our smelters. Additionally, we benefit from a vast and rich ecosystem. This paper demonstrates how we are leveraging this solid foundation to go further and faster while enhancing our organization.

Keywords: Innovation organization, Academic and industrial partnership, Technology development.

1. Introduction

Innovation is about doing things better and trying new approaches. Rio Tinto's purpose – finding better ways to provide the materials the world needs – relies on innovation to find new pathways. Our focus on innovation has helped us achieve our goals in the past, but the context we operate in is changing rapidly, and our approach to innovation must evolve accordingly [1].

2. A Balanced Portfolio for the Aluminium Value Chain

2.1 Strong Foundations

To tackle new challenges, improve efficiency, and accelerate progress, we are firstly strengthening our internal foundations. At Rio Tinto, we have extensive experience in developing aluminium technologies, supported by our R&D centres and experts, our history of technology sales, and our strong connections with our smelters.

We oversee and develop technology across the entire aluminium value chain, from bauxite to final metal products, from production processes to residue valorisation, and metal recycling. In R&D and Technology, we have spent decades developing tools and knowledge that enable us to deliver industry leading performance. Our technology stack includes modelling tools, development platforms, process control products, specialized operational and maintenance equipment, and process engineering packages.

Due to these strengths, Rio Tinto Aluminium (RTA) now runs the world's most productive cells in terms of tonnes produced per square meter. Over the past 20 years, a consistent increase in amperage of about +1 kA per year has boosted the Saguenay Lac-St-Jean region annual production capacity by over 215 000 tonnes.

All these elements give us a strong core business position that we can optimize and improve continuously upon. It is only the first and foundational step in building a broader R&D portfolio.

2.2 New Challenges and New Technologies

Whilst in recent years most of our R&D effort has been centred on productivity and efficiency initiatives – we are pivoting in line with the Rio Tinto Group strategy and building a balanced portfolio to support our drive against delivering impeccable Environmental, Social, and Governance (ESG) performance and to solve new system constraints such as power supply sources.

Just some of the opportunities and challenges to solve for include enabling our smelters to deal with the intermittent energy supply resulting from renewable power and removing CO₂ from our production processes as it contributes to around 21 % of Rio Tinto's Scope 1 & 2 emissions alone [2].

Regarding R&D and Technology approach, there are two key differences between recent decades and the existing and future context:

- We need to integrate technologies, solutions and tools which are no longer in-house designed and built. For example, the existing CO₂ capture technologies are not specific to the Aluminium process. While we need to tailor these technologies to our specific context, we lack the expertise and time to start from scratch. Additionally, there are multiple technologies available, each with varying levels of maturity and distinct advantages and challenges, especially for aluminium production. Our goal is to identify the optimal solution from these different technology options.
- We must accelerate our efforts and leverage Industry 4.0 technologies. Big Data, artificial intelligence (AI), and smart sensors are now essential. Given our time constraints, we must once again identify, evaluate, and utilize the right tools and partners instead of doing everything ourselves.

Reflecting on this context, one could say that to solve for our R&D portfolio we must focus on sourcing technology and procuring it. Yes and No:

- Yes - The R&D and Technology teams need to adapt their working methods. While they should continue developing in-house processes and tools, they must also increasingly focus on identifying, evaluating, and effectively managing partnerships.
- No - The key to success is finding the right balance between strong in-house expertise and external input. To evaluate and identify the right external technologies and partners,

and to validate and adapt them, we need a deep technical understanding of how they fit into our business and the ability to specify our functional requirements in detail.

The aluminium production is a complex process with numerous constraints and specific requirements. Therefore, to continue to develop our new balanced portfolio, we must have:

- Strong in-house foundations
- Agility to adapt our way of working with new players.

2.3 Finally, What is a Balanced Portfolio?

2.3.1 How to Build a Well Balanced Portfolio

We must clearly identify the challenges that could hinder our strategy and the opportunities that could support it. By focusing our innovation efforts on these areas, we ensure alignment with our goals. We have accordingly adopted a disciplined approach to road mapping and managing our portfolio.

In developing this roadmap, we must consider Rio Tinto’s aspirations alongside the requests of internal stakeholders (operations, health, safety and environment (HSE), strategy, marketing, commercial, etc.). We need to review all projects through these perspectives to determine how they address our “business drivers” before selecting key priorities (programs and projects) and allocating resources.

First the process must define key business drivers. The business drivers consider all internal and external constraints and requests of the aluminium value chain and are aligned with Rio Tinto strategy (Figure 1). From there several benchmarks help us also to optimize our business driver structure.

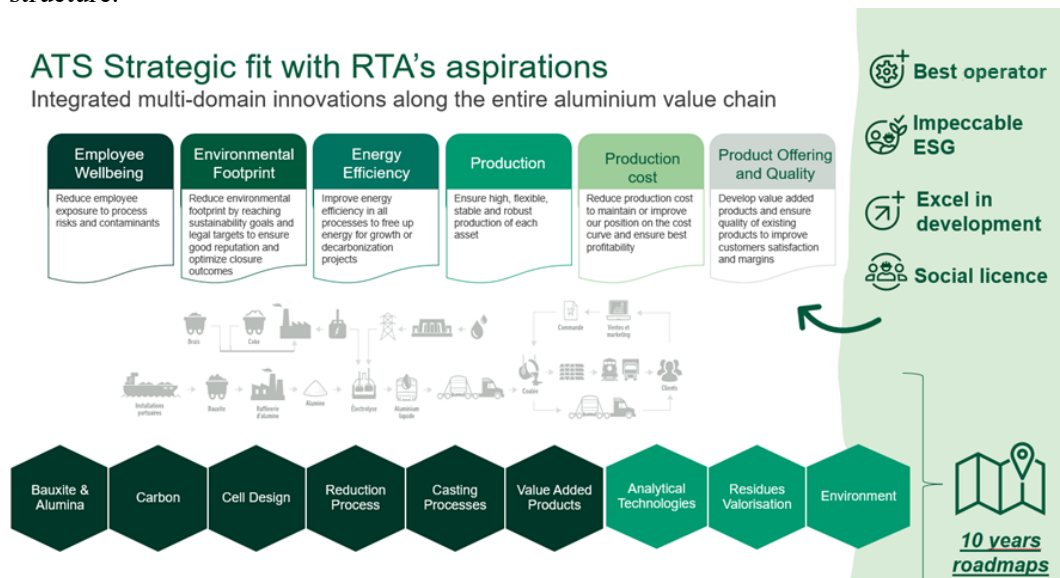


Figure 1. Translating Group’s aspirations into key business drivers for R&D and Technology (ATS = Aluminium Technology Solutions).

Then, for each business driver across each step of the value chain, we clearly define the process features and associated targets. For example, looking at Figure 2:

- Business driver is on Employee wellbeing
- One key process feature is reducing employee exposure to process risks and contaminants.

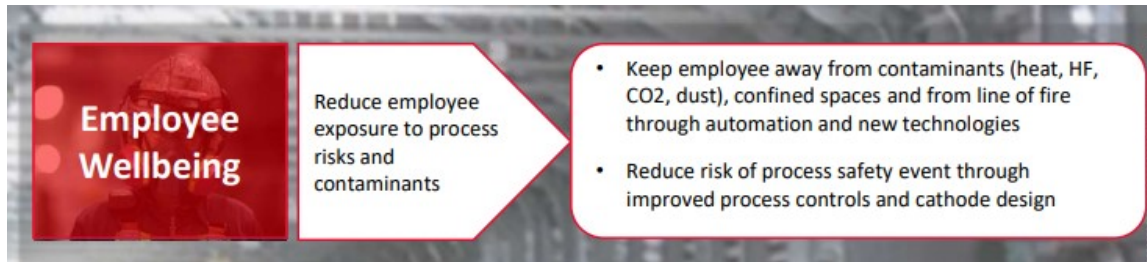


Figure 2. Translating Group's aspirations into key business drivers for R&D and Technology (ATS = Aluminium Technology Solutions).

Finally, we prioritize the list of projects according to these process features and targets.

We complete this exercise each year to ensure we are focused on the highest value projects. We can then build our plan and define how we go after the problem by either solving internally or through our external support ecosystem (partnerships, academic studies, ventures ...).

2.3.2 How to Keep and Manage this Well Balanced Portfolio

Our prioritised process of portfolio review and updating our roadmaps, is embedded in our R&D Annual Cycle (Figure 3).

A few years back, we introduced a new R&D review cycle to enhance our agility. This allows us to quickly stop, start, or re-size projects, ensuring we stay aligned with needs and deliver the right projects at the right time.

Specifically, we moved from a large intensive annual review process to a more dynamic quarterly review process which is focused only on projects that need to be put on hold or stopped and new projects to be established. This has allowed us to adapt a balanced portfolio and whilst having a strong base of projects over several years that are focused on addressing our major challenges.

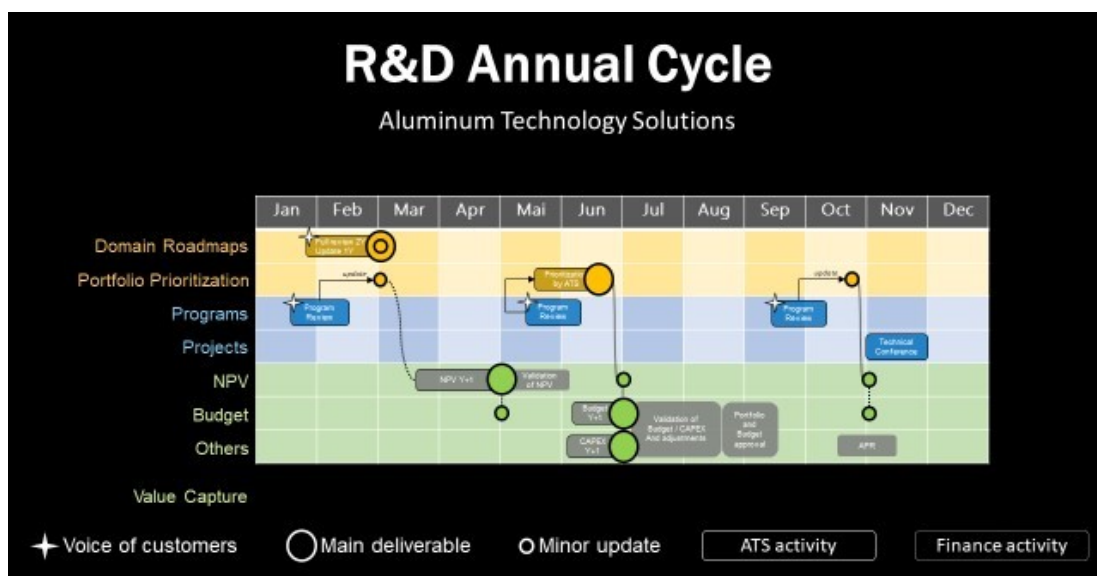


Figure 3. R&D annual cycle.

3. Levering the Strength of Rio Tinto's Diversity

The second key element that underpins our approach is centred on leveraging Rio Tinto's extensive scale and diverse exposure in the metals and mining industry. We believe that, delivered in a highly efficient way, it can bring a step change in execution speed from idea to real world implementation in a way that is differentiating. Specifically, we aim to lever the Group diversity in three ways.

3.1 Sharing Excellence

Firstly, we work to share our human capabilities, technology development centres and technology test beds to maximise results at a Rio Tinto Group level. We bring to bear the requisite technical, digital and environmental and community skills that are central to solving for our industry's key ESG challenges in ways that transcends a traditional single commodity focus. This step change also has a very real efficiency benefit as we can flow these capabilities in line with the dynamic demands of the technology development lifecycle.

We are enhancing our approach by centralizing key and specialised capabilities, integrating them into the most significant projects at the right time. These skill sets are designed to complement the existing capabilities across Rio Tinto's various businesses. Similarly, we are leveraging the specialized focus of our technology development and test centres to benefit other parts of the Rio Tinto Group.

Examples include our China Technology Innovation Centre (CTIC), which connects Chinese research institutions, universities, and companies to collaborate on carbon mineralisation. We also share material science and electrolysis expertise to develop breakthrough alloys like our aluminium-scandium alloy. As well, we bring together reduction and modelling expertise from across Rio Tinto to support our work on steel decarbonisation.

3.2 Synchronizing Initiatives

Secondly, we aim to solve for common opportunities and challenges in a coordinated and 'concurrent' way. We do not take a bureaucratic and one size fits all approach but rather we focus the technology development on the part of Rio Tinto for where value is the highest, while considering the functional requirements and specifics of other parts of the Group. This allows us to move quickly whilst avoiding duplicative developments in other parts of Rio Tinto at later dates. Working in ways that consider other parts of Rio Tinto's needs further reinforces the fluidity of resources.

Simply put, a given part of Rio Tinto will see other parts of the Group working on technologies that will directly benefit it and is similarly working on technologies for its assets whilst ensuring the technologies will support other parts of Rio Tinto. This drives, shared ownership, teaming and commitment.

Important examples of this include our work on diesel transition where we are driving a coordinated programme for heavy mobile equipment decarbonisation. We are focused on developing a portfolio of technologies that solve for different pit operating conditions, geometries and sizes to help deliver our 2030 decarbonisation targets.

3.3 Piloting Synergies

Thirdly we are aggressively targeting high impact areas of synergy, where bringing together operations, studies and skills from across the metals and mining lifecycle (find, develop, extract, process, move and sell and close) can unlock untapped value.

Examples of this include how we are looking to test our leading exploration technology at selected existing assets and sites. This not only drives improve calibration and modelling but is improving fundamental knowledge of the orebody and waste which in turns is allowing us to further enhance mine plans and schedules and organise our rehabilitation and closure activities in new ways. Similarly, to reduce mine-impacted water and closure costs, we are focusing on recovering and capturing trace metals. This work is inspiring new flowsheet designs for critical mineral extraction in both greenfield and brownfield studies.

3.4 Enablers

Achieving our goals in leveraging diversity through those three ways, relies also on a series of building blocks and enabling capabilities we have established. We have constructed a framework to deliver these outcomes, which includes a vibrant, company-wide innovation and R&D community, high transparency across all work, a collaborative approach to driving innovation processes, and a carefully tailored funding strategy.

4. External Partnerships

We know we do not have all the answers to our technology challenges. Much of the technology to meet our 2050 net zero goal, does not exist today. We must therefore contribute, support and partner to make it a reality.

The third pillar of our approach is in building meaningful partnerships and connections to help us tackle these challenges and drive change through multiple channels focused on the various stages of technology maturity.

4.1 Academic Partnerships

This is a key channel for early-stage research and accessing emerging technologies. We collaborate with universities through scholarships and project-based partnerships, establishing a global network of enduring research programs and centres with leading institutions across our operational footprint.

Some examples are:

- In 2023 we announced a 150 MUSD commitment to establish the Rio Tinto Centre for Future Materials (RTCFCM) led by Imperial College London. The RTCFCM brings together four leading universities to find innovative ways to provide the materials the world needs for the energy transition. The RTCFCM will fund research programs to transform the way vital materials are produced, used and recycled and make them more environmentally, economically and socially sustainable.
- Another notable example is our ongoing partnership with Ecole Polytechnique de Lausanne (EPFL) for more than 30 years. We work with EPFL to develop and continuously optimize our modelling tools.

We have a value-based approach to academic partnerships. A number of key strategic partnerships are managed centrally where the partnership offers cross-Product Group benefits (e.g. RTCFCM)

and maintain a structured portfolio of partnerships providing flexibility to Product Groups to work directly with leading academic partners on specific product group-related challenges (e.g. EPFL).

4.2 Start-Ups

We work with start-ups to access rapidly developing technologies of interest to advance our Innovation Imperatives, leveraging the capabilities and speed found in start-ups.

In 2021, we created a dedicated venture capital fund to invest in technology and start-ups to help solve critical business challenges. Since then, we have continued to invest in innovative companies that are consistent with our strategy.

A recent example in this area, is ÉVOLYS (Biocarbon) with Aymium to develop and trial a renewable biocarbon product for use as an alternative resource to reduce emissions in large-scale industrial processes.

4.3 Industrial Partners

We continue to partner across our value chain, with other mining competitors and suppliers on areas such as decarbonisation, safety and ESG.

Examples:

- BHP and Rio Tinto are joining up on their efforts to electrify their fleets of haul trucks, in collaboration with manufacturers Caterpillar and Komatsu [3].
- ELYSIS is an unprecedented world-class partnership of two major aluminium industry pioneers, Alcoa and Rio Tinto, developing a new breakthrough technology, known as inert anode (Figure 4).
- The C4 Capture project: A French consortium with a group of companies with diverse but complementary skills around decarbonation the aluminium process (Aluminium Dunkerque, Trimet, Fives, Rio Tinto). The focus is to develop and test at an industrial facility CO₂ pre-concentration, capture and treatment technology that would be compatible with the CO₂ emissions from a primary aluminium smelter.



Figure 4. Nigel Steward, Chief Scientist of Rio Tinto, with the ELYSIS team, inspecting an ELYSIS pot line [4]

4.4 Internal Support

Overall, our external partnerships are supported internally by Rio Tinto Experts and R&D centres ensuring that we are properly set up to integrate and implement the developed technology.

The Aluminium Development and Research Centres in France and Canada, which are central to Rio Tinto's aluminium supply chain development, along with the Bundoora Technical Development Centre (BTDC) in Australia, known for its multi-commodity technical and processing expertise, play crucial roles in testing, validating, and bringing in such technologies.

5. Bringing the Outside World In

In recognition of the need to partner with others, our focus is also about how we can more effectively bring the outside world into Rio Tinto.

5.1 Open Innovation

Our collaboration with the outside world goes beyond traditional external partnership agreements. We have established an Open Innovation channel to solve Rio Tinto's local challenges with a global ecosystems approach. Open innovation is the key to accessing collective knowledge, it unlocks the potential of shared creativity and paves the way for breakthroughs that Rio Tinto can't achieve alone. Through our Open Innovation channel, we actively seek external input, including ideas, technologies, and expertise.

It involves partnerships with external entities like customers, research institutions, and even competitors, to accelerate innovation. This model promotes the sharing of knowledge and expertise across organizational boundaries, fostering a culture of open exchange of ideas. It includes both inbound (acquiring external ideas and technologies) and outbound (leveraging internal assets externally) approaches and encourages the development of innovation ecosystems, where organizations can connect, collaborate, and share resources to drive innovation forward.

The open innovation ecosystem is led at the front by our own capabilities. Our development centres bring the best of Rio Tinto's technologies to the forefront – and lead our competitive advantage. Our customers are part of our journey and will continue to frame our demands, requirements and outcomes. They can be a great source of open innovation, all to deliver the materials that the world needs for the energy transition.

5.2 Pioneer Portal and Open Business Challenges

We use the digital tool "Pioneer Portal" to bring in, outside ideas focused on curated business challenges to deliver opportunities for the Group and transformational ideas from external companies and groups (Figure 5). The platform allows any external potential partner to proactively pitch their innovative solutions and seeks for a collaboration opportunity relevant to our business.

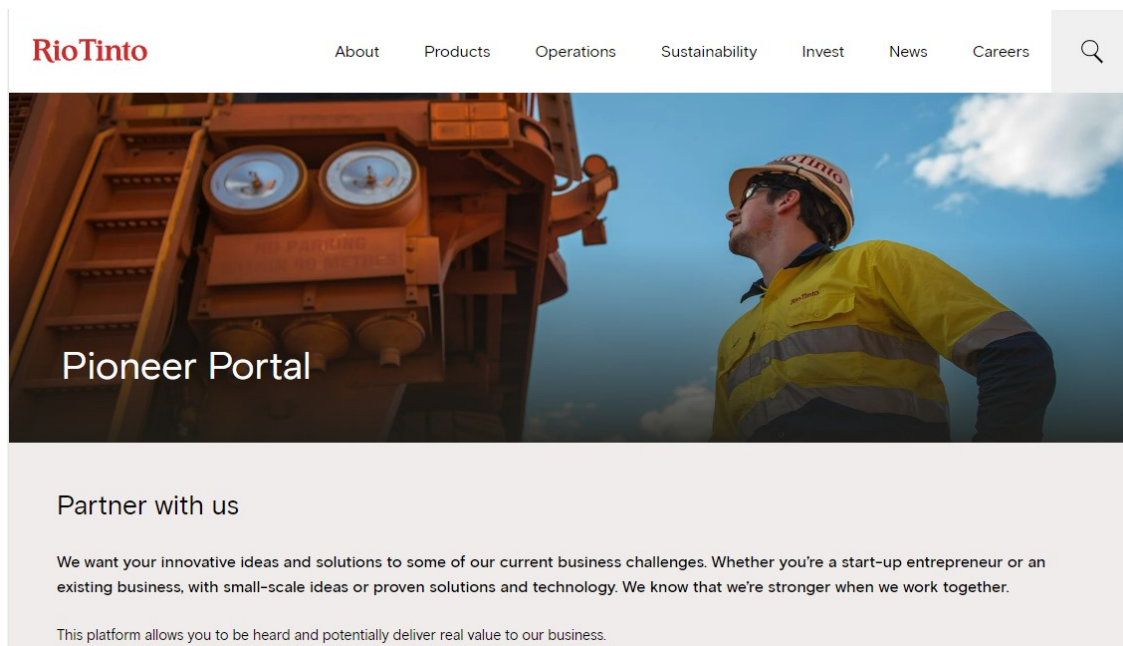


Figure 5. Pioneer Portal [5]

Conversely the Pioneer Portal allows us to openly seek for solutions to some specific challenges. For instance, we have formed a Tailings Consortium with BHP to develop solutions to improve tailings dewatering and management. Together we have launched the “Tailings Technologies Open Call” to identify and accelerate the market availability of innovative, holistic, and economically sustainable technologies to improve the dewatering, transportation, monitoring and stacking of mine tailings, and reduce potential safety risks associated with tailings facilities. This open call has been relayed through our Pioneer Portal.

5.3 Innovation Advisory Committee

In 2023 we established an Innovation Advisory Committee [6] comprising innovation and R&D experts from around the world. The Committee members have diverse expertise to provide insights on ways we can accelerate our innovation portfolio as well as offer guidance on emerging and disruptive technologies in areas including health and safety, environment, social and governance, growth, carbon abatement, and productivity.

The committee meets twice a year and holds open discussions with R&D leaders from across the Rio Tinto Group. They provide Rio Tinto with external insights on our innovation programmes, independent and candid feedback on our innovation performance, and recommendations on areas of improvement and how to improve their innovation performance.

6. Taking a Right-Sized Approach to Risks, Failing Fast and Learning from Failure

Finally, we have changed the way we think about innovation. These changes to our mindset will help us succeed. To find better ways, it takes to recognise that not all failures are created equally. Innovation is one area that we do not want people to be risk averse. If we all embrace the idea of “failing forward” – it will really help us get to where we want to be.

The great inventor Thomas Edison once said, “*I have not failed. I have just found 10 000 ways that won't work*”. That sums up how we should all think about failure. There are good ways to fail, and we should not be afraid of this. “Intelligent failures” are to be celebrated. We can learn

from these and share what we have learned. It is experimentation like this that leads to innovation and ultimately success (Figure 6).

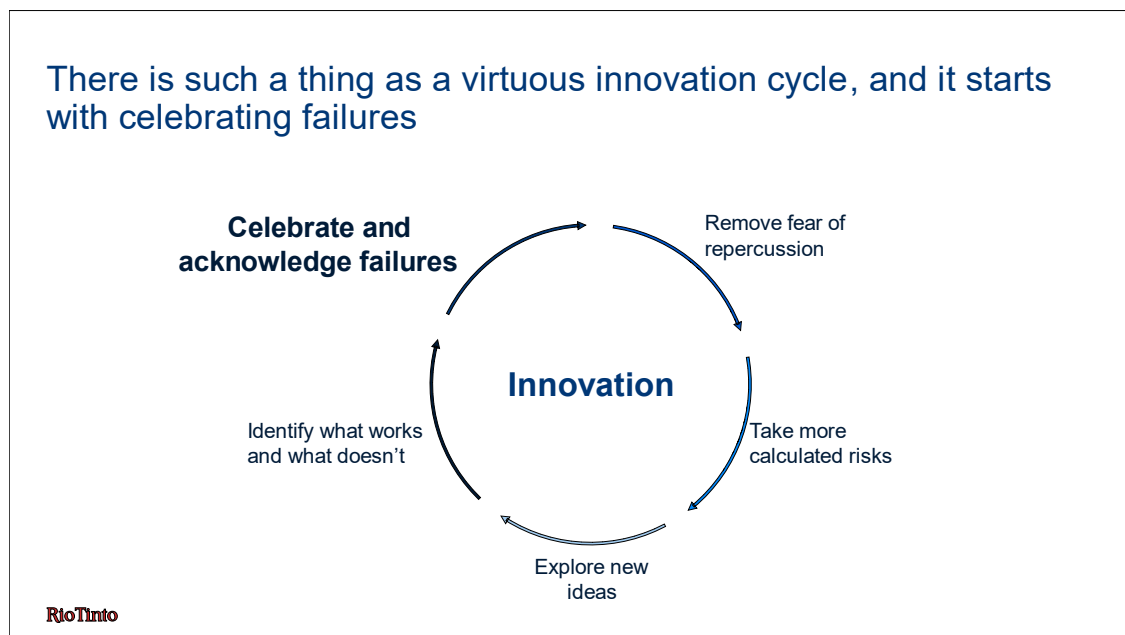


Figure 6. Virtues of celebrating failures.

To help with changing our approach, we are embedding several concepts and tools to help us change:

- **Right-sized approach to risks**
 - Use stage gates to clearly define and assess the technology development risk and potential value in each stage
 - Define the objectives of each stage to focus on challenges that are manageable but still push boundaries.
 - Break the uncertainty of the technology development to manageable risk at each stage-gate with a clear pathway to the full potential value
 - Balance the risk with the level of value and investment required
- **Fail Fast, Fail Small**

The stage-gates approach provides us with the flexibility to try new solutions by designing quick and small-scale experiments to test new ideas so that projects can be adjusted or stopped quickly if they do not work.
- **Embrace Failure as learning**

We are embedding that failures are to be used as learning opportunities. We analyse what failed to gain insights to make informed adjustments and refine future experiments and design successful outcomes (Figure 7).
- **Knowledge management**

We are setting up a central solution to capture the lessons learnt from failures to share across the organization ensuring that the entire organization benefits from the experience.
- **Culture of Experimentation**

Promoting a culture of experimentation and embracing failure as learning is crucial for fostering innovation and growth within the organization. We promote a psychologically safe environment, where taking calculated risks and learning from both successes and failures are valued.

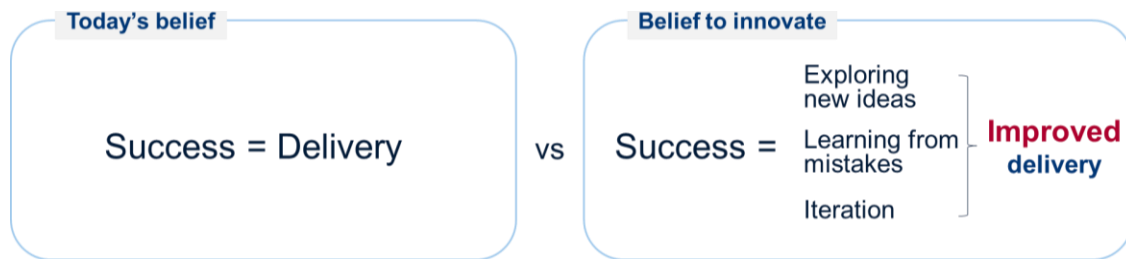


Figure 7. Learning from failures leads to improved delivery.

7. Conclusions

Our strong heritage of innovation continues but addressing climate change and embedding the energy transition require us to think, and to do, differently. The capabilities and technologies needed now surpass our historical achievements. Many challenges we face lack ready-made solutions, making innovative approaches essential. To meet global demands for changing our operating practices, we must mobilize solutions quickly. While some of our greatest innovations took decades to develop, we no longer control the timeline in delivering for the energy transition.

Our overarching response lies in “innovating our innovation,” which, as demonstrated above, involves multiple areas of our organization. We need to optimize and rationalize our portfolio while unlocking our full potential by leveraging our rich internal diversity. Engaging our external ecosystem of partners to develop new ideas and scale up together is crucial. This also means improving the flow of ideas from the outside world and, perhaps more fundamentally, continuously challenging and enhancing our cultural mindset. Importantly, this transformation extends beyond the Aluminium product group to encompass the entire Rio Tinto organization and our broader ecosystem.

Ultimately, everything we use and consume originates from nature. We must use our precious resources wisely and minimize our impact on the earth – whilst providing society with the materials it needs. Science, engineering, and technology development will be crucial in achieving this goal in the safest, net-zero carbon, and lowest ESG footprint manner possible, while creating benefits for society.

8. References

1. Dan Walker, “Why we have to innovate faster than ever”, *Rio Tinto Group News*, 2024 August 18th.
2. Rio Tinto Climate Change Report, <https://www.riotinto.com/invest/reports/climate-change-report>
3. Rio Tinto and BHP collaborate on battery-electric haul truck trials in the Pilbara, *Businesswire (A Berkshire Hathaway Company)*, 2024, May 24th.
4. Nigel Steward, “The right time for science: Introducing Rio’s first Chief Scientist”, *Spirit (RT Newspaper)*, 2021, July 12th.
5. Pioneer Portal - <https://www.riotinto.com/en/about/innovation/pioneer-portal>
6. Innovation Advisory Committee - <https://www.riotinto.com/en/about/innovation/rd-and-technology>