Hands-on Proximity Detection and Collision Avoidance Systems Workshop

Prevention of Vehicle Interaction Collisions

Proximity Detection Systems PDS
Collision Avoidance Systems CAS
Collision Awareness Systems CAS

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Department of Employment, Economic Development and Innovation
Safety Clip
Aim of Workshop

• Workshop to showcase current technologies and solutions – CAS OEMs
• ‘Making a Case for Proximity detection’
• …raise awareness of vehicles interaction hazards and resultant risks… so we can make **better and safer decisions** … and design safer places of work
• Share industry leading practise with each other – free lessons – better Risk Assessments and Scoping
• Collective Industry issues – Collective Solutions – Win/Win - Future
• Raise awareness of **current** solutions used
  …about Control Effectiveness of those solutions – robustness of your SHMS … Additional Risk Controls

• What do the equipment OEMs do?
• **Enable you to scope THE collision avoidance system for your site**
‘Take Home’ Questions - Control Effectiveness

• How good/\textbf{effective} are the controls you \textbf{currently} have in place?

• Where are you pitching your controls – Elimination or PPE?
  – \textbf{Are the controls actually available}?
  – \textbf{Are the controls reliable, robust/resilient and effective}?
  – \textbf{Does the control actually address/match the hazard}?
  – ‘\textbf{How good is it ???}’ Individually – as a system???
  – \textbf{Will the controls be used}? ‘\textbf{Feelgood vs real application}’
  – \textbf{Does the control rely on the intervention of a person, eg the operator, or are they automatic}?
  – \textbf{Do your controls meet legislative requirements}?

• Have you looked at the design of your equipment?

• \textbf{KPIs} – how do you measure effectiveness of your solutions)
Elimination?

An example from a recent Queensland workshop on pitwall safety
Presentations

- Collision of Surface Plant – Case Study - Steve Bath
- Investigation Unit Report – Tony Smith
- Functional Safety SIL – Marcus Punch
- Human Factors - Julie Pengelly
- ‘How good do our people need to be’ – Peter Standish

- Morning Tea 1025 to 1045
- Facilitated Discussion 1045
- Manufacturers presentations 1130
- Lunch 1230 – 1300
- Manufacturers presentations
- Wrapup 1530 - 1630
'Discussion' 1045 - 1130

• Some thoughts first…

• Current issues
• Future legislative requirements
• Control effectiveness

What are the outcomes you need to get from this workshop?

What are the questions you need to ask to pick the right system for your site?
Parental guidance recommended

The following presentation is rated PG, it contains

Pictures
Graphs
Disturbing & Thought provoking
May cause bouts of unease
May contain traces of nuts
For a mature audience – you!
Sorry, no nudity
Work

Environment

Controlled

Competent People

Safe Production

Safe Work Practices

Fit For Purpose Equipment

What about your workplace culture?
Why do we see what we see…

Increasing dependence on mine vehicles – OC & UG
More & more vehicles, increase in size & speed
  – **Visibility** around machine
  – Operator & Pedestrian **behaviour**
  – **Recurring accidents**
  – **Same picture worldwide**

**Key mining hazard** but there are solutions

**Its up to all of us** to solve the problem….
Figure 1.1 Fatalities in Queensland mines

~ 3 out of 4 = ~ 75%
- vehicle related
## ‘Pegging’ the Risk - Rank

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Almost certain (common / repeating)</th>
<th>Likely (has happened)</th>
<th>Possible (heard of it happening)</th>
<th>Unlikely (not likely to happen)</th>
<th>Rare (almost impossible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consequence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catastrophic (eg fatality)</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Major (eg permanent disability)</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Moderate (eg medical / hospital treat)</td>
<td>6</td>
<td>9</td>
<td>13</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Minor (eg first aid)</td>
<td>10</td>
<td>14</td>
<td>18</td>
<td>21</td>
<td>23</td>
</tr>
<tr>
<td>Insignificant (eg no injury)</td>
<td>15</td>
<td>19</td>
<td>22</td>
<td>24</td>
<td>25</td>
</tr>
</tbody>
</table>

- **Maximum reasonable consequence?**
- **Most likely consequence?**
- **Likelihood?**
Does the size of your equipment matter?
Hazards:
• LTA visibility
• LTA hazard awareness
Hazards

- Moving equipment (‘tons’ of kinetic energy - CAT 797F, payload 360 ton GVM 623 tons, 3,800 HP, top speed 67 km/h, 14.8m long, ~10m wide)

- Boeing 747-400 178 tons 3.5*

- LTA visibility
- LTA hazard awareness
LTA awareness = function (Selection, Induction, Training, LTA Hazard & Risk management, Risk Normalisation, Supervision, personal attitudes and capabilities etc.)
Some typical OC scenarios….

- V2V V2P slow speed e.g. Parkup areas
- V2V – overtaking collision
- V2V – high speed rear end collision
- V2V - rear end collision
- V2V – slow speed rear end collision
- V2V collision or reversing over dump
- V2V – head on collision
- V2I or V2P forward collision
- V2V V2P V2I reversing collisions
- V2V collision - intersection
- V2V collision – mining face
- V2V collision – fast –slow moving vehicles
Typical Underground Scenarios, there are many more.....

No Go-Zones!
MSHA - UG Fatalities - Continuous Miner

Most/all could be avoided if Proximity Systems had been available and installed

Of the 29 fatalities, 72% of victims were operating the remote at the time of the accident.

Legend
- Victim location
- Operating the remote
- Not operating the remote
- A moving RCCM collided with another at an intersection, causing the stationary RCCM to pivot and crush the other Op
- Maintenance activity
HPI analysis – equipment type vs outcome, n= 286 as of July 2007

Count of Outcome

- Continuous miner
  - cable damage
  - fault condition
  - uncontrolled movement
  - personal injury
  - drill steel
  - fall of material onto cm
  - broken cutter head
  - gas release
  - knee injury material on floor
  - personal injury mesh
  - potential pers injury

- Shuttle car - underground
  - cable damage
  - uncontrolled movement
  - electric shock
  - incorrect isolation
  - machine damage
  - potential crush of person in no go zone
‘There are only so many ways to kill people, and we know them all’
Visibility = Opportunity to identify a hazard & react in time
Shuttlecar or Truck

Miner
Person vs Machine 1

People are inherently unreliable

Mental processing time
- Sensory – perception/recognition
- Interpretation – what does this mean – friend or foe? (Car stopped in the middle of the road)
- Response Selection

Expectation
- Expected to brake – 0.7 secs = 0.5 secs perception 0.2 secs movement
- Unexpected – 1.25 secs = 1.05 secs perception 0.2 secs movement
- Surprise – 1.5 secs = 1.2 secs perception 0.3 secs movement

Movement time
- Brake engagement time – foot movement, on pedal, depress, mechanical delays
Person vs Machine 2

People are inherently unreliable

• **Other factors**
  • Urgency – time to collision
  • Cognitive load – ‘non driving’ matters – music, mobile phone, ‘autopilot’
  • Age ~ lower levels of fitness ~ lower response capability
  • Gender
  • Nature of signal – can it be seen? Is it distinct? Is the vehicle in front accelerating/decelerating? Aspect – frontal/from side
  • Visibility
  • Reaction time at night – visual contrast
Distance travelled (m) vs time (secs)

- 5 km/hr
- 10 km/hr
- 20 km/hr
- 30 km/hr
- 40 km/hr

Time secs

Distance travelled m
Note: Collision Avoidance system defects only rank #2 priority on this truck prestart checklist

<table>
<thead>
<tr>
<th>Priority #1: Defined as a task that must be done now and do not operate.</th>
<th>Priority #2: Defined as a task that does not have to be done now, however should be done before next service and or repaired with in 24 to 48 hours notify Dispatch.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steering, Services Brakes, Warning System, Fire Extinguisher, Seat, Seat belt, Fuel Tank major damage.</td>
<td>Emergency Steering, Park, Brakes, Fire Suppression, ROPs, FOPs, Brake System leaks, Major Tyre Damage, Major coolant leaks.</td>
</tr>
</tbody>
</table>

Would you be happy for your airline to treat collision avoidance with the same level of ‘concern’?
• Your thoughts
• Current issues
• Control effectiveness
• Legislative requirements

• Brainstorm: What are the outcomes you need to get from this workshop?
  – What are the questions you need to ask to pick the right system for your site?
System Feature Questions 1

• What can it do – what can it not?
• Low Speed vs High Speed - mix
• V2V, V2P V2I (vehicle to vehicle, vehicle to person, vehicle to infrastructure)
• Detection Capability & Range – near and far field
• Detection Sensitivity – near/far field, vehicles, people, stationary objects, infrastructure
• Directional Algorithms – Context – collision likely?
• Standalone vs dependant on other systems – Integration - OEMs
• Active vs Passive systems – machine shutdown? (Energy control)
System Feature Questions 2

- Redundancy – fail safe – self checking
- Intuitive & Simple – human interface
- Normalisation – desensitization of operators - false alarming
- Operator Interference
- Cabin Clutter – Veiling - Ergonomics
- Interference from other systems & environment – Physics
- Golden ‘Rules’ & Company standards
- KPIs – effectiveness – how do we know it helps us?
- How will contractors be protected?
Day 1 Presentations

Preco
AMT
Lunch
Sick
Becker
InfoTronix
Afternoon Tea
Ivolve
MST

Issued raised – Gap Analysis – Wrap up 1530 - 1630
Day 1 so far

• Issues
• Gap analysis
• Wrap up
Day 2 - Start 0830 hrs

Enjoy your evening
Day 2 Presentations

Accumine
Safemine
Modular Mining Systems

Morning tea

WesTrac
Recap Day 1 and manufacturers presentations
Thiess

Lunch

Moolarben Coal
Rio Tinto

Afternoon Tea

Recap – Brainstorm – Conclusions
Closing Address 1600
Homework
Recap
Manufacturers Presentations
Recap

Conclusion – where to from here?
Some CAS Technologies

- RFID – tags and readers
- Radar
- ‘Magnetic bubble’
- Laser scanning
- GPS – surface only
- Cameras
- Combination of the above

- Opencut and Underground metalliferous - available now
- Underground Coal – requires IS certification - 2011
- Cost from $5k per vehicle
Hierarchy of Controls

1. **ELIMINATE** (remove the hazard, or the need to perform the hazardous activity altogether)

2. **SUBSTITUTE** (hazardous substance, process, equipment, work method for safer alternative)

3. **ENGINEERING / ISOLATION** (Redesign, enclose, or isolate/separate people from the hazard by use of lockout system or use of barriers/distance/time)

4. **ADMINISTRATIVE** (Training, Rules, Procedures or Safe Systems of Work)

5. **PPE** (Includes: eye/face/skin/foot/head/respiratory/hearing/fall protection and contingencies such as fire fighting equipment)

6. **SAFE BEHAVIOUR** (situational awareness/alertness and compliance with rules and procedures, instruction)
Reverse ICAM - Consider a Systems Approach – Control Effectiveness - ALARA

NO CRUSH INJURIES

ALARA? Take Home Questions – Risk Assessment

AND

Reliable Organisational factors

Reliable Team & Individual factors

Known & Controlled Environment

AND

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81% System Success

19% System Failure

Reverse ICAM - Consider a systems approach – control effectiveness

<table>
<thead>
<tr>
<th>Reliable Organisational factors</th>
<th>Reliable Team &amp; Individual factors</th>
<th>Known &amp; Controlled Environment</th>
<th>Reliable Defences</th>
</tr>
</thead>
<tbody>
<tr>
<td>95%</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Individual Success</th>
<th>System Success % (Reliability)</th>
<th>System Failure% (Unreliability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>99%</td>
<td>96%</td>
<td>4%</td>
</tr>
<tr>
<td>90%</td>
<td>65%</td>
<td>35%</td>
</tr>
<tr>
<td>85%</td>
<td>52%</td>
<td>48%</td>
</tr>
<tr>
<td>90% and 99% for ‘reliable defences’</td>
<td>72%</td>
<td>28%</td>
</tr>
</tbody>
</table>

| 90% and 99% for ‘reliable defences’ | 72% | 28% |
Tilmans ‘Meaning of Life’ Ver.1.0

Risk
1. Major Hazard Baseline RA
2. Project/Change Issue RA eg. Coll. Awareness
3. Routine & Non Routine Task Planning RA
4. Individual ‘continuous’ Face RA

Reliance on People to control risk

RA Tools
1. High Level QRA, Engineering type analysis, FTA, BTA, FMEA, HAZOP, WRAC
2. FTA, BTA, FMEA, HAZOP, WRAC
3. WRAC
4. JSA

Degree of Difficulty

HR
Elimination
Substitution
Engineering Control
Administrative Control - Procedure
PPE
Human behaviour

RA Tools

Risk & Issue
People
Control Options
Req’d HR Resources

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Challenging but more effective

Easy – not very effective

Other Controls (procedural and administrative)
What can it do? Other uses – detection of fixed hazards

Powerline hazard – Pyrolysis

Q: Is the system capable of helping here?
Example of a well delineated and well designed ‘walkway’ to the truck ‘go line’

‘Isolation’ – hard barriers – note ‘height’ of bunds ½ hub height of largest vehicle
Risk Management is all about Control
Specifically….. 1

1. Are collision hazards, risk and controls are captured in your Risk Register?
2. Does your mine site induction elements address collision hazards? (golden rules, separation distances, speed limits, prestart checks, fatal risk control protocols)
3. What are your site’s ‘controls’ – procedures, rules, training materials, training routines etc. that address collision hazards?
4. Current controls’ – vehicle – cameras, mirrors, changes in cab design?
5. Current site’s ‘controls’ – people?
6. Current site controls- working environment – delineation, marking and separation of roads, signage, speed controls, intersection design
7. Signage conforming to standard? Can they be seen? Cleanliness?
8. Road design standard address collision hazards
9. % of vehicles that are/are not equipped with a prox detection/collision avoidance system?
Specifically….. 2

1. Is there a **prestart check** for the proximity detection system?
2. If found unserviceable during prestart what is the **stated procedure**
   e.g. parkup, notification to maintenance, no procedure etc?
3. **Vehicle separation distances**? How do you know they are actually observed?
4. Speed limits?
5. Full **risk assessment** covering vehicle collision hazards **as its main concern/theme**?
6. Conflict points incl. overhead services
7. Are all **relevant collisions hazard identified and addressed** in the risk assessment? Cross reference them to other incidents?
8. Separation of pedestrians from other traffic - Pedestrian crossings?
9. Separation of LV from other traffic, Separation HV to HV?
10. How are ‘human **factors**’ – ie operator interaction with the prox. system, cab layout, ergonomics, alarming, operator interference are resolved?
Specifically ….3

1. Lighting sufficient?
2. In-vehicle noise levels?
3. Give-way policy?
4. Speed limiting devices – are they fitted? Are they working?
5. Are speed limits enforced?
6. Vehicle housekeeping? (visibility – windows, mirrors and cameras)
7. Separate access points into the traffic circuit? Do they maximise visibility?
8. Well marked and well controlled railway crossings? Do they maximise visibility?
9. Site working on **scoping** up a prox system?
10. Are you planning to involve a **human factors specialist** to cover human factors aspects while scoping up a proximity system?
11. Made contact with any of the **proximity systems manufacturers** to discuss a possible site trial or system implementation?
12. Made contact with any of the **mining equipment manufacturers** to discuss OEM assistance re prox system?
1. **Risk Controls** generally – where do they lie in the **hierarchy of controls**? Please describe the range of controls.

2. **Controls from the risk assessment** actually been implemented? Are they actually **available and in place**?

3. How do the **controls provide effective protection**?

4. Do the **controls** rely on the intervention of a person, eg the operator, or are they automatic?

5. How did you establish **effectiveness of your control approach**?

6. How did you measure the **effectiveness of the controls**?

7. Standard **Vehicle separation distances** (m) – normal traffic, queuing, parkup.

8. In the field – estimate **separation distances between vehicles** and compare to site standards

9. Your site’s approach of **vehicle parkup process and areas**? Designated parkup areas? How are vehicles parked up?

(thanks to Prof Tim Horberry UQ for helping with this list)
In Summary

- (V2V, V2P V2I) **Accidents are preventable**
- If we don’t do it – there will be more fatalities
- Proximity detection systems are not the complete answer but are an essential part of the solution
- **Must also look at human factors** – human unreliability
- Up to industry as end-user to scope proximity system functionality and work with designer/manufacturers
- Proximity Detection Technology is available or rapidly becoming available
- Australian Underground coal mines not covered yet due to IS approval issues
- Need a side by side integrated combination of approaches
- **COLLISIONgate – 2010 – UQ-DEEDI (ACARP)**
No silver bullet but collision awareness/avoidance systems will help in creating a higher level of safety.
Decisions – in a nutshell

Decisions can be life taking
Decisions can be life giving
Its your call…
Closing Address

Steve Bentham
Senior Inspector Electrical Engineering