WEBINAR

Designing Autonomous Systems That Eliminate Human Risk in Hazardous Environments

The case for autonomy in mining — Komatsu FrontRunner & Sandvik AutoMine

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Disclosure: the speaker works for Sandvik as a Graduate Trainee. Views are her own and do not represent Sandvik.
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ROADMAP

What we'll cover



01

The scale of the problem

Global mining fatality & injury data

02

Why PPE isn't curbing it

The hierarchy of controls, and its weakest rung

03

Komatsu FrontRunner

Autonomous haulage at surface mines

04

Sandvik AutoMine

Autonomy underground, where it's hardest

05

Progress & what's next

Adoption trajectory and the remaining gaps



PART ONE

The Hazard

Why mining remains one of the most dangerous industrial environments on earth

THE HAZARD

The scale of the problem

42

Fatalities across ICMM member companies in 2024 — a second straight year of increases

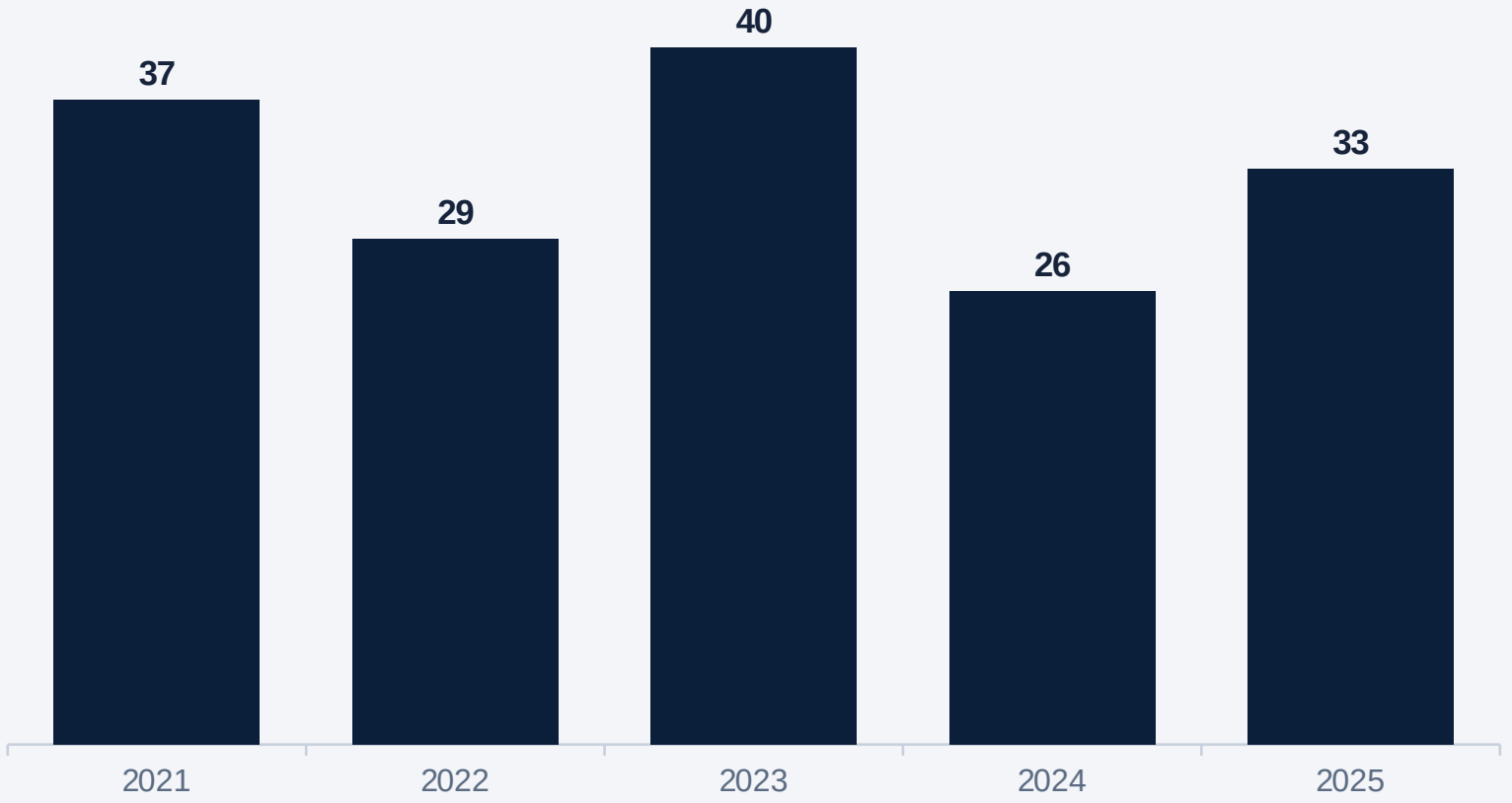
33

US mining fatalities in 2025 (MSHA) — up 27% from 26 in 2024

39%

Share of 2025 US mining fatalities caused by powered haulage alone

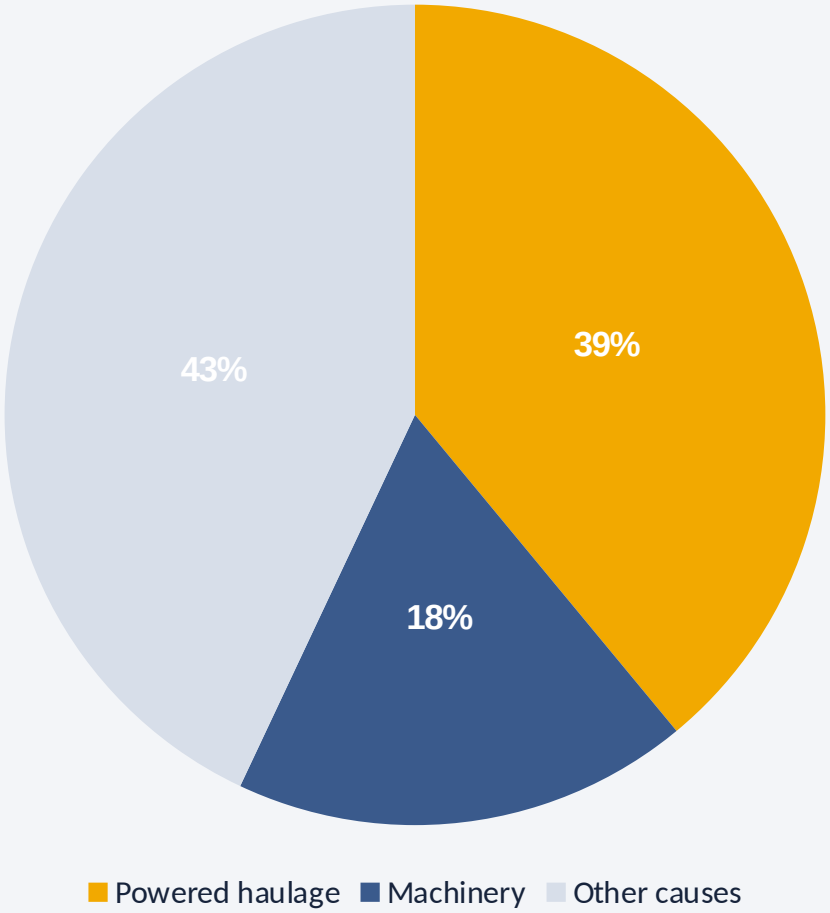
US mining fatalities by year (MSHA)



Sources: MSHA [1]; ICMM [2]

THE HAZARD

The real killer: powered haulage



2025 US mining fatalities by accident classification (MSHA)

Haul trucks: common and dangerous

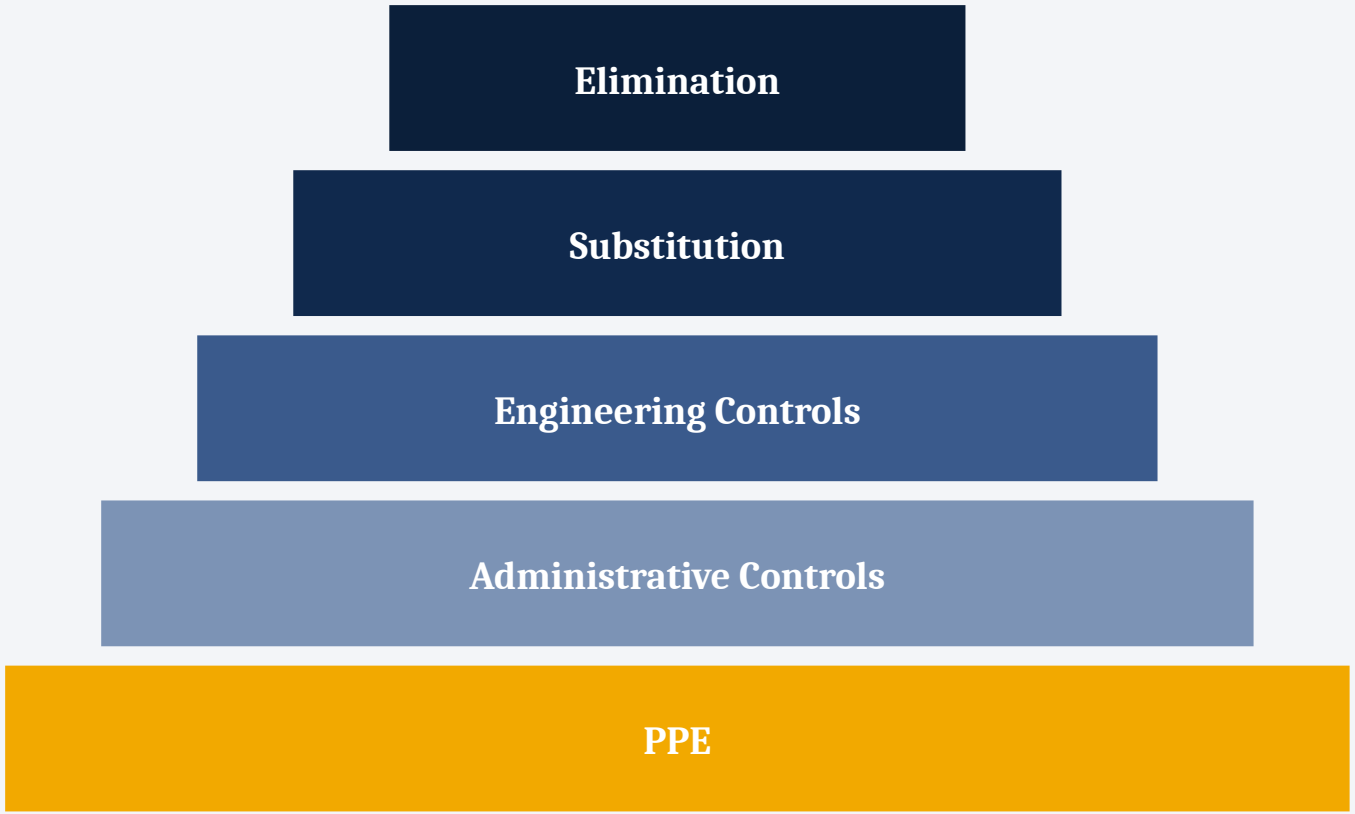
- Powered haulage has accounted for roughly half of all mining fatalities in a typical year historically
- Haul trucks make up over 45% of all mining equipment worldwide — over 48,500 trucks (90 t+) in use
- That ubiquity is exactly why haul trucks are tied to nearly a quarter of all fatalities in peak years
- Failure modes: blind spots, small-vehicle collisions, loss of control — none of which PPE addresses

Sources: MSHA [1]; NIOSH [3]

THE HAZARD

Why PPE isn't curbing this

The hierarchy of controls — PPE is the last, weakest line of defense



Remove the hazard entirely

Replace with something safer

Autonomy, proximity detection, access control

Training, procedures, scheduling

Helmets, vests, gloves — protects, doesn't prevent

Main barrier to PPE compliance: lack of supply (72%), followed by discomfort, poor training, and time-pressure.



PART TWO

Enter Autonomy

Engineering the human out of the hazard zone, not just protecting them inside it

i. *ISO 17757 (Autonomous Mining Safety)*

   ISO 21815 (Collision Warning & Avoidance)

ii. *IEC 61508 / ISO 26262 (Functional Safety)*

SURFACE MINING

Komatsu FrontRunner

Autonomous haulage, since 2008

Fully autonomous — not remote-controlled

One controller can monitor a full truck fleet from thousands of kilometres away, 24/7.

Where it started

First commercial deployment: 2008, Codelco's Gaby copper mine, Chile

Where it runs today

Deployed across North & South America, Australia and Europe

Built-in safety

Removes the driver entirely from the highest-risk role in mining

Side benefit

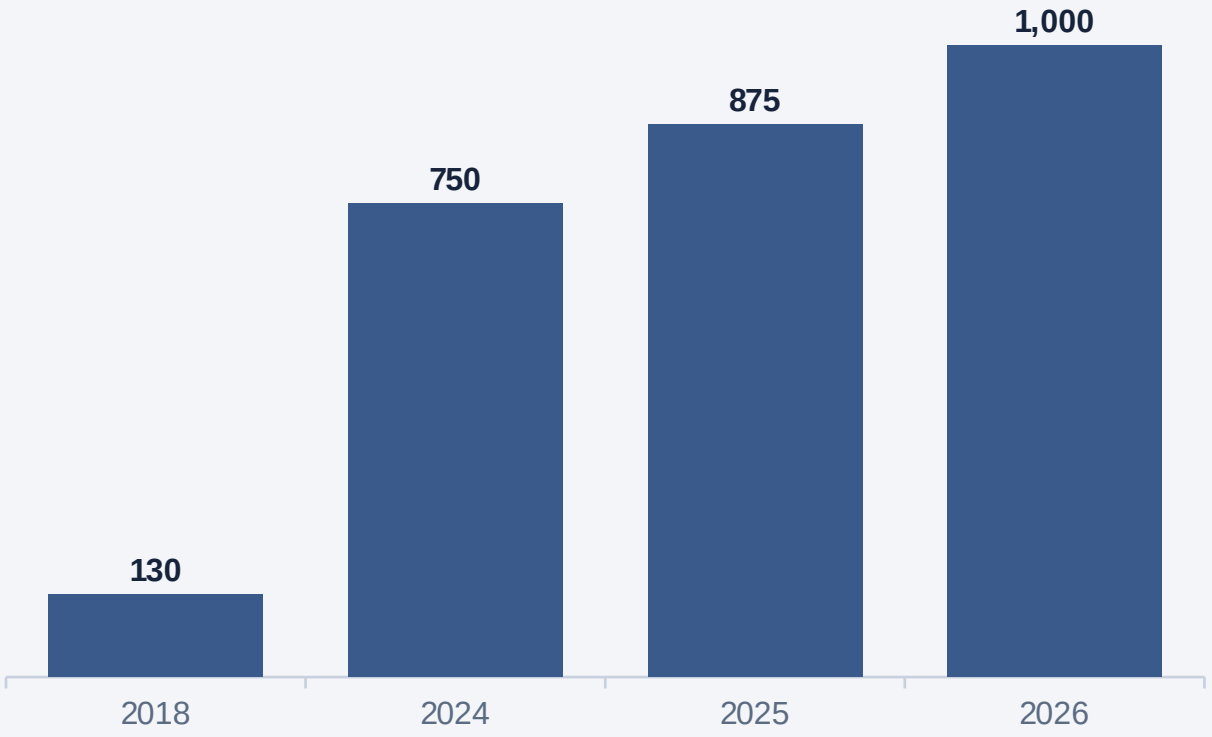
40% longer tire life, 13% less overall maintenance (2018)

Image: © Komatsu

SURFACE MINING

Komatsu, by the numbers

Autonomous truck fleet growth



11.5B

Metric tonnes of material moved autonomously since 2008

1,000

Autonomous ultra-class haul trucks commissioned worldwide (2026)

0

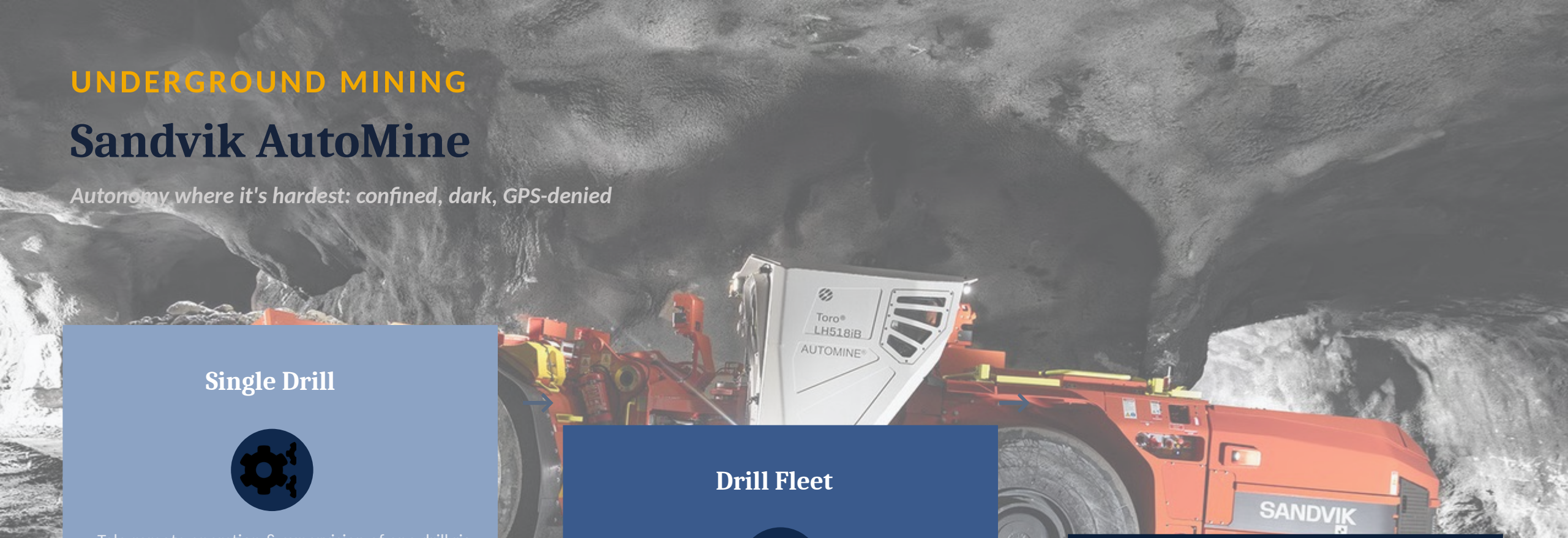
System-related injuries across 5.3 billion tonnes moved — the headline safety record

Sources: Komatsu [4]

UNDERGROUND MINING

Sandvik AutoMine

Autonomy where it's hardest: confined, dark, GPS-denied



Single Drill

Tele-remote operation & supervision of one drill rig

Drill Fleet

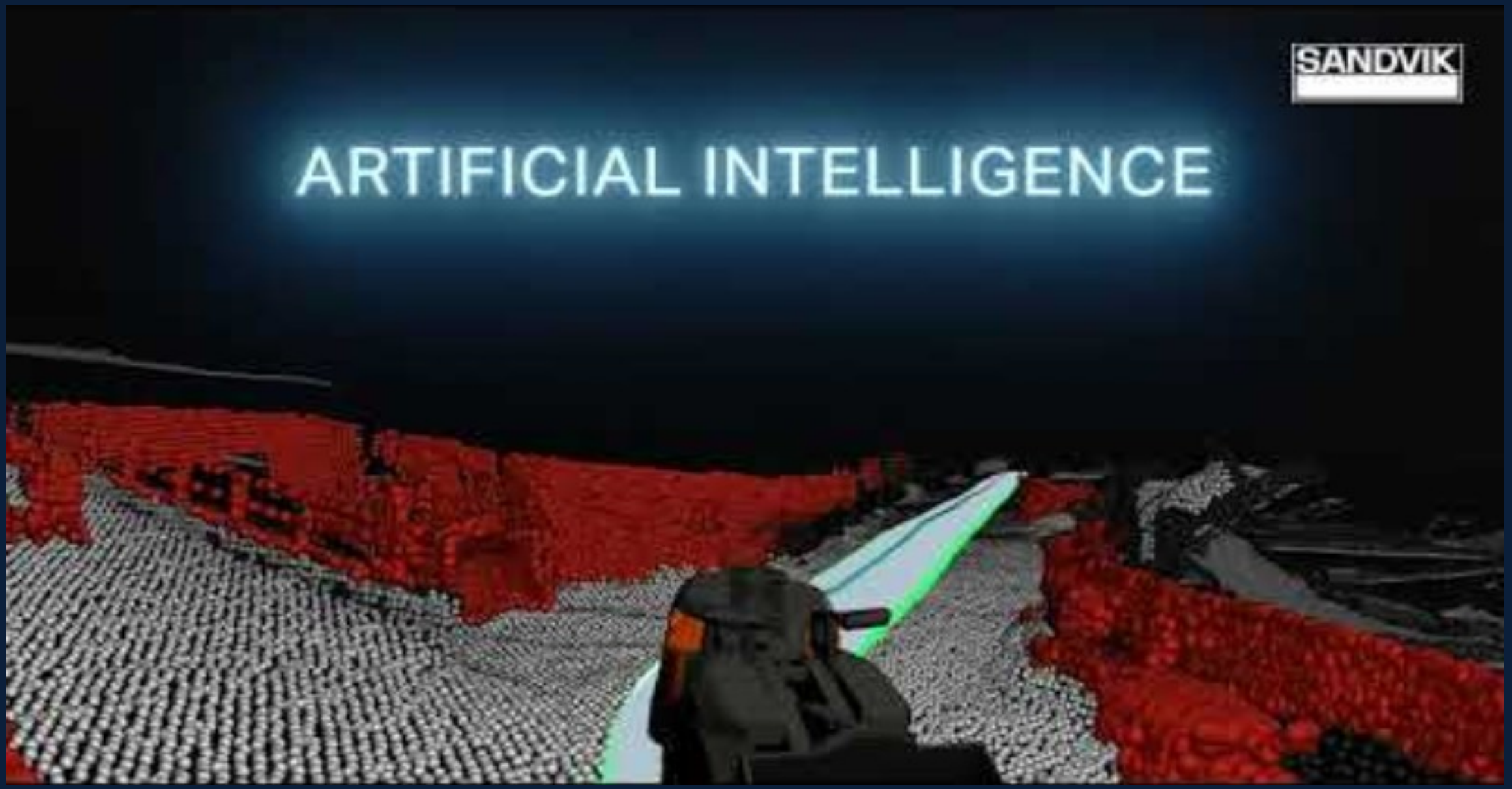
Remote control of up to 3 rigs from one station

Machine Fleet

Traffic management + safety gates across loaders & trucks

Image: © Sandvik

Source: Sandvik [7]



Video: © Sandvik, youtube.com/watch?v=N4b8kD8Ej_c



Video: © its owner, youtube.com/watch?v=6Nw7q0t2A9o

MOMENTUM

This is already industrial infrastructure



~3,800

Autonomous haul trucks in operation worldwide (July 2025) — about 55% in China



3x

Caterpillar's target: from 690 autonomous trucks (2024) to 2,000+ by 2030



20%

Productivity gain from Sandvik's ORB autonomous dispatch optimization

Mining's autonomous fleets already outnumber the combined robotaxi fleets of Waymo and Tesla — this shift happened quietly, years ahead of the public conversation.

Sources: Mining Technology [6]; Caterpillar [5]; Sandvik [7]

THE GAPS

What's still missing



OEM lock-in

Most systems are vendor-locked (Komatsu trucks + Komatsu control) — mine-wide safety needs cross-vendor interoperability



Humans still on site

Maintenance, inspection and light-vehicle staff remain exposed inside and around automated zones



The artisanal gap

Small-scale and artisanal mining — where much global fatality risk concentrates — has no automation at all



Capital intensity

Full retrofits remain expensive, slowing adoption at smaller or older operations

LOOKING AHEAD

Where this is heading

Multi-machine coordination

Loaders, trucks and drills sharing one autonomous traffic system, not isolated automations

Richer perception

3D perception platforms like AutoMine Aura pushing toward genuinely zero blind-spot awareness

Predictive, not reactive

Sensor fusion feeding failure-prediction, catching hazards before they become incidents

Mine-to-mill autonomy

Dispatch optimization (Sandvik's ORB) linking automation to full production planning

SOURCES

References & credits

[1] MSHA fatality data as reported in: Safety+Health, "MSHA: Miner deaths decrease overall, but machinery-related fatalities up" (10 Feb 2023); Safety+Health, "MSHA optimistic about ‘downward trend’ of fatalities, silica rule development" (20 Mar 2024); K. Yanik, Pit & Quarry, "MSHA: Industry finishes 2025 with 33 miner fatalities" (5 Jan 2026).

[2] Global Mining Review, "ICMM reports 2024 safety performance of members" (Jul 2025).

[3] NIOSH, Haul Truck Research Roadmap Report 2020 (CDC/NIOSH, 2020).

[4] Komatsu: "FrontRunner Autonomous Haulage System sets new record" (15 Nov 2018); "Komatsu achieves major autonomous milestones" (30 Jul 2024); "Komatsu becomes first OEM to commission 1,000 ultra-class autonomous haul trucks" (21 Apr 2026); Autonomous Haulage System product page. F. Raczon, Construction Equipment, "Autonomous mining trucks approach milestone" (8 Oct 2018).

[5] International Mining, "Caterpillar sets out to hit over 2,000 autonomous mining trucks by 2030" (7 Nov 2025).

[6] GlobalData, "China emerges as global leader in autonomous surface mining trucks", Mining Technology (8 Aug 2025).

[7] Sandvik: "Sandvik launches AutoMine® Aura, a first-of-its-kind automation platform for the future of mining" (26 May 2026); "Autonomous mass mining" web page (AutoMine Access Control System; ORB by Polymathian).

[8] ISO 17757:2019 Earth-moving machinery and mining — Autonomous and semi-autonomous machine system safety; ISO 21815-1:2022 Earth-moving machinery — Collision warning and avoidance — Part 1: General requirements; IEC 61508 Functional safety of E/E/PE safety-related systems; ISO 26262 Road vehicles — Functional safety.

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Thank you

Questions & discussion

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