Root-Cause Analysis Report

MINING: MOBILE EQUIPMENT

September 28, 2018

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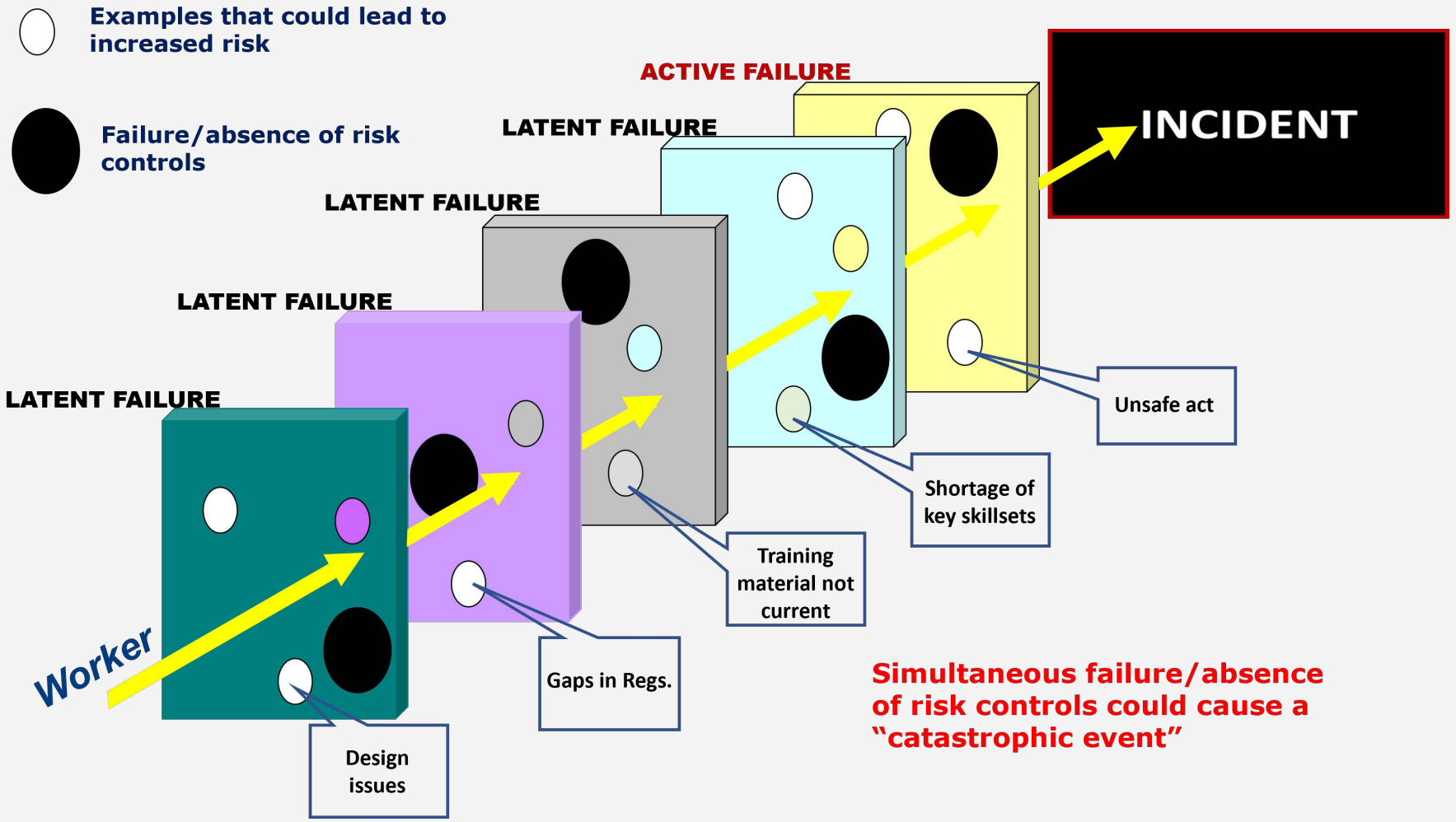
Risk Assessment Project: The Subject Of Inquiry



Simultaneous failure/absence of risk controls could cause a "catastrophic event"

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Revisiting 2014 Risk Assessment Results: Top 10 Risk Events

Risk Rank	Category	Situation or Condition or Factor that could result in Injury or Illness OR What could keep you up at night?	L		C		Risk
			L	sd-L	C	sd-C	
1	Ground control	Rock bursts underground	4.75	0.66	4.50	0.50	21.38
2	Mobile Equipment	Large vehicle and pedestrian or small vehicle interaction is common and lethal	4.38	0.70	4.75	0.43	20.81
3	Ground control	Loose rock at the face continues to kill and injure workers UG	4.25	0.97	4.63	0.48	19.68
4	Ground Control	Existing underground mines in Ontario are becoming deeper and incurring higher extraction ratios. These situations can result in various forms of ground instability	4.50	0.71	4.25	1.09	19.13
5	Ground control	High faces not scaled and secured to protect workers	4.25	0.97	4.50	0.50	19.13
6	Mobile Equipment	The mobile equipment employed in many underground mines is getting bigger. Bigger equipment can often result in poorer operator visibility (i.e. more and larger blind spots). This can result in collisions with other vehicles or contact with pedestrians.	4.25	0.66	4.38	0.48	18.62
7	Occ. Disease	Exposure to hazardous substances(dusts, materials, metals), gases/ fumes, biological materials or forms, Physical Hazards (vibration, noise, heat/cold stress, light.)	4.63	0.70	4.00	0.71	18.52
8	Fatigue	Working Shiftwork resulting in disrupted sleeping patterns	4.63	0.48	4.00	0.87	18.52
9	Ground control	Fall of ground while installing ground support	4.38	0.86	4.13	0.60	18.09
10	Training	Supervisors in some mines in Ontario lack the proper experience and Training. Inexperienced and improperly trained supervisors pose a threat to themselves and their direct-report workers.	4.38	0.70	4.13	1.05	18.09

Revisiting 2014 Risk Assessment Results: Top 10 Risk Categories

#	Category	Situation or Condition or Factor that could result in Injury or Illness OR What could keep you up at night?
1	Ground control	Rock bursts underground
2	Mobile Equipment	Large vehicle and pedestrian or small vehicle interaction is common and lethal
3	Occ. Disease	Exposure to hazardous substances(dusts, materials, metals), gases/ fumes, biological materials or forms, Physical Hazards (vibration, noise, heat/cold stress, light.)
4	Fatigue	Working Shiftwork resulting in disrupted sleeping patterns.
5	Training	Supervisors in some mines in Ontario lack the proper experience and Training. Inexperienced and improperly trained supervisors pose a threat to themselves and their direct-report workers.
6	Ventilation	Little in the way of controls on diesel equipment operating in certain areas. No way for workers to know how much equipment is working in any given area. Diesel emissions now a recognized cause of cancer.
7	Lockout/ Guarding	Failure to isolate energy as a result of inappropriate lockout/tagging
8	Mine Services	Working from a scoop-tramp bucket (i.e.. For fan installation and the provision of other services)
9	Water Management	Run of muck due to water in an ore pass
10	Hoisting	Lack of proper signals when hoisting

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Root-Cause Analysis: Risk Statement

Based on the results of the Mining Review, the following risk statement was selected by the subject matter expert participants for Root-Cause Analysis using the **“Fishbone”** approach. It was decided that the risk statement would cover both Underground as well as Surface Mining

“ Motor vehicle contacts workers”

Workshop: A Bipartite and Collective Process

- Workshop participants were peer-recognized subject matter experts
- Workshop process was open, transparent and collaborative
- Workshop was face-to-face. No teleconferencing
- Any ranking/prioritization of causal factors was done using Employer and Worker input only (Ministry of Labour does not vote)

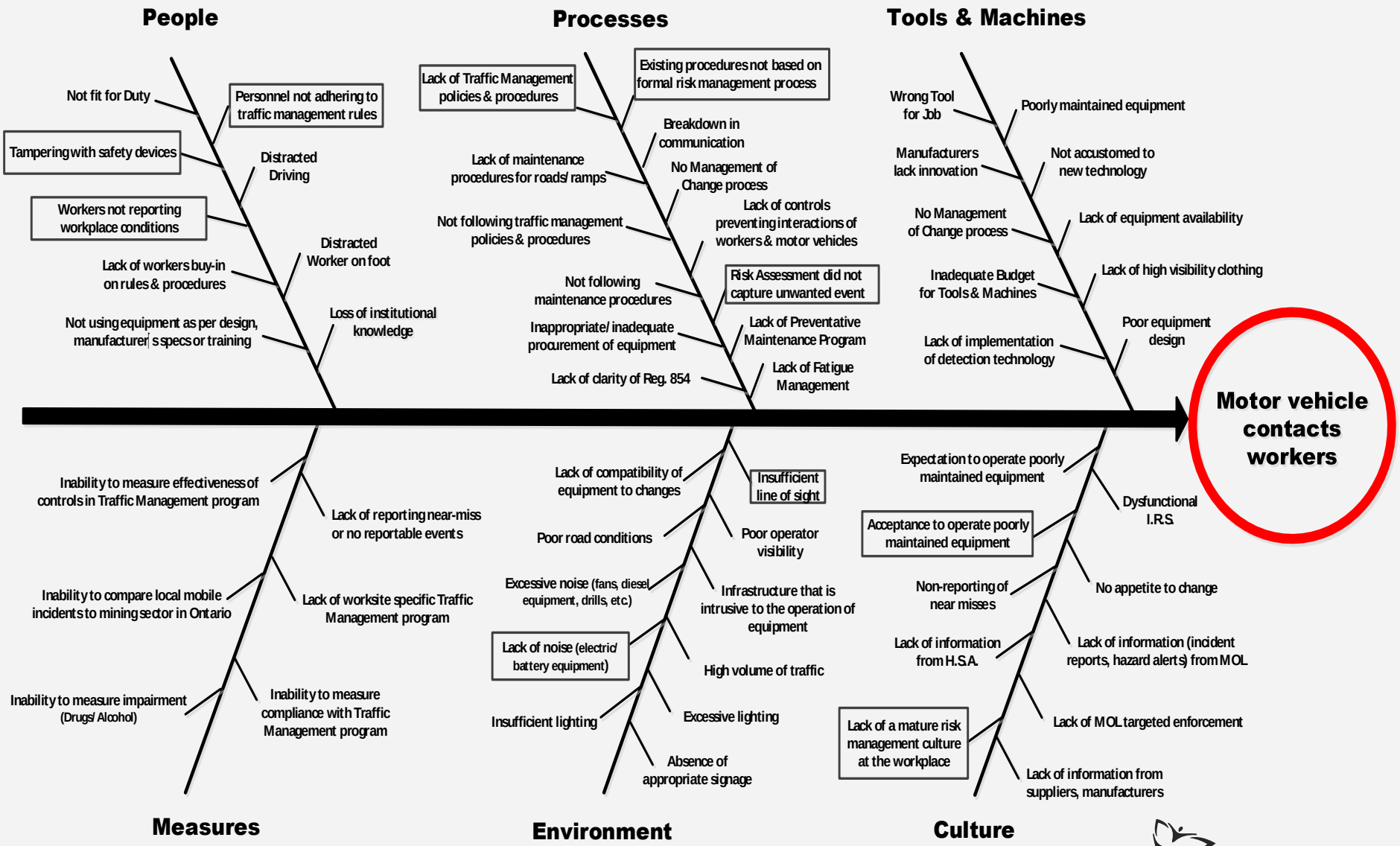
Mobile Equipment: Workshop Participants

#	Name	Company/Representation
1	**Alain Arsenault ***	USW Local 6500
2	**Jan Romo***	Unifor
3	**Shawn Hembruff***	Glencore
4	**Darren Toner ***	KGHM
5	**Alison Godwin**	Laurentian University
6	**Joe Guido**	USW Local 6500
7	**Jamie Cresswell**	MOL (Operations)

#	Name	Company/Representation
8	**Robert Barclay**	MOL (Operations)
9	**Glenn Staskus**	MOL (Operations)
10	**Peg Scherzinger**	MOL (Operations)
11	**Christine Bibby**	MOL (Corporate Management) - **Workshop Tech Support**
12	**Sujoy Dey**	MOL (Prevention)- **Facilitator**

***Voting participants**

"Fishbone" Diagram: Primary Causal Factors



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May 2018

Created by: Christine Bibby, Risk Assessment Team, Ministry of Labour

Mobile Equipment RCA: Top 10 Primary Causal Factors

1. Existing procedures not based on a formal risk assessment process
2. Acceptance to operate poorly maintained equipment
3. Lack of a mature risk management culture at the workplace
4. People tampering with safety devices (E.g. Bypass whisker switch)
5. Insufficient line of sight
6. Lack of noise (electric or battery equipment)
7. Risk Assessment did not capture unwanted risks
8. Personnel not adhering to traffic management rules
9. Personnel not reporting workplace conditions (i.e. hazards & near-misses)
10. Lack of traffic management policies & procedures

1. Existing Procedures not based on a Formal Risk Assessment Process- Controls

a. Have a formal risk management framework for the development of operational procedures (E.g. Job Safety Analysis (JSA), Failure Mode and Effect Analysis (FMEA), etc.)
b. Formal framework to review old/outdated procedures using risk management process in consultation with Joint Health and Safety Committee (JHSC) or worker health and safety representative
c. Convince leadership and workers (everyone) for the need to get older procedures into the risk management fold

Note: Control list not in any order of priority

2. Acceptance to Operate Poorly Maintained Equipment-

Controls

a. Build in a safety factor into all incentive (money) programs
b. Education/awareness of risks of using sub-standard equipment vs a good one
c. Sharing and learning of past examples/incidents to account for “it cannot happen to me” attitudes
d. Role of the HSAs to bring lessons/lessons learned to industry (it should not take MOL blitz plans to stir HSA proactive action)
e. Sharing maintenance requirements on tolerance on equipment standards
f. Having requirements for line management on job observations
g. Senior leadership should drive safety culture (“Culture starts at the top”)
h. Having all personnel understand cost implications on poorly operated/maintained equipment
i. Ensure maintenance programs exist in all workplaces

Note: Control list not in any order of priority

3. Lack of a Mature Risk Management Culture at the Workplace - Controls

a. Educate and involve all workplace parties in the power and the fundamentals of risk assessment and management
b. Train people on risk management facilitation
c. Provide risk assessment guidelines
d. Better capability of HSAs to provide support on risk assessments
e. Make task risk assessment routine work considering the hierarchy of controls
f. Proper lineups allow the task hazards and controls to be identified
g. Work permit controlling traffic flow to minimize risk of motor vehicle contacting worker
h. Senior leadership action should drive safety culture through employee engagement and buy-in

Note: Control list not in any order of priority

4. People Tampering with Safety Devices (E.g. Bypass Whisker Switch)- Controls

a.	Engineering out ability to tamper (make it tamper-proof)
b.	Zero-tolerance on such activities by worker or supervisor (everyone)
c.	Tampered device should warrant investigation as to why there was a need to “tamper”
d.	Proper training and lockout training as pertains to mobile equipment
e.	MOL enforcement: add ticket to tampering of safety devices
f.	Safety devices should be included in equipment maintenance schedule
g.	Post-op of the equipment
h.	Formal reporting system that identifies defective safety devices

Note: Control list not in any order of priority

5. Insufficient line of Sight- Controls

a.	Consider “line of sight” in mine design/road design/building design
b.	Consider optimal line of sight during procurement of equipment
c.	Encourage OEMs to interactively consider line of sight in their products
d.	Integrate proximity detection technologies (e.g. Using artificial intelligence)
e.	Management of Change (MOC) process for adding anything to equipment that could impact line of sight
f.	Risk assessment of operating environment/changes to the operating environment
g.	Review line of sight evaluation on equipment ensuring it is incorporated in operator training
h.	Maintenance personnel should be cognizant of line of sight issues
i.	Line of sight education/training to everybody (not just the operator)
j.	HSAs to be more proactive for line of sight issues
k.	Increase the visibility of smaller vehicles through the use of light shining at the back (e.g. blue lights adopted in Sudbury)
l.	Use of personal strobes
m.	Restricting access to work area
n.	Signage should be standardized and durable

Note: Control list not in any order of priority

6. Lack of Noise (Electric/Battery Equipment)- Controls

a. Traffic management program should take into consideration hazards associated with equipment that do not generate a lot of noise
b. Risk assessment should include hazards associated with equipment that do not generate a lot of noise
c. Consider engineering strobe lights on such vehicles/equipment
d. Proximity detection in specific areas
e. Encourage OEMs to work with each other to factor in hazards associated with equipment that do not generate a lot of noise

Note: Control list not in any order of priority

7. Risk Assessment did not capture Unwanted Risks-

Controls

a. "Real-life" validation of residual risk and controls by the end-user
b. Training in risk assessment and hazard identification
c. Ensure the right people are involved in the process
d. Training in risk facilitation
e. Report near-miss data to incorporate into risk assessment analysis
f. Tangible results on operations based on risk assessments (closing the loop on the risk management cycle)
g. Better analytics to feed into risk assessments
h. Better data and analytics to reduce subjectivity
i. Better capability of HSAs to provide support on risk assessments
j. Maintain an active "risk register" (constantly being updated)
k. Integrate risk assessment analysis into a functional system (e.g. Intelex) where people can access the information and act accordingly
l. MOC process includes updating the risk register

Note: Control list not in any order of priority

8. Personnel not adhering to Traffic Management Rules-

Controls

a. Develop a risk-based traffic management plan
b. Communication and monitoring of the traffic management plan to personnel
c. Awareness on the requirements of the traffic management plan and how it specifically impacts the worker
d. Monitor and ensure compliance with the traffic management plan
e. Understand protocols when working close to rail lines
f. Proper orientation of external personnel (e.g. contractors) with respect to the traffic management plan
g. Workplaces enforce non-compliance to traffic management rules

Note: Control list not in any order of priority

9. Personnel not reporting Workplace Conditions (i.e. Hazards/Near-Misses)- Controls

a. Functioning IRS that encourages reporting
b. Proper training in hazard/near-miss identification
c. Develop a “stop and correct” program
d. Create a culture to “stop and correct/report” unsafe conditions as part of the “stop and correct/report” program
e. Opportunity with the HSAs to show examples of an empowered workplace
f. Ensure a simple process for reporting is in place.
g. Build in a safety factor into all incentive (money) programs

Note: Control list not in any order of priority

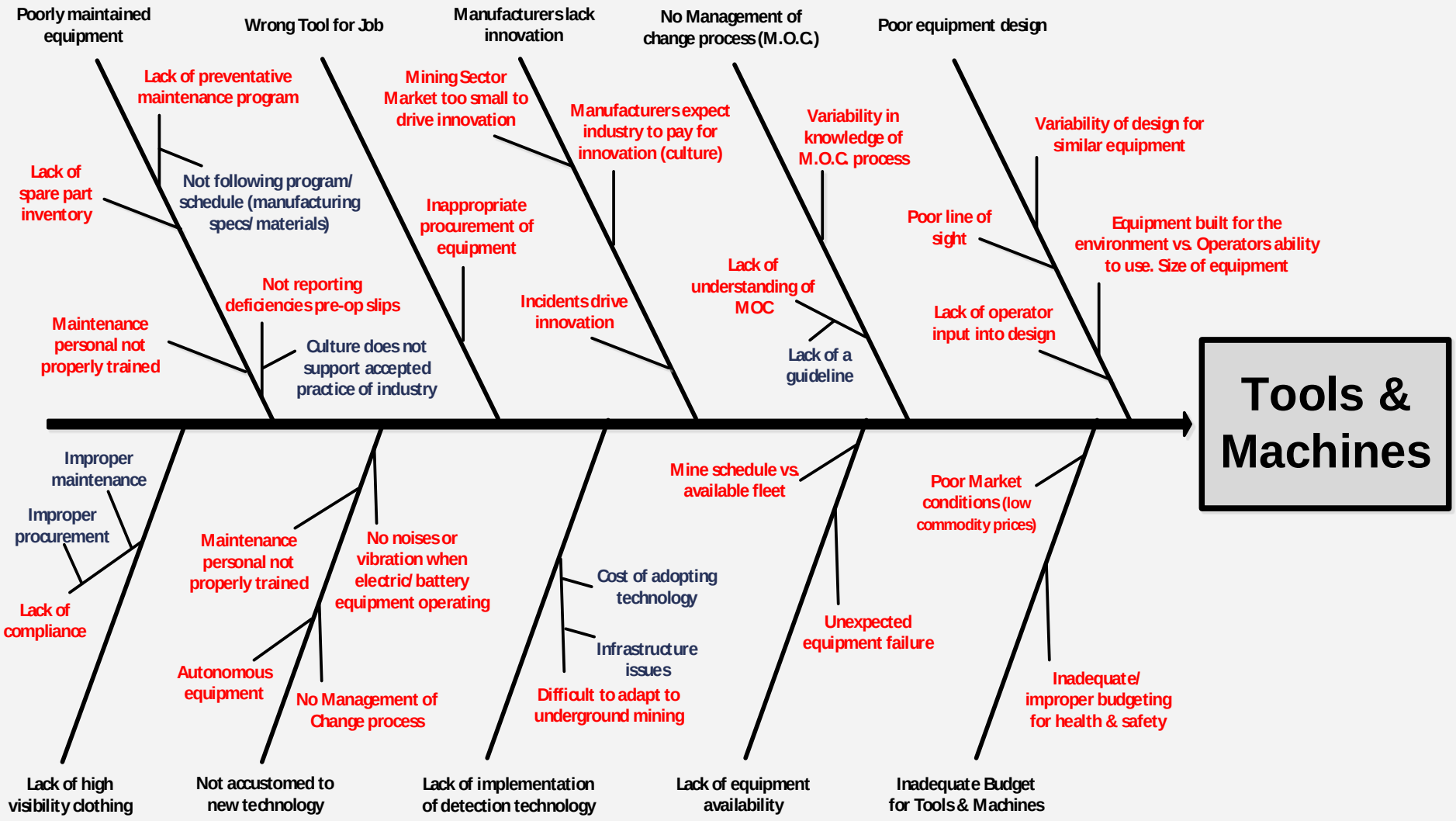
10. Lack of Traffic Management Polices & Procedures-

Controls

a. Have a formal risk management framework for the development of traffic management polices & procedures
b. Get the HSAs to provide training to help industry develop traffic management policies & procedures
c. Understand the expectations of a traffic management program (e.g. MOL guideline)

Note: Control list not in any order of priority

Appendix I: Tools & Machines



Top 10 Primary Root-Cause
Primary Root-Cause
Secondary Root-Cause
Tertiary Root-Cause

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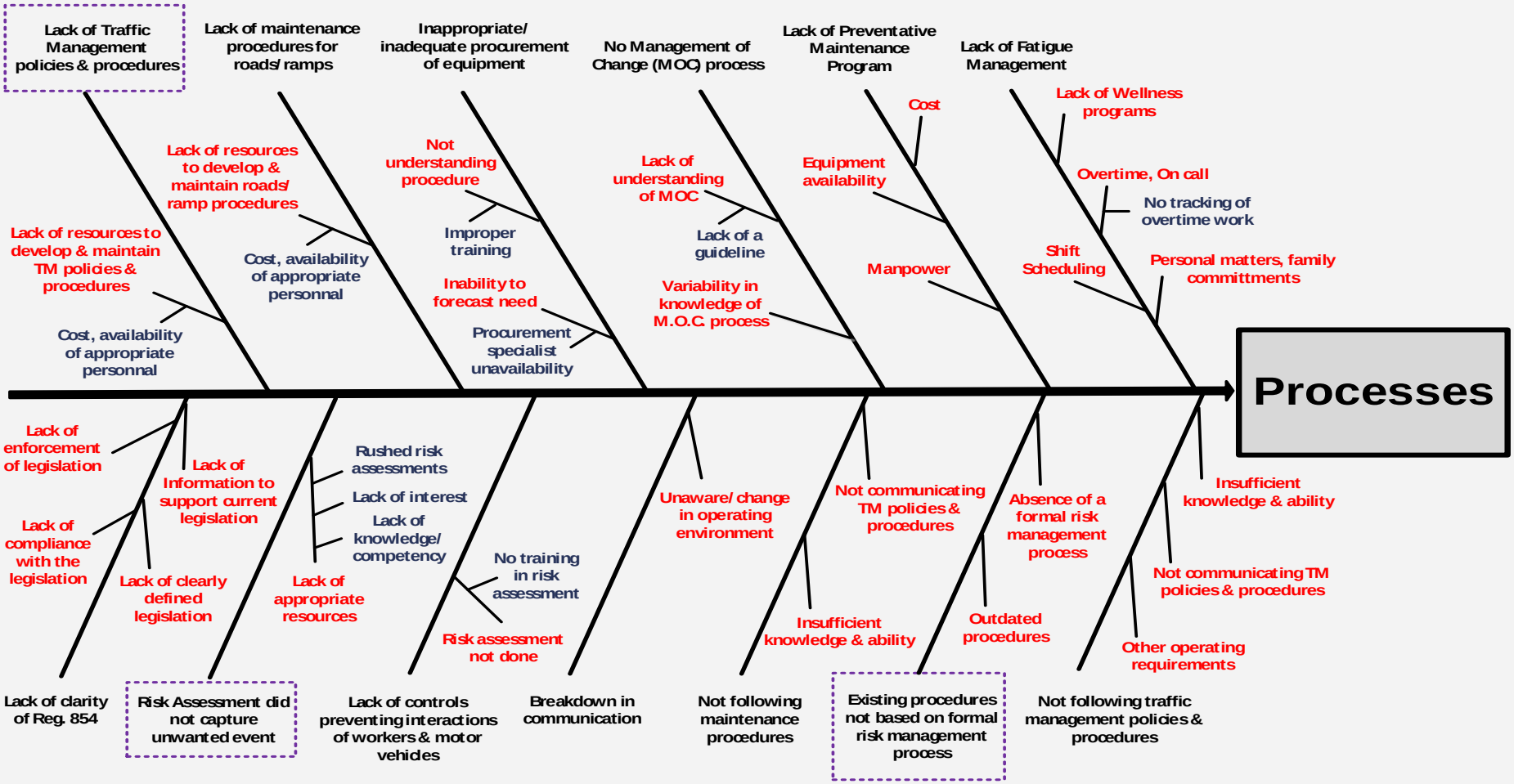
Appendix II: Processes



TM: Traffic Management

Top 10 Primary Root-Cause
Primary Root-Cause
Secondary Root-Cause
Tertiary Root-Cause

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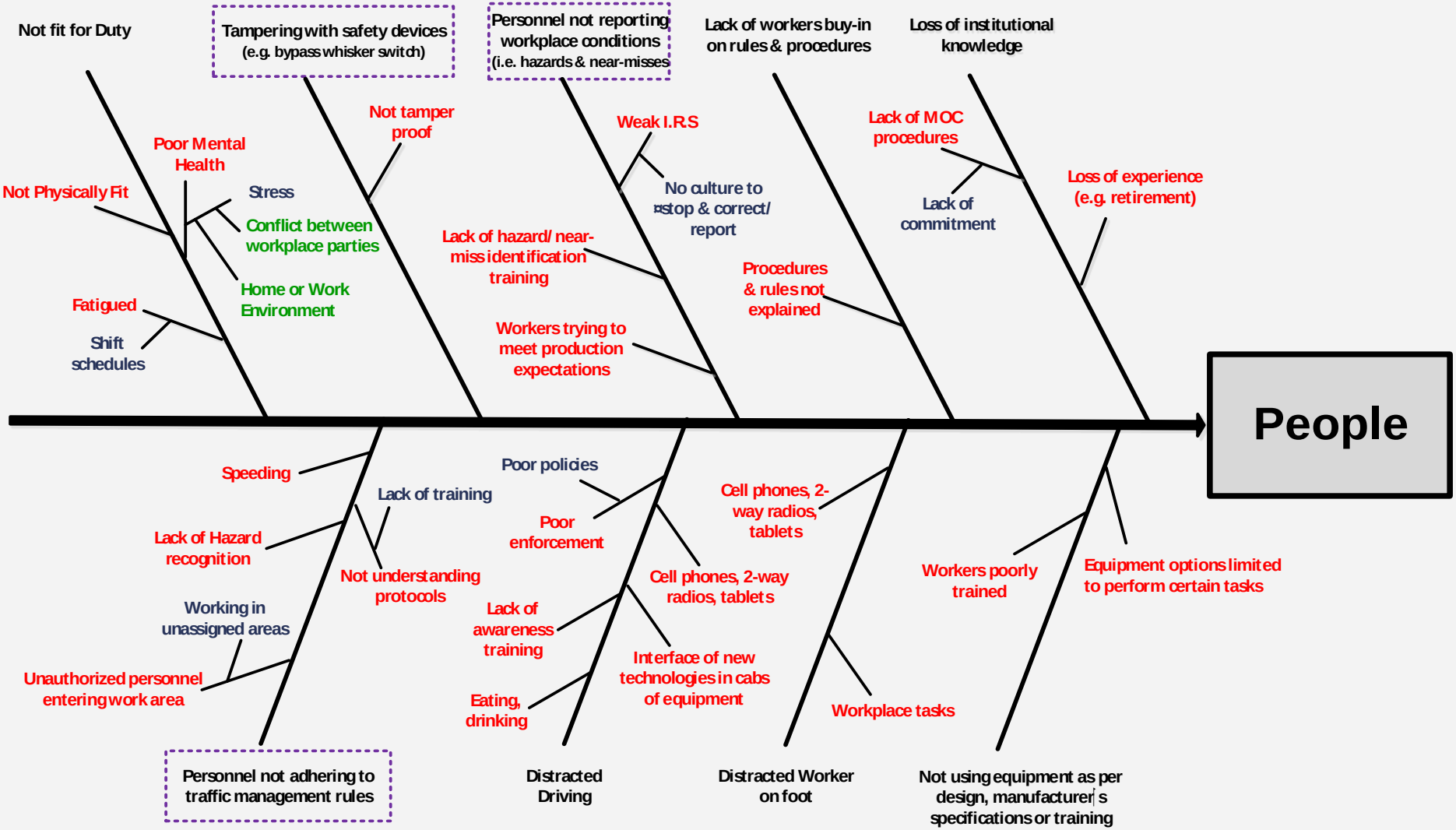
Appendix III: People



Top 10 Primary Root-Cause
Primary Root-Cause
Secondary Root-Cause
Tertiary Root-Cause
Quaternary Root-Cause

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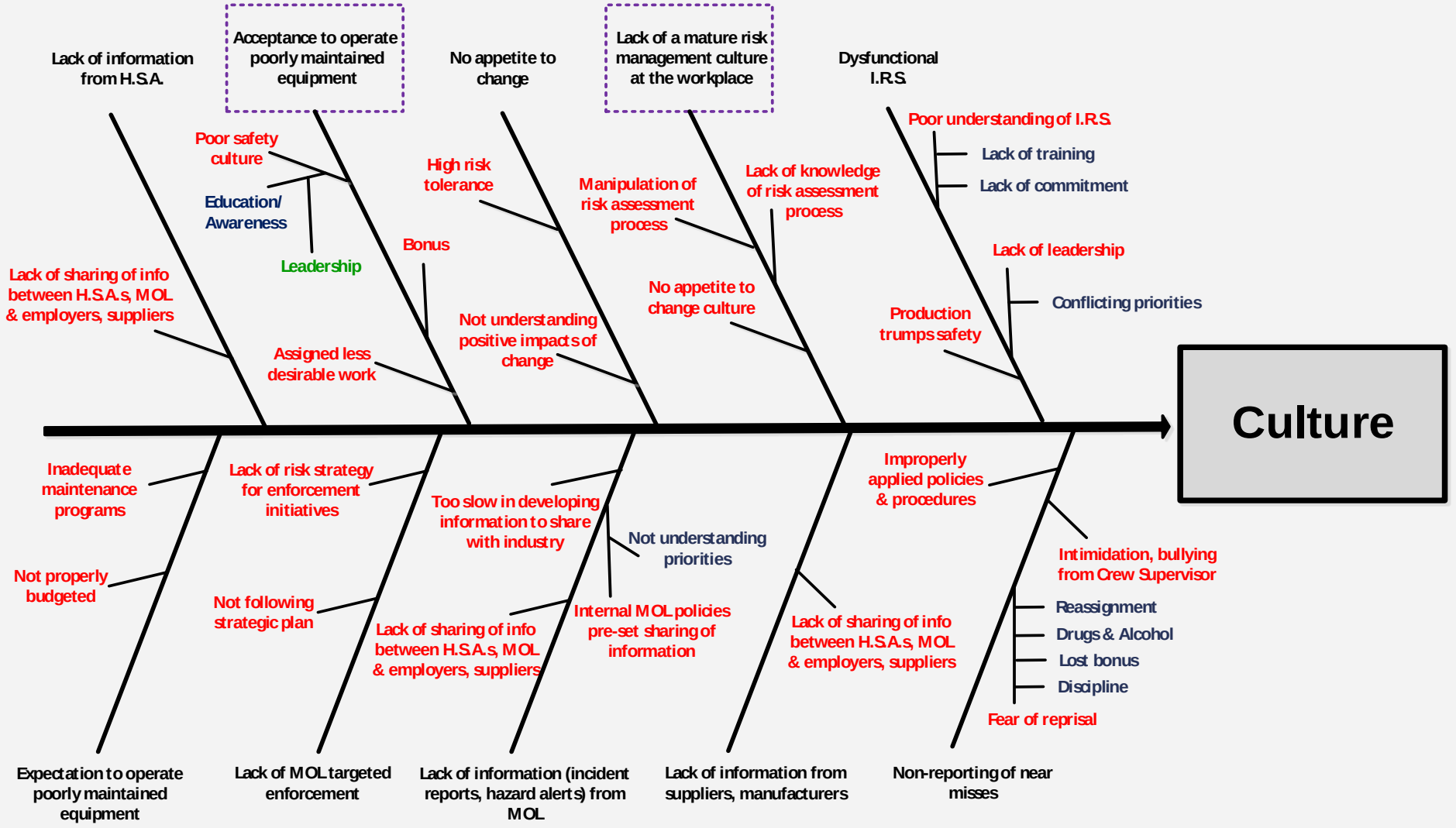
Appendix IV: Culture



Top 10 Primary Root-Cause
Primary Root-Cause
Secondary Root-Cause
Tertiary Root-Cause
Quaternary Root-Cause

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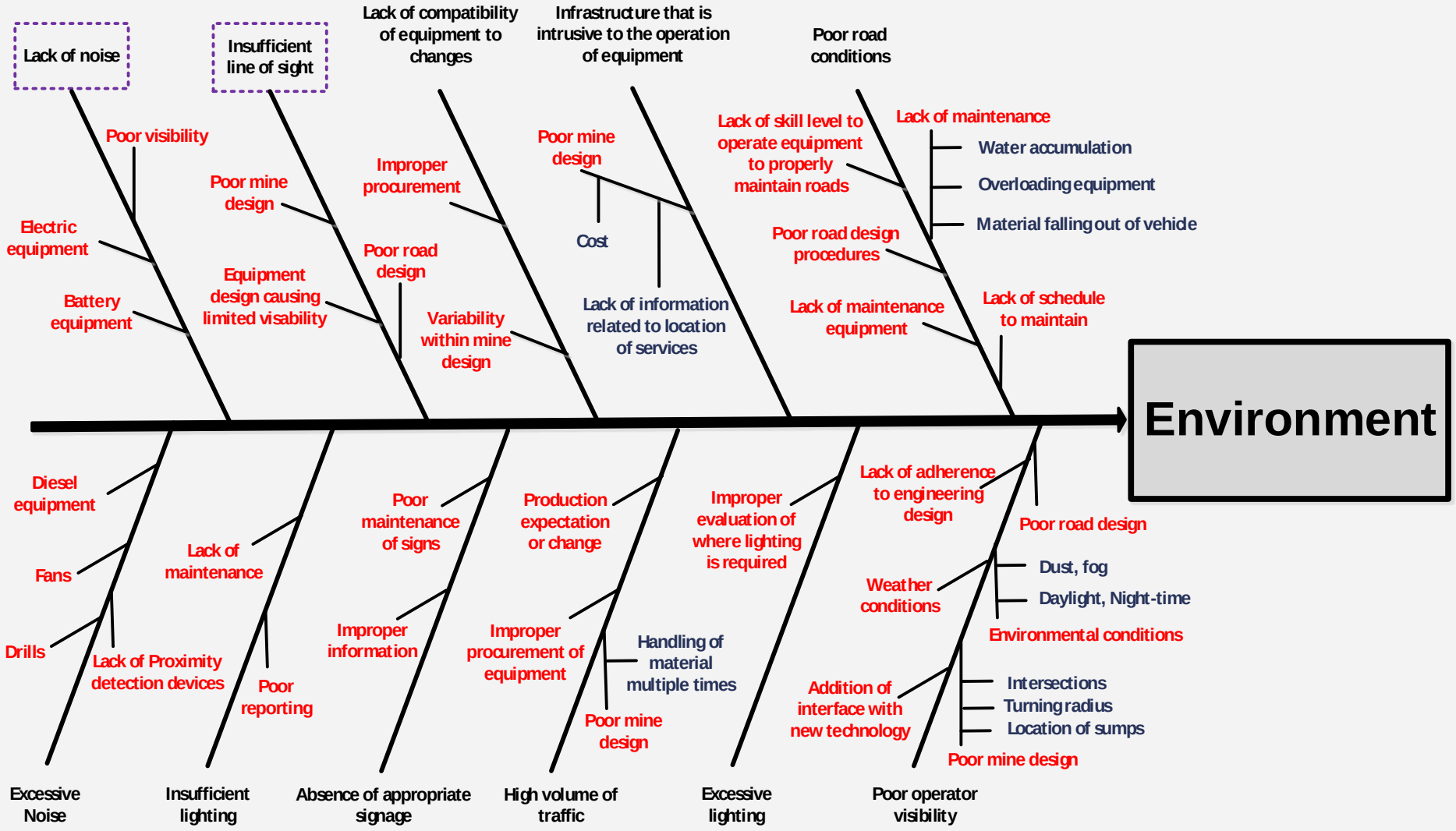
Appendix V: Environment



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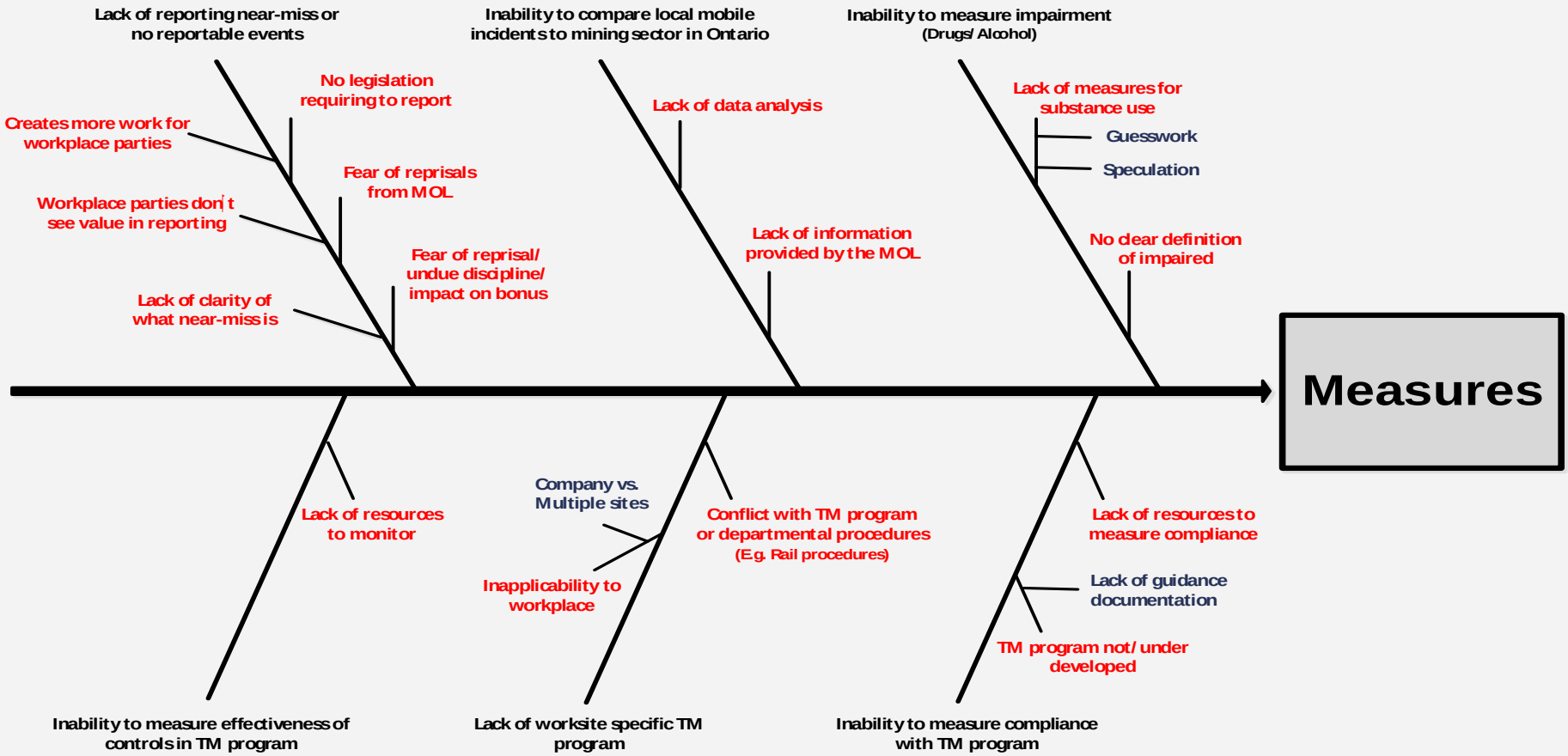
Appendix VI: Measures



TM: Traffic Management

Top 10 Primary Root-Cause
Primary Root-Cause
Secondary Root-Cause
Tertiary Root-Cause

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Appendix A: Risk Assessment Methods/Standards*

1. Bayesian Analysis
2. Bow tie analysis
3. Brainstorming (e.g. what-if)
4. Business impact analysis
5. Cause and effect analysis
6. Checklists
7. Computer Hazard and Operability Studies (CHAZOP)
8. Consequence Analysis (also called Cause-Consequence Analysis)
9. Likelihood/Consequence matrix
10. Construction Hazard Assessment and Implication Review (CHAIR)
11. Decision tree
12. Delphi technique
13. Energy Barrier Analysis (or Energy Trace Barrier Analysis)
14. Environmental risk assessment
15. Event tree analysis
16. Failure Mode and Effect Analysis (FMEA)
17. Failure mode, effect and criticality analysis
18. Fault Tree Analysis
19. Fishbone (Ishikawa) Analysis
20. Hazard analysis and critical control points
21. Hazard and Operability studies (HAZOP)
22. Human Error Analysis (HEA)
23. Human reliability analysis
24. Job Safety Analysis (JSA)
25. Level of Protection Analysis (LOPA)
26. Markov analysis
27. Monte Carlo Analysis
28. Preliminary Hazard Analysis (PHA)
29. Reliability centered maintenance
30. Scenario analysis
31. Sneak circuit analysis
32. Structured/semi-structured interviews
33. SWIFT (i.e. structured what-if)
34. Systemic Cause Analysis Technique (SCAT)
35. Workplace Risk Assessment and Control (WRAC)

Risk Management Standards:

1. Risk Management Principles and Guidelines (ISO 31000:2009)
2. Risk Assessment Techniques (ISO/IEC 31010:2009)
3. OH&S Hazard Identification and Elimination and Risk Assessment and Control (CSA Z1002)
4. Process Safety Management (CSA Z767-17)
5. Enterprise Risk Management (COSO 2004)
6. Global Minerals Industry Risk Management (GMIRM)
7. International Council on Mining & Metals (ICMM)

*** Not an exhaustive list**

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Appendix B: Ministry of Labour Contacts

- For additional information or questions, please contact:

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