Risk Mentor

Gold Fields
Tarkwa Mine

Executive Summary and Key Findings

Vehicle Interaction Control Effectiveness

Performance Review with Baseline

Version 1.1

Limited Distribution | For Client Comment

Acknowledgements

Thank you to Mr Daniel Korsah and Mrs Abigail Kuffour who coordinated the Tarkwa Mine site activities and inputs for this Vehicle Interaction Control Effectiveness Review at Tarkwa Mine.

The authors also acknowledge the capability, commitment, and contributions of the Tarkwa personnel representing maintenance, site operations, senior management, business partners, and support functions.

This executive summary and key findings report, supporting appendices, and digital knowledge and performance reporting platform, are built from their experience, insights, and understanding of the current effectiveness of vehicle interaction controls at Tarkwa Mine.

Over the last eight years, in collaboration with the ICMM, EMESRT and multiple resource industry clients, Risk Mentor has developed the content and processes used globally to undertake Vehicle Interaction Control Effectiveness (VICE) performance reviews.

This Tarkwa Mine review is supported by Risk Mentor proprietary software and Risk Mentor Version 3 Reference Content, released in June 2024.

Executive Summary

Tarkwa Mine: A Strong Operation with Opportunities for Improvement

Tarkwa Mine is a well-managed, productive operation with robust practices that align with industry standards. The VICE Baseline confirms that site processes are well-documented, implemented effectively, and generally reliable.

Key Findings: 71 Opportunities for Improvement (OFIs). Despite its strong foundation, the review identified 71 OFIs, highlighting:

- **Gaps Between Intent and Practice**: Discrepancies between documented procedures ("work as documented") and real-world execution ("work as done").
- **Commitment to Excellence**: Many OFIs build on current practices, reflecting the dedication of participants to drive continuous improvement.

Focus Areas for Improvement

A structured, iterative approach is needed to address OFIs, emphasizing relevance, practicality, and value-add Key focus areas include:

- **Road Design and Maintenance**: Review intersection standards and haul road construction/maintenance protocols.
- **Communication Practices**: Enhance positive communication protocols for vehicle interactions.
- **Operational Consistency**: Address equipment selection, planning, and system design gaps.

Challenges at Tarkwa

Tarkwa's incident patterns and OFIs differ from similar mines, potentially due to its integrated contractor model and underreporting of non-equipment damage incidents.

Next Steps

Senior management should appoint review teams to review the opportunities for improvement summarised in Section 2 of this report with full details available on the Tarkwa Mine Knowledge and Performance Platform.

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Incident Analysis - Key Observations

Risk Mentor analysts reviewed three years of incident data as part of preparing for the baseline workshop in November 2024.

1. **Incident Reporting Volume**:
   - A total of **133 incident reports** were provided, which is significantly lower than the typical **2,000+ reports** observed at mines of a similar size.
   - This suggests potential **under-reporting** of incidents at the site.

2. **Required Operating State (ROS):**
   - **ROS 01 - Vehicle Operators Maintain Adequate Clearance** constitutes a **notably larger proportion** of total incidents compared to other sites.
   - The higher proportion reflects the **prevalence of equipment damage** in the reported incidents also suggest underreporting of non-equipment damage vehicle interaction incidents.

3. **Credible Failure Modes:**
   - Incidents linked to **failed equipment components** represent a **higher fraction** of the total incidents than observed at similar sites.
   - **Mistakes in estimating clearance** account for **33% of incidents**, which is approximately **50% higher** than the industry norm of 20%.

4. **Consistency with Industry Patterns:**
   - The analysis confirmed that **no unique failure modes** were identified at Tarkwa Gold Mine.
   - This finding, along with feedback from workshop attendees, validates that the **control framework model** is applicable for the site.

Additional Information: The **detailed analysis**, including summary graphics and underlying data, is accessible via the [report portal](#). A direct link to the [summary page](#) has been provided for ease of reference.
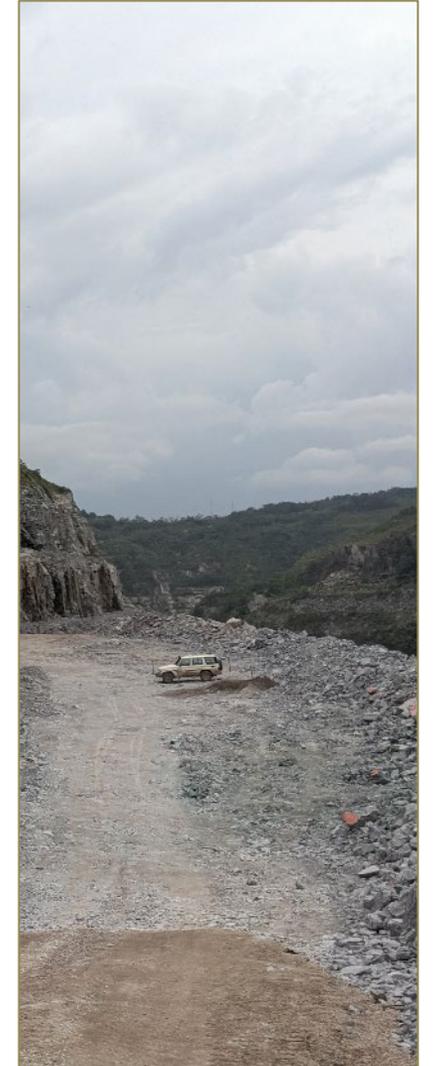
Section 2

Tarkwa Mine VICE Performance Baseline Review Summary Findings

Opportunities for Performance Improvement

Based on:

- The opportunities for improvement and key themes identified by Tarkwa Mine personnel

- The site vehicle interaction incident experience

- The gaps between site documentation and operational practice

- Preparing functional requirements for the next generation of CAS and OAS Technology

Risk Mentor recommends an initial focus on performance improvement opportunities for:

- **Operating Environment,** and

- **Workgroup Interactions**

The Risk Mentor VICE Baseline organizes opportunities to improvement Vehicle Interaction Control Performance across these five categories:

- Personnel

- Equipment

- Operating Environment

- Workgroup Interactions

- System Optimisation.

3. Operating Environment VICE Review Key Findings

The operating environment for mobile equipment is satisfactory; hazards are identified and managed.

This group of Business Inputs focuses on the operational management of mobile equipment covering:

- Standards, rules, and expectations for operating environment design and construction

- Work environment maintenance details covering- gradients, sheeting, drainage, lighting, signage, barriers, segregation etc.

- Work processes for managing changes in operating conditions.

A. **Road and Intersection Design, Construction, and Maintenance**
  - Review site standards and practices for intersection, haul road, and ramp design, construction, handover, maintenance, inspection, and repair. Include:
    – Signage, lighting, and delineators
    – Vegetation control

B. **Parking Infrastructure**
  - Review parking area design, construction, and maintenance, consider options to reduce congestion beside light vehicle parks

C. **Management of Operating Environment Hazards**
  - Develop an assessment for in-pit lighting

D. **Changes in Conditions**
  - Review how changed operating conditions are reported and communicated,
  - Review and update site trigger action response plans TARPs coordinate across Business Partners e.g. for electrical storms and ceasing operations processes

E. **Other Operating Environment Opportunities**
  - Processes for communicating speed limits and monitoring performance

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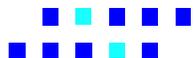
4. Workgroup Interactions VICE Review Key Findings

Mobile Equipment interfaces with pedestrians and other vehicles are well managed.

This group of business inputs focuses on managing interactions with mobile equipment and covers:

- Pedestrians and mobile equipment interaction
- Mobile equipment unit to unit
- Road design including parking and quarantine areas
- Standards, rules and expectations for safe and productive mobile equipment operations between work groups all situations.
  - Protocols for maintenance and service support in operational areas
  - Protocols for service support in operational areas e.g. refuelling

A. **Planning, Schedule and Shift-to-Shift Briefings**
- Review short-term operational planning processes to reduce congestion e.g. between drill and blast and load and haul.

B. **Operational Practice**
- Review site processes for breakdowns, maintenance, and servicing work in operational areas clearance to enter, area delineation, approaching parked heavy vehicles, etc.
- Review site escort and towing processes
- Review processes for managing non-standard loads.
- Review processes for managing access e.g. availability of signs
- Confirm site minimum standards for positive communications including requirements for radios, managing pedestrians, and performance monitoring.
- Review light vehicle access permissions
- Review site refueling practices – location, communication, and spotters

C. **Access Control and Exclusion Zones**
- Review management of pedestrians in operating areas e.g. for excavator access
- Review protocols

D. **Vehicle Interaction Monitoring**
- Develop the use case to leverage installed and planned updates to CAS technology to advise on detected object type e.g. pedestrian, light vehicle, ancillary etc.
- Explore options to leverage data e.g. operational logs of vehicle approaches, heat maps, vehicle category and location etc.

E. **Other Workgroup Interaction Opportunities**
- Link workshop outcomes to CAS and OAS technology projects

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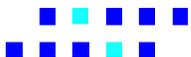
1. Personnel VICE Review Key Findings

Operators and all people working around mobile equipment are trained, competent, authorised, informed, alert, and situationally aware.

These business inputs focus on ensuring:

- Operators in control of mobile equipment are trained, competent, authorised, and situationally aware

- People who routinely work around mobile equipment are trained, competent, authorised, alert, informed and situationally aware

- People who are visitors to mobile equipment locations are authorised, supervised, alert and situationally aware

- Mobile equipment operational requirements (task assignments) are effectively communicated by supervisors to the workforce

- Mobile equipment operations are monitored and adjusted to remain safe and productive e.g. credible failure modes that can compromise alertness and situational awareness are identified and managed

A. **Selection, Onboarding, Inductions and Training**
  - Consult with all stakeholders to confirm alignment between training content and operational practice e.g. for Positive Communications
  - Consider technology options to improve quality and efficiency of refresher training e.g. OAS and PDS technology equivalents on mobile equipment simulator
  - Review site processes for selecting and retaining experienced maintainers and technicians.

B. **Support Information, Instructions, and Briefings**
  - Adapt visual reference training information to all operators and personnel who work around mobile equipment covering:
    - Role and responsibilities e.g. equipment pre-start checks, defect reporting, positive communication requirements, hazard reporting etc.
    - Equipment features e.g. alerts and alarms, equipment blind spots, tyre hazard management, OEM technology features and defect management
    - Operating environment management e.g. mine speed limits, parking in any situation, managing road works, bunding standards, managing road works etc.
    - Emergency response covering incidents, mobile equipment fires, storms etc.

C. **Fitness for Work**
  - Review Tarkwa shift rosters and processes for assessing cumulative hours
  - Review practical responses for fatigued operators e.g. rest rooms

D. **Performance Management**
  - Workshop close out comment – more active supervisor performance management

E. **Other Personnel Opportunities**
  - Involve mobile equipment operators in preparing functional requirements, project planning and deployment of upgraded OAS and PDS technologies.

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2. Equipment VICE Review Key Findings

Mobile Equipment is fit for use, key systems are functioning.

These business inputs focus on ensuring:

- Fit-for-purpose mobile equipment is selected for use

- Equipment is maintained to be operationally safe and productive

- Support equipment e.g., radio communications is fit-for-purpose and remains in service

- Equipment failures during operations are notified and managed.

A. **Human Systems Integration**
- Confirm that the ergonomic layout of operator displays in vehicle cabins meets the site specifications.

B. **Equipment Selection and Site Use Approval**
- Review site processes for specifying, selecting, and approving mobile equipment for site use.
  - Confirm technology installation standard
  - Equipment identification standards

C. **Maintenance**
- Review effectiveness of maintenance backlog management, consider in field inspections to prepare for scheduled maintenance
- Review maintenance planning and the effective use of maintenance windows

D. **Operator Checks and Defect Management**
- Review mobile equipment prestart checks defect classifications including non-OEM technologies.
- Confirm response process for alerts and alarms
- Review radio check processes

E. **Other Equipment Opportunities**
- Review equipment standards for headlights – new LEDs shadow reports
- Review frequency of mobile equipment alarm checks
- Leverage mobile equipment performance information
- Communications infrastructure and network reliability

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5. System Level Optimisation VICE Review Key Findings

Vehicle interaction management is well coordinated, practical and integrated with routine operational and business processes.

This group of Business Inputs includes the system-level business inputs necessary for ongoing safe and productive use of mobile equipment. These focus on having a whole of system overview of activities and when necessary, making modifications. This includes:

This group of business inputs supports operating sites so that:

- Operators in control of mobile equipment are trained, competent, authorised, informed alert and situationally aware
- People who routinely work around mobile equipment are trained, competent, authorised, alert and situationally aware
- Work environments are designed to be as error free as is practical
- Ensuring that mobile equipment interactions are routinely reviewed during production planning and scheduling
- Mobile equipment operations are monitored and adjusted to remain safe and productive
- Operations are monitored; adjusted to remain safe and productive

A. **Leadership Intent and Accountability**
- Review, update, and apply the Tarkwa Traffic Management Plan
- Improve the understanding and application of site mining standards and procedures e.g. for Road Construction and Maintenance

B. **Engagement and Consultation**
- Improve change management consultation and communication e.g. on Traffic Management plan requirements, and selection of new equipment for use on site

C. **Supporting Systems**
- Review site emergency capability, manning, equipment, training, periodic exercises etc.
- Review the effectiveness of change management processes for new equipment
- Review incident management processes – communicating learnings
- Review and align mining operations inspections and task observation processes.

D. **Governance and Assurance**
- Confirm that experienced senior managers have oversight of site Traffic Management Plans

E. **Improvement Planning and Leveraging Technology**
- Confirm and Communicate Plan and Timelines for CAS installation
- Explore if CAS technology, or technology combinations such as CAS and Dispatch can be used to identify different subsets of vehicle interactions
- Apply VICE review outcomes to leverage outcomes from CAS and OAS technology projects e.g. heatmaps, alert discernments etc.

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Next Steps – Reviewing Opportunities for Improvement

Tarkwa Mine leaders review this report and appoint teams to systematically consider the opportunities for improvement in each of the five RM Control Framework categories to confirm their relevance and performance improvement impacts and provide action plan recommendations.

Foundation Concept

All successful vehicle interaction control improvement projects improve task level decision making for personnel operating or working around mobile equipment in two ways (type):

1. By better supporting their **judgement and decision** making e.g., by providing situational awareness technology, and short cycle performance capture, analysis and feedback

2. Through reducing **decision demands** e.g. by lowering the intensity, range, and number of vehicle interactions

As a large and productive open cut mine, this comprehensive performance review confirms that Tarkwa Mine has opportunities to deliver improvements in both categories.

The operational integration of OAS technology is a significant **Type 1** opportunity. Other Category 1 opportunities include aggregating and leveraging existing proximity detection and site data streams and engaging employees to develop processes that:

- Capture, analyse and provide performance feedback to assist decision making at the task level

- Convert task level performance data into information flows that support supervisor decision making, and

- Aggregate, report and analyse information streams to assist with manager and system level decision making

Type 2 improvements begin with a focus on the company systems, standards and process documentation that impact operational workflows for:

- Providing fit-for-purpose equipment

- Managing workgroup interactions

- Identifying and managing operating environment hazards

- Those that are legally required
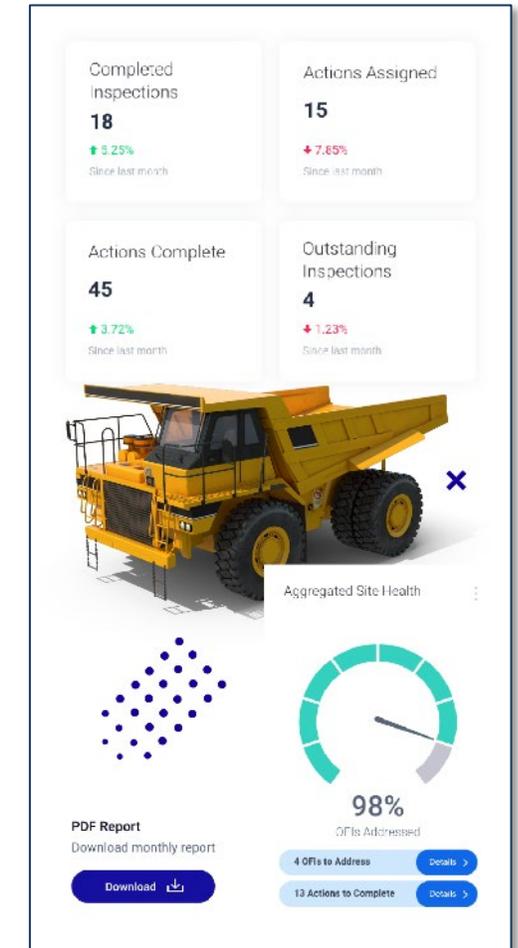
Section 3

Improvement Planning

Gold Fields Mining Multi-Phase Vehicle Interaction Control Improvement Project

A Work Breakdown Structure (WBS) breaks complex projects into smaller components called work packages. This WBS has these component areas:

A. *Manage as a series of interrelated projects over 5 phases (ongoing Project Management)*

B. *Phases 1 and 2 Map and validate your Performance Baseline*

C. *Work with your people to identify existing operational improvements*

D. *Phase 3 - Identify and implement iterative design, operate and technology innovations*

E. *Identify and implement - step change design and technology innovations*

F. *Fit the project into your broader site and company digital strategy. Leverage existing risk and business system investments, develop detailed performance reports, monitor for drift, and provide timely and accurate information that supports good decision making at multiple levels.*

Project Phases

- Phase 1 –Completed
- Phase 2 – In progress

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KEY FINDINGS
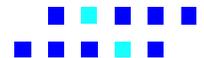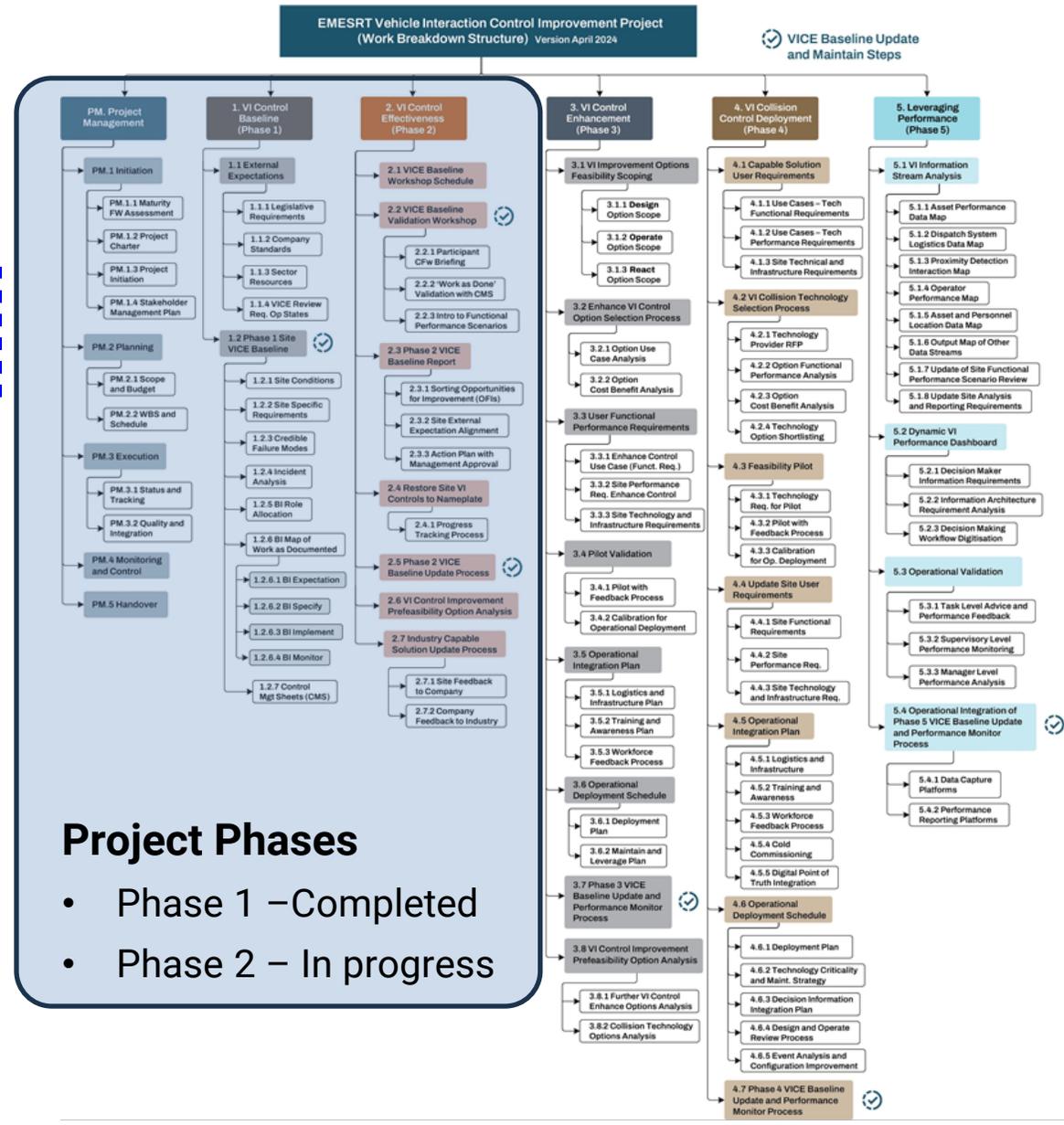
Improvement Planning and Baseline Maintenance

The work to establish a baseline of Tarkwa vehicle interaction controls is a significant investment. Realising its full value begins with teams, nominated by site management, reviewing improvement opportunities for relevance and then preparing plans to address performance gaps and improve and enhance current vehicle interaction controls. It continues with maintaining and updating the baseline:

- As actions to close performance gaps are implemented

- Before, during, and after the reconfiguration, implementation and operational integration of collision avoidance and other technologies.

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OFI Review Process Notes

- Form the Team

- Each group reviews the relevant Appendix C - Opportunities for Improvement from the VICE workshop

- Discuss, confirm and document OFI relevance identifying common themes

- Consider underlying issues – review Potential Return to Name Plate Actions

- List Group agreements covering

- Actions that address the underlying issues

- Other enhancements for site vehicle interaction controls

- Summarise for senior management review

Priority

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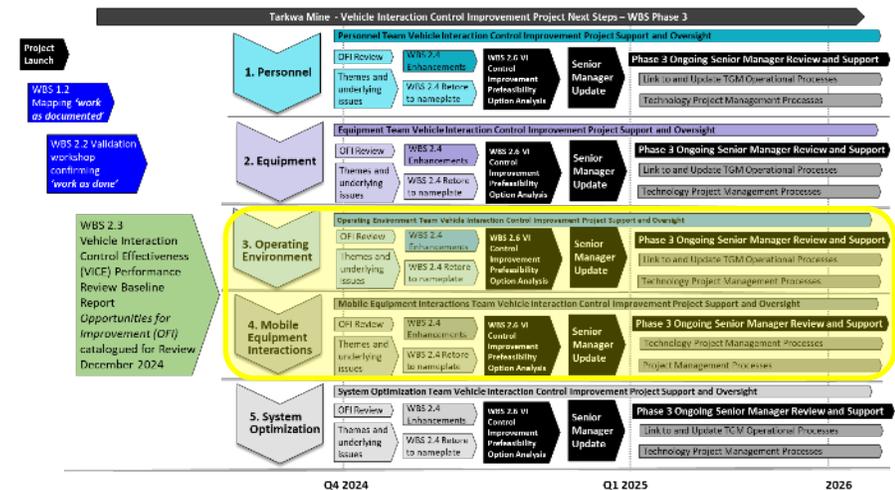
Tarkwa Mine - Vehicle Interaction Control Improvement Project Next Steps – WBS Phase 3

Project Launch

WBS 1.2 Mapping *'work as documented'*

WBS 2.2 Validation workshop confirming *'work as done'*

WBS 2.3 Vehicle Interaction Control Effectiveness (VICE) Performance Review Baseline Report *Opportunities for Improvement (OFI)* catalogued for Review December 2024

1. Personnel

Personnel Team Vehicle Interaction Control Improvement Project Support and Oversight

OFI Review

WBS 2.4 Enhancements

Themes and underlying issues

WBS 2.4 Retore to nameplate

WBS 2.6 VI Control Improvement Prefeasibility Option Analysis

Senior Manager Update

Phase 3 Ongoing Senior Manager Review and Support

Link to and Update TGM Operational Processes

Technology Project Management Processes

2. Equipment

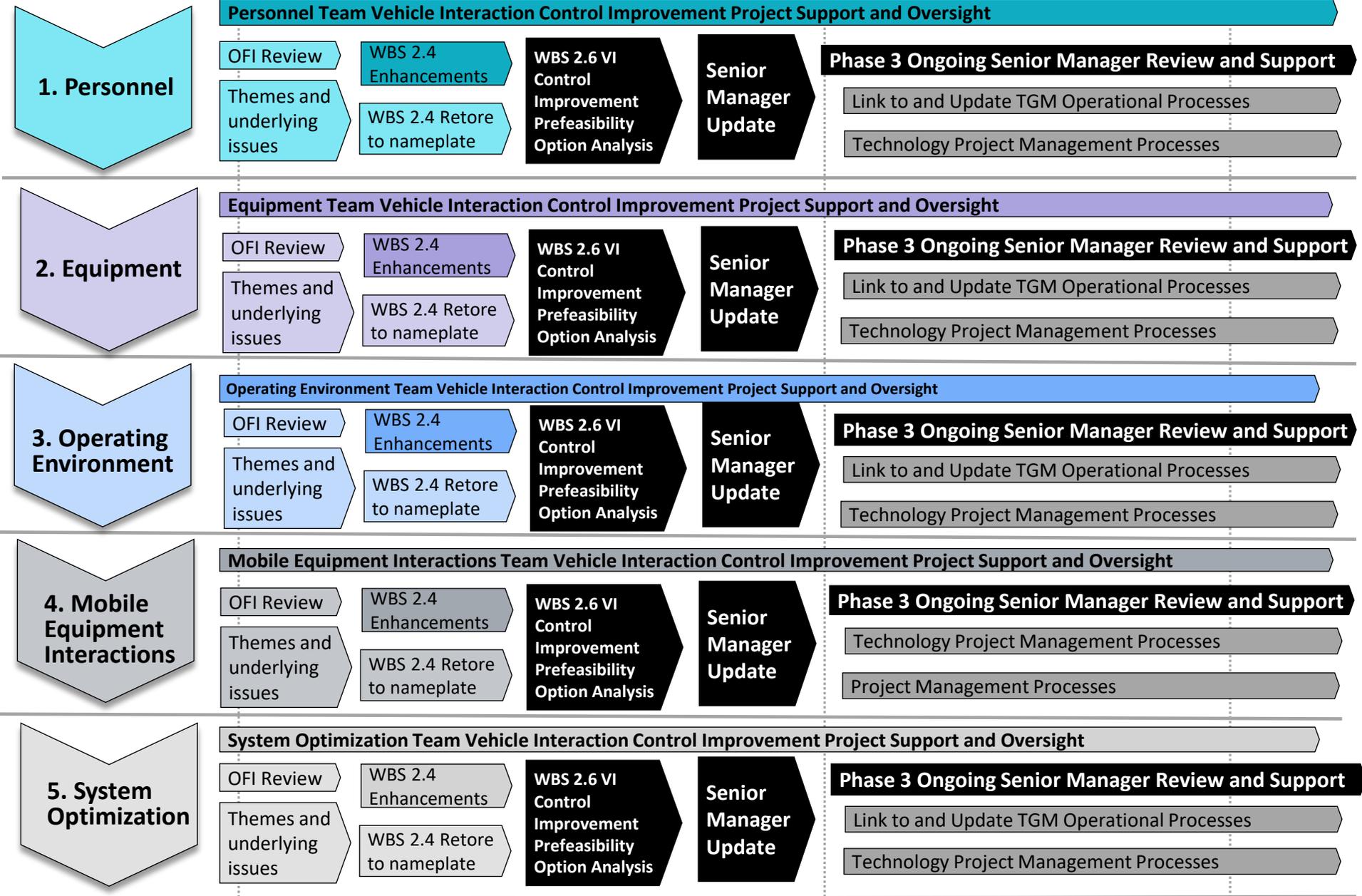**Equipment Team Vehicle Interaction Control Improvement Project Support and Oversight**

OFI Review

WBS 2.4 Enhancements

Themes and underlying issues

WBS 2.4 Retore to nameplate

WBS 2.6 VI Control Improvement Prefeasibility Option Analysis

Senior Manager Update

Phase 3 Ongoing Senior Manager Review and Support

Link to and Update TGM Operational Processes

Technology Project Management Processes

3. Operating Environment

Operating Environment Team Vehicle Interaction Control Improvement Project Support and Oversight

OFI Review

WBS 2.4 Enhancements

Themes and underlying issues

WBS 2.4 Retore to nameplate

WBS 2.6 VI Control Improvement Prefeasibility Option Analysis

Senior Manager Update

Phase 3 Ongoing Senior Manager Review and Support

Link to and Update TGM Operational Processes

Technology Project Management Processes

4. Mobile Equipment Interactions

Mobile Equipment Interactions Team Vehicle Interaction Control Improvement Project Support and Oversight

OFI Review

WBS 2.4 Enhancements

Themes and underlying issues

WBS 2.4 Retore to nameplate

WBS 2.6 VI Control Improvement Prefeasibility Option Analysis

Senior Manager Update

Phase 3 Ongoing Senior Manager Review and Support

Technology Project Management Processes

Project Management Processes

5. System Optimization

System Optimization Team Vehicle Interaction Control Improvement Project Support and Oversight

OFI Review

WBS 2.4 Enhancements

Themes and underlying issues

WBS 2.4 Retore to nameplate

WBS 2.6 VI Control Improvement Prefeasibility Option Analysis

Senior Manager Update

Phase 3 Ongoing Senior Manager Review and Support

Link to and Update TGM Operational Processes

Technology Project Management Processes

Q4 2024   **Q1 2025**   **2026**

First Principles (Types) for Vehicle Interaction Control Improvement Planning

What outcomes will the improvement action deliver at an operational level?

1. Will it better **support the judgement and decision making of the skilled people** operating or working around mobile equipment by:

    a. Establishing task level performance measures

    b. Providing immediate or short cycle feedback on individual task level performance

    c. Aggregating individual performance measures to identify and correct work group level drift

    d. Periodically reviewing aggregated performance measures to confirm that task performance specifications are appropriate, understood, and implemented.

2. Will it **reduce the decision demands** made on skilled people operating or working around mobile equipment by lowering the intensity or number of vehicle interactions (either or both) through:

    a. Workplace design – operating environment layout

    b. Access control

    c. Operational planning and sequencing

Detailed Findings available in separate Appendices and on the Knowledge and Performance Reporting Platform

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APPENDICES

Appendices

Appendix A

Tarkwa Mine Vehicle Interaction Control Effectiveness Performance Baseline

This resource provide full Business Input mapping details with comments, Opportunities for Improvement identified at the workshop, with links to Relevant Requirements.

It is searchable and sortable. Use it as a primary resource for assessing site control effectiveness against industry good practice, improvement planning, and governance outcomes.

Link

Appendix B

Tarkwa Vehicle Interaction Incident Experience

Tarkwa Mine provided a set of 133 incident reports during the preparation phase of the review. This data has been reviewed by Risk Mentor analysts.

Link

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APPENDICES

Downloadable Appendices

Appendix C

Tarkwa Mine Vehicle Interaction Control Effectiveness Performance Baseline

BI Details with OFI and Notes

This resource provide details of Business Inputs with Opportunities for Improvement and Notes.

It provides context for assessing the VICE Performance Baseline Review Opportunities for site relevance, improvement planning, and performance innovations.

Link

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APPENDICES

Knowledge and Performance Management Platform

Tarkwa Mine Vehicle Interaction Control Effectiveness Performance Baseline

Performance Platform

This resource provides dynamic information on the elements gathered during the VICE Baseline work at Tarkwa.

The link on the right takes you to the Dashboard of the platform. This will prompt for a login and from the individual Units there is access to the findings, as well as the Report section which contains links to the dynamic version of this report, the appendices, and the close-out session summary.

Portal

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Executive Summary (Alternative)

Tarkwa Mine leaders, at all levels, are committed to strengthening vehicle interaction controls, especially those that are dependent on operator in-task judgements and where errors can have fatal consequences. In November 2024, site personnel, supported by Risk Mentor, developed a Vehicle Interaction Control Effectiveness (VICE) Baseline to evaluate current performance and identify opportunities for improvement.

As a cornerstone asset for Gold Fields, this initiative at Tarkwa will guide site improvements, including the integration of updated fatigue management and proximity detection technologies. It will also shape the development of company-wide practices and standards to improve vehicle interaction control performance across all operations.

Tarkwa mine is well managed and productive operation and outputs from the VICE Baseline confirm that site operational practices are extensively documented, adequately implemented, align with industry good practice, and are generally reliable. However, the experienced and knowledgeable participants involved in the review still identified **71 opportunities for improvement** (OFI) for management consideration.

Many of these OFI confirm significant disconnects between documented company intent (work as documented) and operational practice (work as done). Others build from the current operational practice and reflect the positive commitment of review participants to work with and assist Tarkwa Mine leaders improve site performance from a sound base. Notably site OFI patterns and site incident experience differ from performance reviews at other similar scale surface mines, and this difference may reflect the integrated contractor model deployed at Tarkwa Mine and an underreporting of non-equipment damage vehicle interaction incidents.

Expected actions at Tarkwa' following management review' include a review of design standards for intersections, haul road and ramp construction and maintenance practices, and the consistent application of positive communication protocols.

Improving an already strong operation requires a structured, iterative approach to test the relevance, practicality, and value of the identified OFIs followed by the development of actionable improvement plans. These are summarized in Section 2 of this summary report and detailed in the Tarkwa Mine Knowledge and Performance Platform.