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Gudai-Darri: How Rio Tinto Built the World's Smartest Mine

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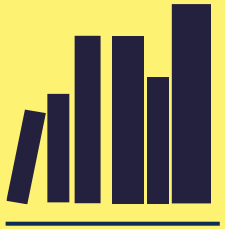

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Gudai-Darri: How Rio Tinto Built the World's Smartest Mine

Destined to be a milestone site

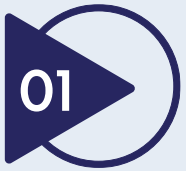
Designed from the ground up for full autonomy, Rio Tinto's Gudai-Darri mine is the company's most ambitious Mining 4.0 deployment to date.

The site integrates robotics, digital twins, AI-driven optimisation, and 5G-connected control systems, all planned from the site's initial blueprint as its primary specification.

Gudai-Darri: A Benchmark for Future Mining 4.0 Design

- **30**% increase in throughput via 24/7 autonomous operation
- **45**% reduction in safety incidents
- **25**% decrease in energy use per tonne
- **18**% cut in CO_2 emissions
- **350+** operational roles transitioned to supervisory or technical functions

Why Building the World's Smartest Mine?



Health and Safety

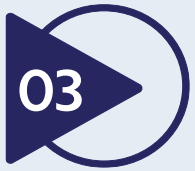
Hazardous working conditions have wide-reaching consequences:

- Human loss
- Low morale and reputational risk
- Downtime and equipment damage
- Higher insurance premium
- Medical and legal costs

Systemic Limits

Older mines lack the digital backbone to support the integration of connected robotics and AI infrastructure.

Retrofitting IT infrastructure is costly and limited by legacy site design. Building autonomy from the ground up enables alignment with evolving digital technologies.



Sustainability Pressure

Regulators, investors, and ESG mandates now demand proof of operational decarbonisation.

It is no longer enough to promise greener mining. Operators must measure, record, and report progress, with regulation expected to tighten further.

Gudai-Darri, Designed to Achieve

- **Attract and retain skilled talent** despite chronic labour shortages in the remote Pilbara region
- **Protect workers** from high-risk tasks through autonomous drilling, blasting, and haulage
- **Reduce operational and financial risks** associated with accidents and unplanned disruptions
- **Deliver measurable progress on decarbonisation**
- **Create a future-ready mine** designed to evolve with emerging technologies

Gudai-Darri's Operating Stack

1 Power & Energy Infrastructure

- Integrated site-wide energy system, including on-site solar farm, powering operations
- Remote monitoring and predictive maintenance
- Managed from Perth ROC (1,500 km away)

2 Communication & Data Infrastructure

- Low-latency private 5G network with 210+ km fibre cabling and power cabling across the site
- Real-time coordination across autonomous systems
- Paperless workflows on site and fully connected field operations

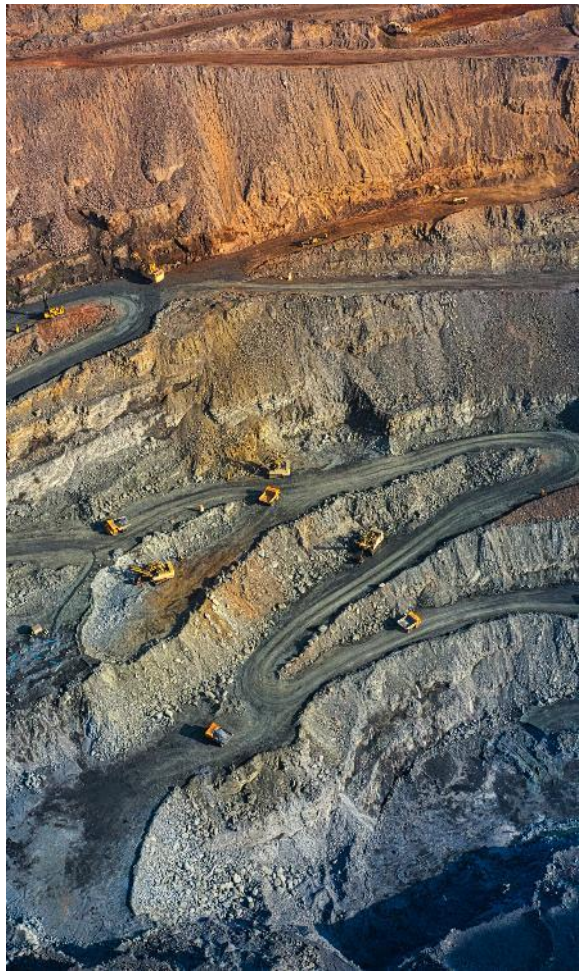
3 Digital Supervision

- Full-site digital twin enables predictive, data-led decisions
- AI-driven routing, diagnostics, and task automation
- Real-time data integration from drones and field systems

4 Robotics

- Autonomous fleet: haul trucks, drills, reclaimer, water carts
- Zero-emissions rail system
- Automated labs and sampling

What Powers the Smartest Mine in the World? (1)



1. **High-voltage substations and power systems** delivered by ABB
2. **On-site solar PV farm** of 34 MW capacity (≈100,000 panels) built by NRW Holdings
3. **Battery-electric haul truck** trials in collaboration with BHP is underway, based on the Komatsu 930E platform, testing future-ready low-emission vehicle deployment
4. **Site-wide private LTE/5G network** built by Telstra & Nokia
5. **Remote Operations Centre** (ROC) located ~1,500 km away (Perth), controlling operations
6. **Paperless** (tablets) field mobility & connected workforce
7. **Digital twin** & control system using AVEVA software
8. **Drone fleet** for daily 3D mine mapping & survey
9. **VR-based training simulations**, enabling operators to learn procedures in a fully modelled 3D replica of the plant environment: "Operators train in a fully modelled 3D replica of the plant."
10. **Existing workforce transitioned** into supervisory and remote-operations roles,
11. **The world's first operational zero-emissions autonomous haul truck fleet,** developed in partnership with Caterpillar
12. **AutoHaul™ heavy-haul rail system**: the world's first fully autonomous heavy rail network, integrated with site-wide vehicle and logistics systems, enabling a future zero-carbon logistics chain.
13. **Autonomous haul trucks** (Komatsu 930E series) enabling continuous ore movement under remote and AI coordination
14. **Autonomous drill rigs (**Epiroc PV-271), performing precision drilling integrated with digital blast planning

What Powers the Smartest Mine in the World? (2)

15. **Autonomous water trucks** (160,000-litre capacity), developed with Caterpillar, equipped with **driverless navigation and a self-refill system** for haul road maintenance.
16. **Robotic blast-hole sampling laboratory** (first of its kind in the Pilbara), providing continuous geochemical analysis directly after blasting.
17. **Autonomous water carts**: 160,000-litre autonomous trucks for dust suppression, developed with Caterpillar; trigger water application via onboard AI
18. **Fully automated ore-sampling laboratory:** conveyor-fed robotic system handling sample preparation and grade analysis to enhance visibility and throughput.
19. **Rotatable bucket-wheel reclaimer: A patented first-of-its-kind** design allowing complete wheel module change-out, reducing maintenance shutdown time
20. **Autonomous mobile robots (AGVs)** operating within the warehouse to transport heavy tools, parts, and consumables.
21. **2,500+ IoT sensors** across plant, vehicles and conveyors

Engineering Autonomy: The 5-Year Journey

"*The mining industry is at a critical point in time, a juncture between a traditional and quite conservative past and an exciting and truly transformative future.*" Stephen McIntosh, Group Executive Growth and Innovation, Rio Tinto.

"*What we have learnt during the rapid ramp-up of Gudai-Darri has given us the confidence to find better ways to increase capacity.*" Matthew Holcz, Managing Director, Rio Tinto

2018–2019

Planning and approval

Rio Tinto's first site fully designed for autonomous operation, set to be a landmark in mine design.

2019–2022

Construction

The new build includes a process plant, 166 km rail line, on-site solar power, and a dedicated airport for workforce access.

2022–2023

Autonomy in Action

First ore delivered in 2022, full named capacity of 43 Mtpa reached in 2023.

From Billion-Dollar Build to Scalable Value

Following its first full year of operation, Gudai-Darri provides an early benchmark for the performance potential of fully autonomous mine design.

The preliminary KPIs presented in the table reflect measurable improvements across throughput, energy efficiency, emissions, and workforce transformation, offering a clear **signal of long-term value creation from integrated operation and digital infrastructure**.

Gudai-Darri Preliminary ROI & Operational KPIs, 2022-23

Capital investment	USD 3.1 Bn
Full capacity in <12 months	43 Mtpa
Energy per tonne (est.)	–25%
CO_2 saved per year (solar)	–90,000 t
Roles transitioned (internal data)	350+

Indusights, 2025

Take Away for the Industry

End-to-end design is essential for impact
Gudai-Darri shows that significant gains in autonomy, efficiency, and emissions reduction are only possible when the entire system is planned as a unified whole from day one.

Technology must be integrated, not layered
The mine's performance reflects tight coordination across automation, digital twins, energy systems and control infrastructure. Retrofitting cannot deliver this level of return.

Execution depends on organisational readiness
From partner selection to workforce transition, results were enabled by deliberate planning, phased rollout, and a strong change management framework.

About this case study

This case study documents the transformation of Rio Tinto's Gudai-Darri mine in Western Australia. It offers a clear benchmark for large-scale integration of automation, energy systems, and digital infrastructure. It is a must-know reference for anyone operating in the mining B2B environment.

It forms part of a broader research initiative by Indusights, focused on automation, data integration, and operational performance across industrial sectors.

To learn more about our research or explore collaboration opportunities, visit **www.indusights.com** or contact **info@indusights.com**