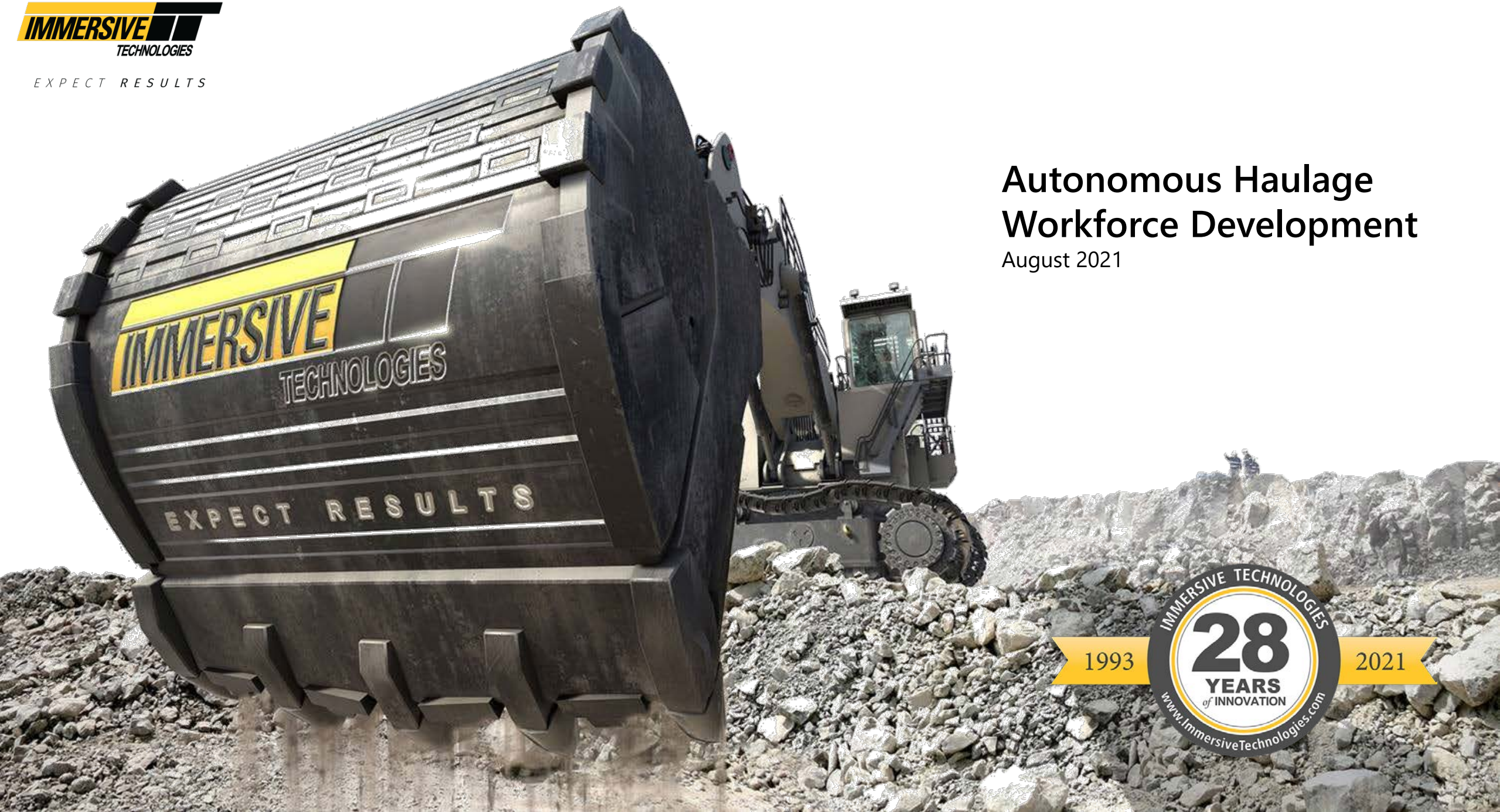
IMMERSIVE TECHNOLOGIES

EXPECT RESULTS

Autonomous Haulage Workforce Development

August 2021



Workforce Development Challenges

For Autonomous Haulage Operations

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How to reduce safety[1][2][3][4] risks and impact to production?

Safety/Production Impact due to:

- In-field Training (safety risk, low asset productivity, reduced performance)
- Human errors
- Large operator variability.

Do we have an effective workforce development strategy to properly upskill?

Ineffective training lowers learning retention leading to reduced competency levels.

- Combined with a new type of role criticality being introduced into the operation, risks to safety and particularly productivity are far more significant than in a non-autonomous operation

How to train a large no. of people in a short period of time?

Inability to train a large number of people effectively in a short period of time.

How to measure and assess skills consistently?

Inconsistent assessment of people to determine permit-to-work create large operator variability.

[1] https://www.amsj.com.au/haul-truck-runs-over-light-vehicle/
[2] https://www.amsj.com.au/autonomous-truck-incident-fmg-how-vulnerable-is-the-wireless-mesh-network/
[3] https://www.dmp.wa.gov.au/Documents/Safety/MS_SIR_226_Collision_between_an_autonomous_haul_truck_and_manned_water_cart.pdf
[4] http://www.mining.com/bhp-blames-heavy-rains-autonomous-trucks-crash/

Workforce Performance Management

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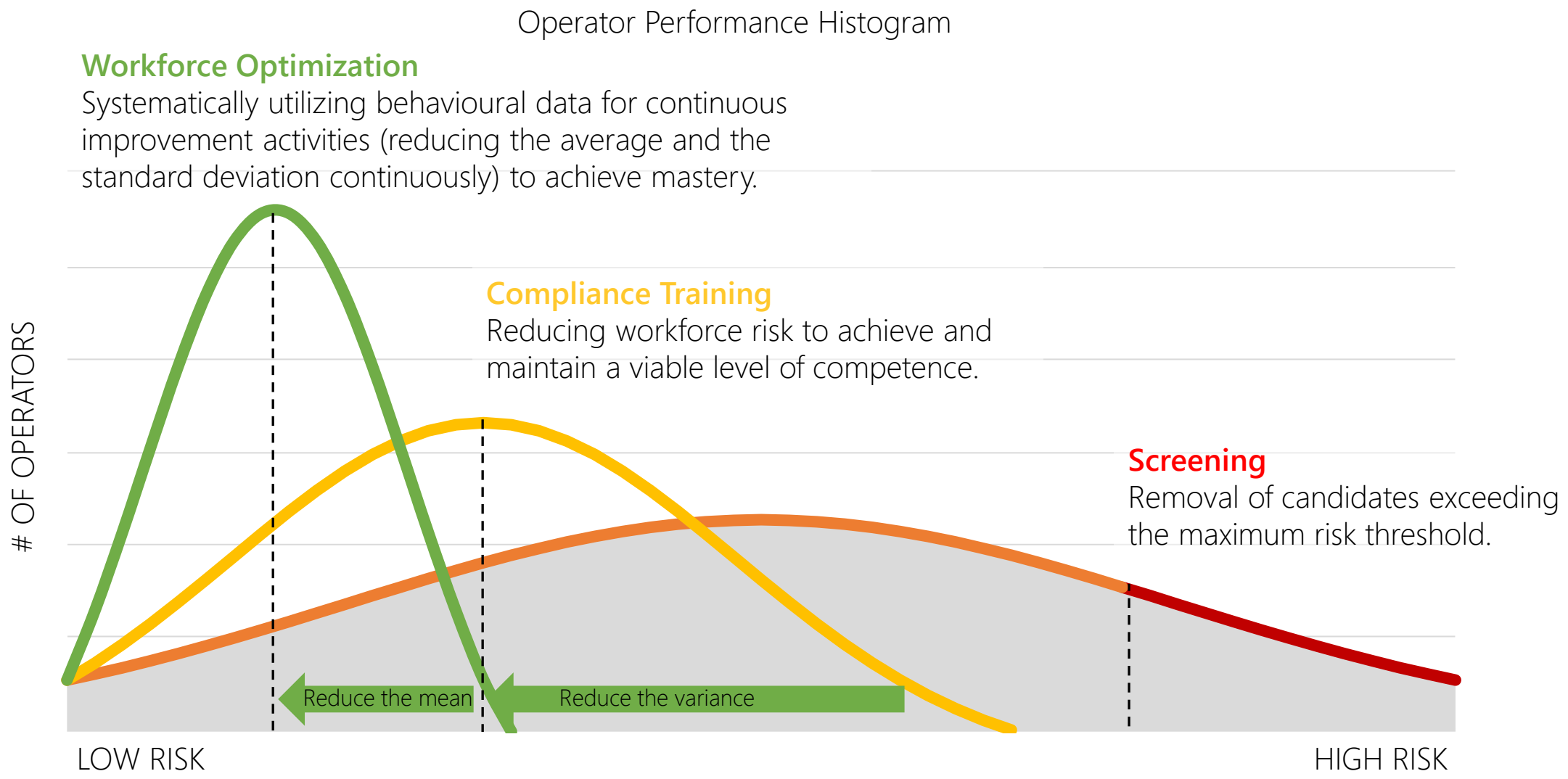
Methodology Behind Simulation



Variability Example

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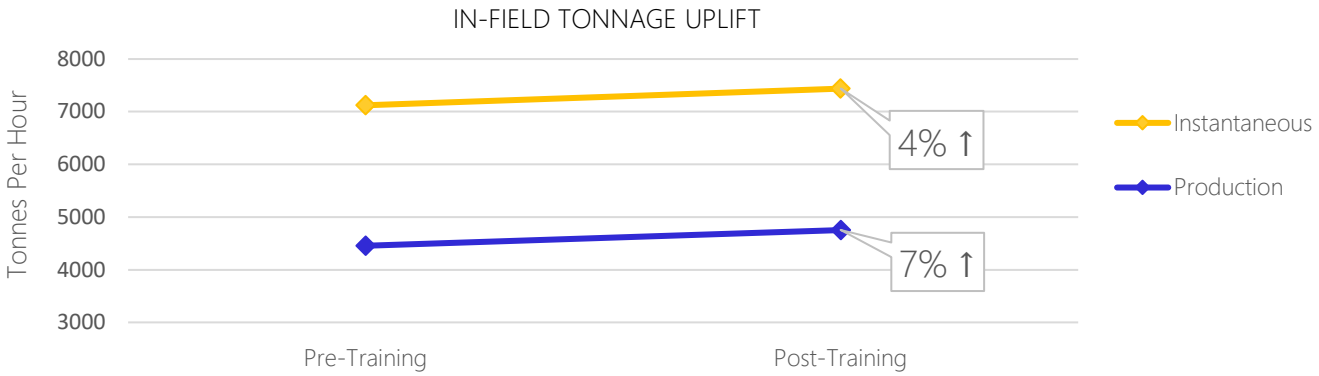
CAT Command

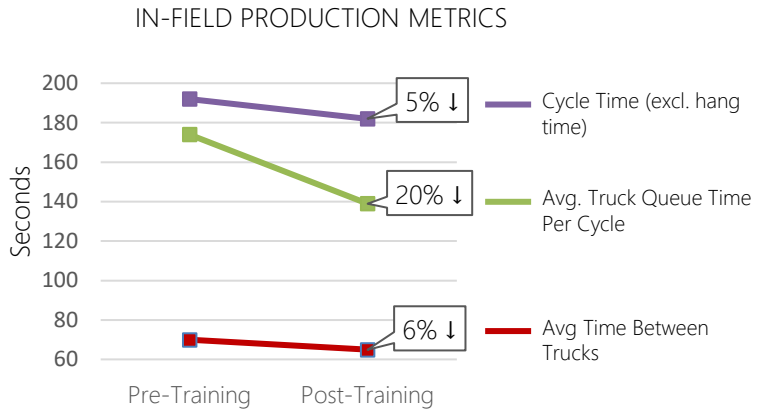
Background:

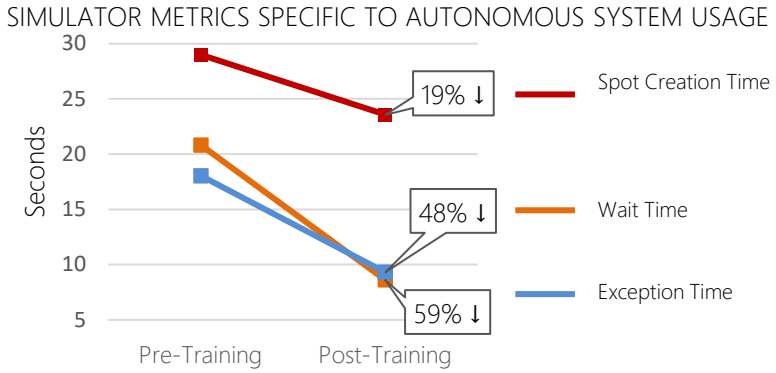
After exhausting engineering controls to uplift production, addressing experienced operator variance became a priority on the basis of low implementation cost versus high production payback. The project business case included improvements in truck availability, clean-up time, managing difficult conditions, including the handling of various types of material which directly impact operator Production outcomes.

Context:

Analysis of operator production data revealed variance between upper and lower quartile performers, impacted by unproductive usage of an in-cab autonomous system, resulting in lower than required production rates.

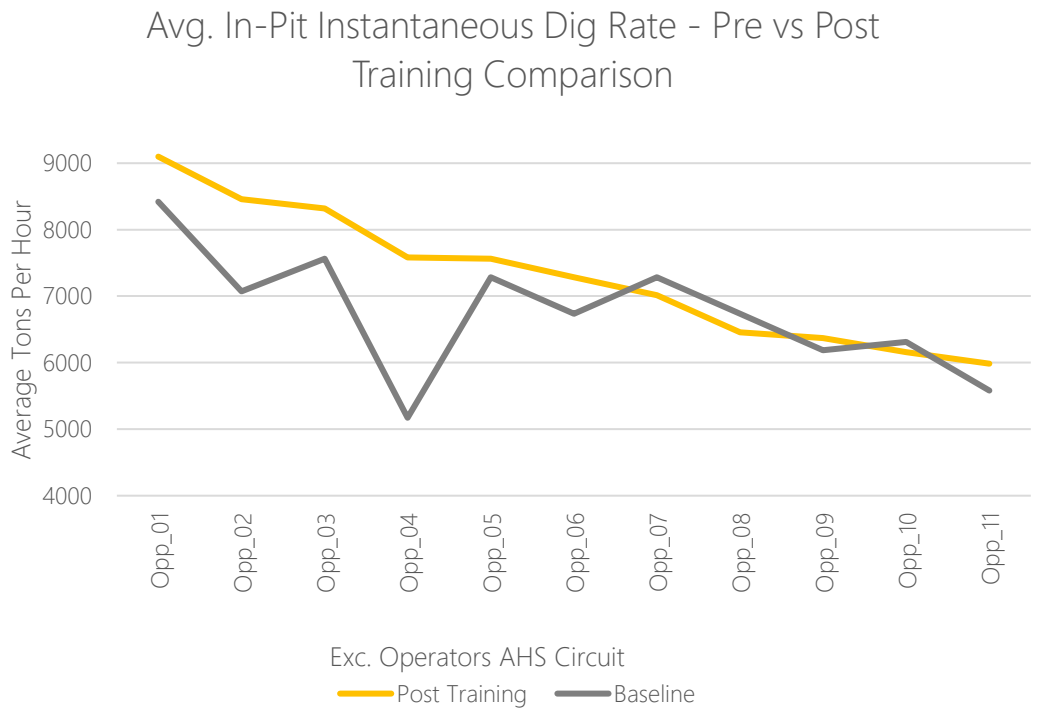




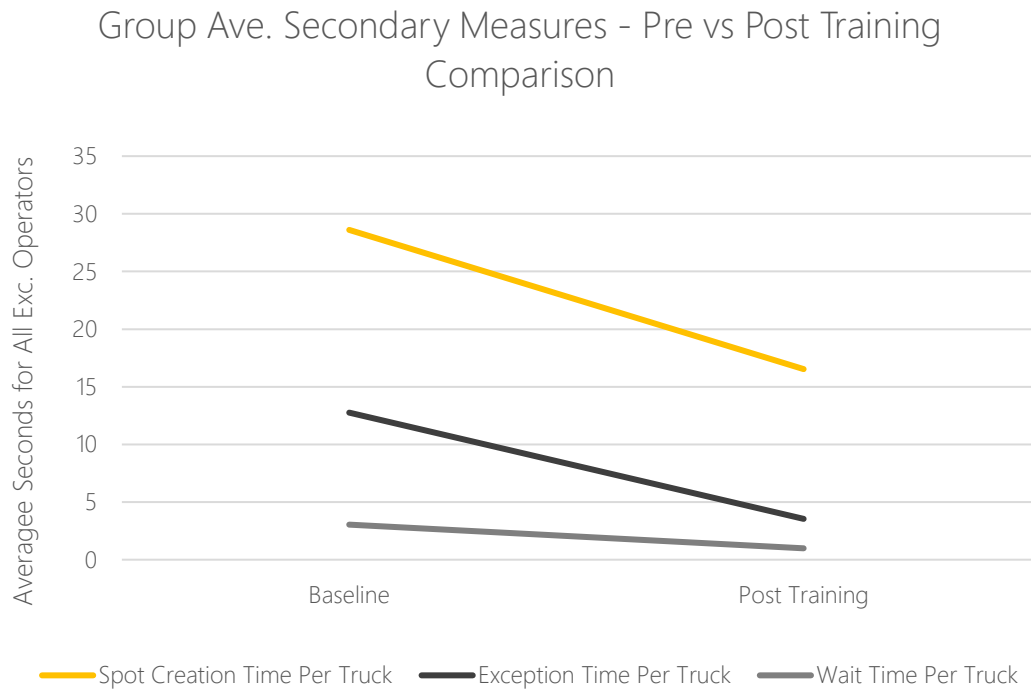


Variability Example

Komatsu FrontRunner



In-Pit Metrics	Pre-Training (avg.)	Post-Training (avg.)	Improvement (avg.)	Improvement (%)
Inst. Dig Rate (T/Hr)	6,737	7,285	548	8%



Simulator AHS Metrics	Baseline (Avg. Sec.)	Retention (Avg. Sec.)	Improvement (Avg. Sec.)	Improvement (%)
AHS Spot Creation Time Per Truck	28.6	16.53	12.07	42%
AHS Wait Time Per Truck	3.02	0.97	2.05	68%
AHS Exception Time Per Truck	12.75	3.52	9.23	72%

Manned vs Autonomous Operation

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What are the workforce development differences?

- The difference is in the shift away from primary truck workforce development and towards dig unit and ancillary machines, where the way those machines are operated have a far greater impact on the effectiveness of the autonomous machines in operation.
- Due to this increase in risk, we are seeing a more considered approach to workforce development where learning pathways from candidate screening right through to skills optimisation are being deployed in autonomous operations globally.

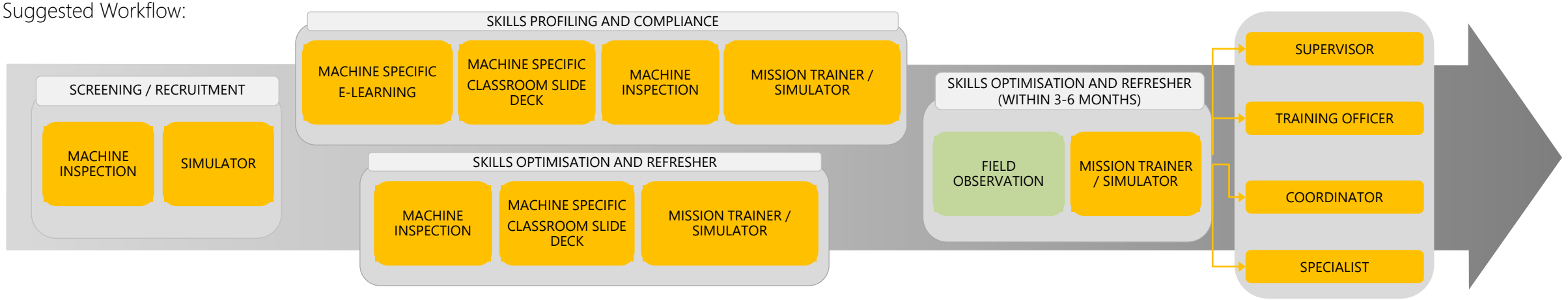
System "Mission" Trainer

Machine Inspection

System Panel Integration

System Specific eLearning

Suggested Workflow:



Skill differences in Loading operations

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Additional tasks performed by loader operators within Autonomous haulage operations

- Setting optimal Spot Points for Autonomous Trucks.
- Ensure efficient interchange of Autonomous Trucks by calling and sending Autonomous Trucks in a timely manner.
- Ensuring optimal cusps/switchbacks are set for Autonomous Trucks when reversing to the Spot point.
- Ensuring load area surveys remain accurate for Autonomous Trucks to get to the spot point in an optimal manner.
- Cleaning up spillages in the load area in an effective manner without stopping Autonomous Trucks.
- Emergency Stop procedures to stop Autonomous Trucks around the loading area.
- General Safety and Site-specific safety protocols within autonomous areas.

Learning Pathway

Blended Learning Model

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Knowledge retention increases.

eLearning

Develop a base of the autonomous system knowledge and vocabulary including 'what' and the 'why'.

Classroom

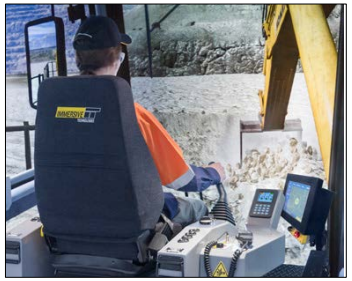
A SME covers focused information, answering learner's specific questions and allowing discussion and collaboration to enhance the learning experience.

Machine Inspection

Allows the detailed visualization of equipment components including AHS components without the need for taking a machine out of production.

Virtual Classroom

Build procedural memory through learning by doing to understand the 'how'. This utilizes interactive desktop simulations allowing personnel to perform autonomous operational tasks.



Simulation

Advanced simulation provides the ultimate learning experience to practice and hone their skills where key automatous operational aspects are rehearsed and assessed prior to any interaction with the live autonomous system.

In-Field*

A SME provides direct, hands-on coaching and validation in the field. This is the final step of performing an in-field assessment which confirms personnel are ready to commence their tasks in a live operating environment.

Learning Systems

Machine & Virtual Classroom

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Machine Inspection

NOTE: Particularly important in AHS applications for checking sensor function.

Virtual Classroom

Simulators

Emulated version of the OEM Panel integrated to simulators.

Key Training Objectives for Loader Operators

- Setting optimal Spot Points for Autonomous Trucks.
- Ensure efficient interchange of Autonomous Trucks by calling and sending Autonomous Trucks in a timely manner.
- Ensuring optimal cusps/switchbacks are set for Autonomous Trucks when reversing to th Spot point.
- Ensuring load area surveys remain accurate for Autonomous Trucks to get to the spot point optimally.
- Monitoring Autonomous truck payload
- Cleaning up spillages in the load area in an effective manner without stopping Autonomous Trucks.
- Emergency Stop procedures to stop Autonomous Trucks around the loading area.
- General Safety and Site-specific safety protocols within autonomous areas.

Key Training Objectives for Ancillary Vehicle Operators

- Entering/Exiting Autonomous area.
- General Safety and Site-specific safety protocols within autonomous areas.
- Driving Rules and Radio protocols within the autonomous environment.

Results Need More Than Technology!

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The Pitfalls Of Incomplete Solutions

Without the **Right Technology**, processes and people are less effective and less efficient

Without the **Right People**:

- No critical skills to perform activities
- No stakeholders to set the strategy
- No champions to manage the process
- No specialists to execute the plan

Without the **Right Process** there is:

- No guidance for streamlining and validating training needs
- No consistency in training application
- No standardization of communication or validity of continuous improvement

Global Autonomous Haulage Operations

What is Immersive's expertise in this area – sites with simulator integration

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KOMATSU CATERPILLAR

OEM yet to be decided
Simulator Add-on Panel

Komatsu AHS Site in North America
- Simulator Panel Add-on for multiple machines

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- Simulator Panel Add-on for multiple machines

Komatsu AHS Site in North America
- Simulator Panel Add-on for multiple machines

Cat Command for Hauling Site in South America
- Simulator Panel Add-on for multiple machines

Komatsu AHS Site in South America
- Simulator Panel Add-on for multiple machines
- Virtual Classroom

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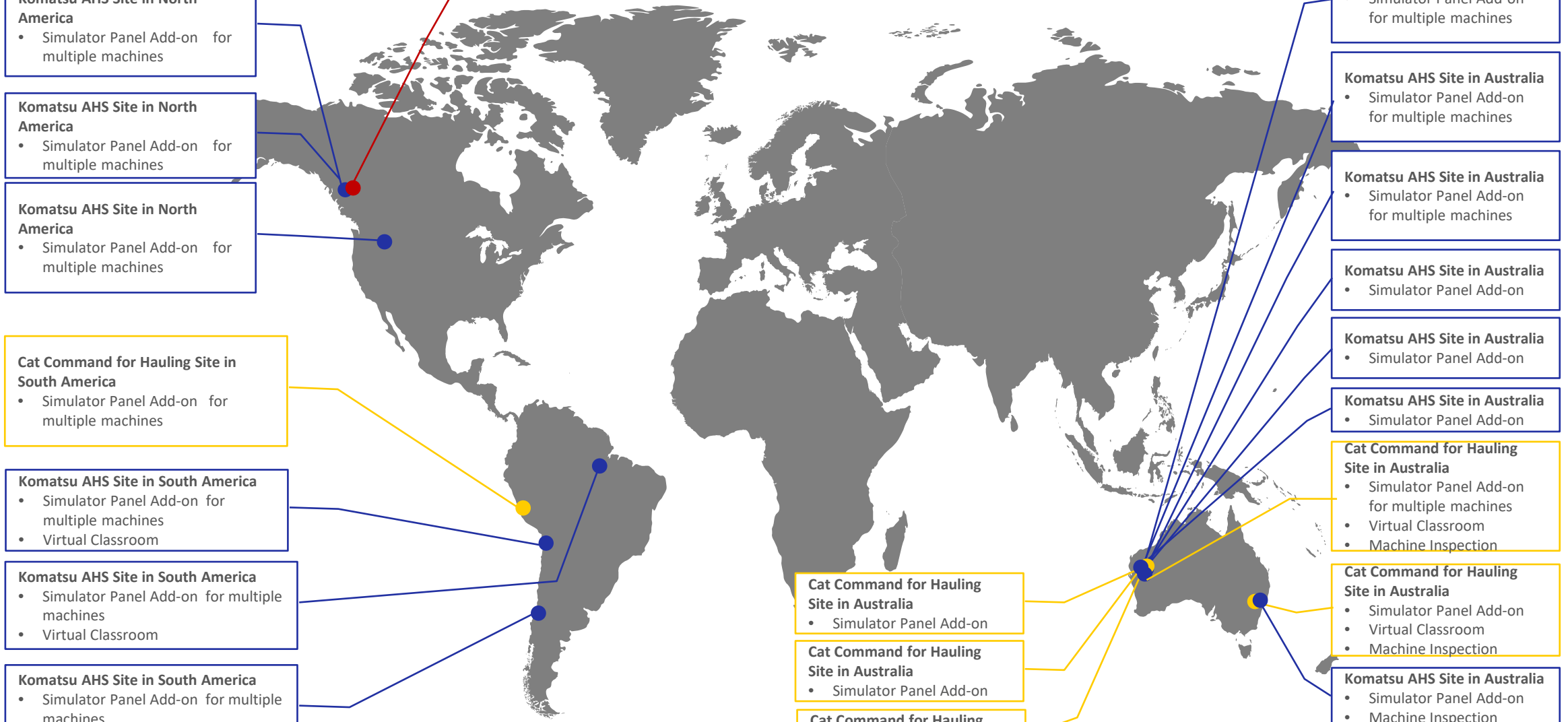

Cat Command for Hauling Site in Australia
- Simulator Panel Add-on

Cat Command for Hauling Site in Australia
- Simulator Panel Add-on

Cat Command for Hauling Site in Australia
- Simulator Panel Add-on

Komatsu AHS Site in Australia
- Simulator Panel Add-on for multiple machines

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- Simulator Panel Add-on for multiple machines
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Komatsu AHS Site in Australia
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28 Years of Global Leadership

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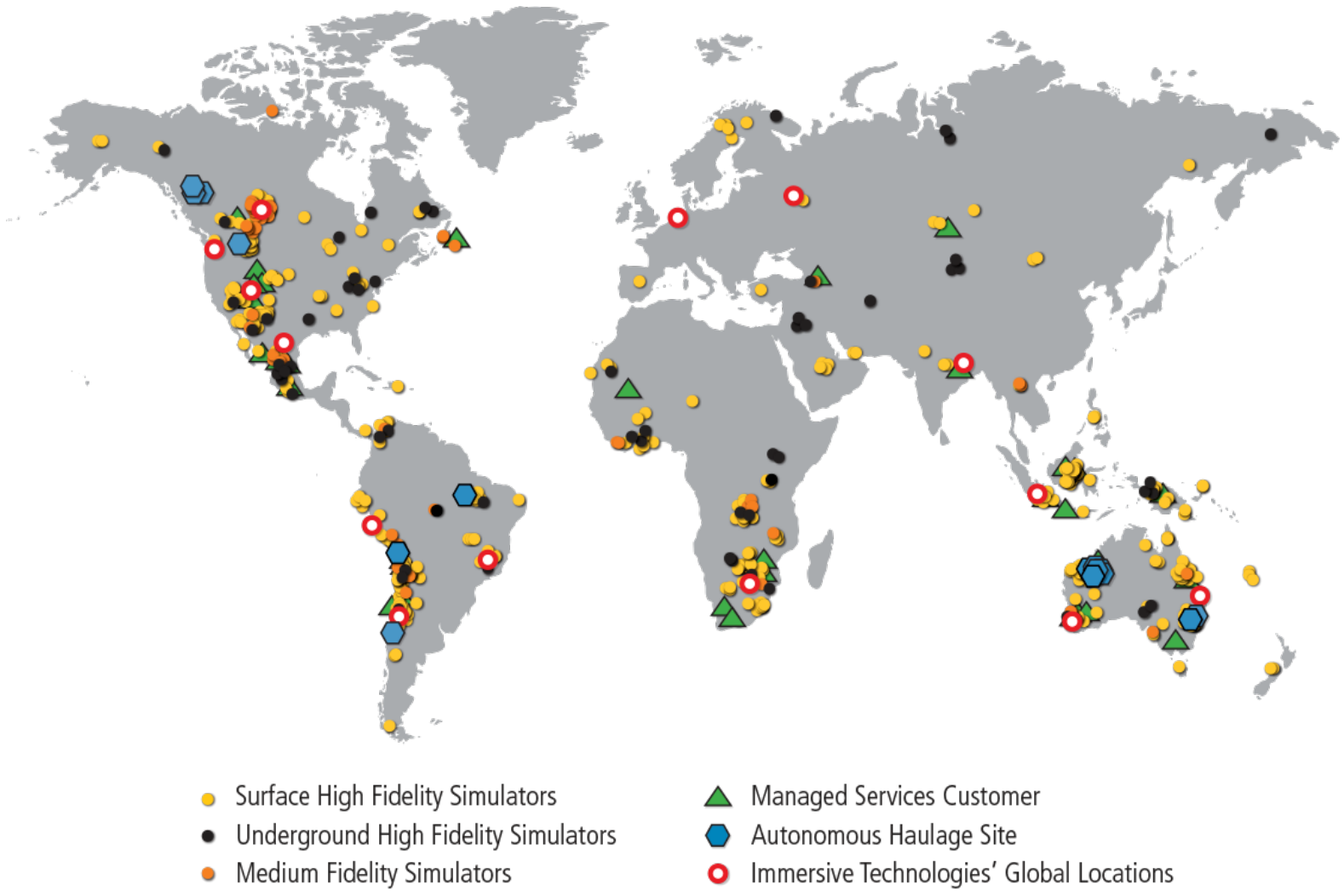

76%
of Global Mining Simulator Sales are Immersive

19
Autonomous Haulage Mining Deployments

320+
Global Mining Companies

150,000+
Mining Equipment Operators Trained

45
Countries with Deployed Simulators

1190+
Mining Equipment Simulator Modules Deployed

Highest Levels of Repeat Business