Safety and Comfort Aspects of Personnel Transport Vehicles (PTV) used in Underground Coal Mining

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Presentation Outline

- Safety and comfort in current vehicles
- ACARP Project C14037
- Kestrel retrofit project
- New concept vehicles
- Conclusions
Safety and Comfort in Current Generation of PTV’s

- The personal injuries related to personnel carriers in the Australian underground mining industry are considered to be unacceptably high.
  - Back injuries
  - Neck injuries
  - Ankle injuries

- The level of safety provided is also not considered adequate
  - Predominantly side facing seating
  - No or poor restraint against sudden deceleration
  - Rigid and heavy vehicle structures

- The level of comfort provided is poor
  - Poor cabin ergonomics – layouts, seats
  - Seats with no suspension
  - Very rigid vehicle suspension
  - Open cabin – no AC, coal dust

MTI Involvement

- Industry group consisting of four underground coal mines approached MTI to review the current situation and develop a proposal for improvements

- MTI, Monash University Accident Research Centre and Monash University Art and Design developed a proposal for ACARP funding

- Kestrel Mine Management took immediate action and proposed a fast-track program to retrofit their fleet of nine Driftrunners

- ACARP project C14037 has been completed
  - Specifications
  - New concept designs

- A new ACARP proposal has been submitted to complete the engineering design of a new concept design
The roll of project C14037 was:

a) To deliver a formal set of vehicle specifications that would lead to:
   • A decrease in the incidence rate and severity of loss time injuries (LTI’s) as well as restricted work injuries (RWI’s)
   • Positive changes to the safety culture of personnel
   • Industry-wide standardisation of personnel carriers in underground mines

b) To create the basis for a new concept underground mining personnel carrier.

The key features responsible for vehicle related injuries include:

• Poor ergonomic consideration to layout and seating
• Too stiff vehicle and seating suspension
• Lack of personal restraint in the event of a vehicle impact or rapid deceleration

The specifications developed address many current short-comings in terms of safety and comfort, with particular emphasis on:

• Cabin layout
• Seating
• Effective Personnel Restraint
• Suspension Characteristics
• Multi-functionality
Kestrel Coal Retrofit Project

- Kestrel wanted a fast-track program to retrofit their Drifrunner fleet
- Project started in Nov 2004 and first vehicle completed in March 2005
- The objectives were to improve Safety and Comfort

The work comprised:
- Layout design – 11 personnel foreword/rear facing seats
- Suspension seats
- Restraint system
  - lap/sash with a 4N retractor
  - stainless steel aircraft buckle
  - Enlarged tongue
- Chassis modifications and testing
  - lowered chassis rails
  - Improved rear axle location with trailing links
  - Fitted progressive rate suspension springs

Kestrel Coal Drifrunner Retrofit Project (Cont.)

Before Retrofit

Before Retrofit
Kestrel Coal Driftrunner Retrofit Project (Cont.)

After Retrofit

Redesign Guidelines and Specifications

Rear Cabin Layout

The main function of the mine car seat is to provide stable body support in a posture that is:

- Comfortable over the duration of the journey
- Appropriate for the transportation of fully kitted mine personnel

Typical characteristics of rear cabin seating of current PTV are:

- Troop carrier type layout
- Poor posture
- Lack of personnel restraint system
- Insufficient headroom
- Poor comfort
- Inadequate of safety
Critical requirements for PTV:

• Flexibility
• Personnel carrying capacity – 10 acceptable 12 preferred
• Seating orientation – forward/rear facing
• Appropriate level of safety and comfort
• User-friendly restraint system
• Reduction in transmitted road vibration
• Strength and protection requirements

Dimensional Constraints:

• Total vehicle height: 1800-2000 mm
• Vehicle width: 2000-2150 mm
• Rear cabin length: 3200 mm (max)
• Ground clearance: 300-400 mm
• Exit step: 300 mm (max)

In view of the dimensional constraints, particularly the vehicle height, it was not possible to implement a complete ergonomic design.

Certain compromises had to be made keeping in mind sound ergonomic principles.

The approach in obtaining an acceptable solution was as follows:

• Select/design a chassis that provided the greatest floor-to-roof height
• Design seating layout to maximise the use of available space
• Introduce forward/rear facing seats
• Install an effective restraint system
• Modify existing suspension to reduce whole body vibrations
12 personnel capacity vehicle:

- Monocoque chassis
- Vehicle height: 2000 mm
- Seat-to-canopy height: 1060 mm
- Folding seats to maximise equipment carrying facilities
- Removable cargo barrier to enable simultaneous transportation of personnel and equipment
- Compliance with MDG No:1 guidelines for strength and protection requirements
- Provision for carrying a stretcher patient by folding centre seat
- Rear and side access to rear cabin

For access to mine areas with restricted height, a vehicle was designed with an overall height of 1800 mm featuring:

- 9 personnel carrying capacity
- Seat-to-canopy height 1005 mm
- Folding seats to maximise equipment carrying facilities
- Removable cargo barrier to enable simultaneous transportation of personnel and equipment
- Compliance with MDG No:1 guidelines for strength and protection requirements
- Provision for carrying a stretcher patient by folding centre seats
- Rear and side access to rear cabin
- Estimated ~2 tonne weight reduction cf conventional rail chassis vehicle
New Concept Vehicles

- Several new concept vehicle designs were produced
- MTI in collaboration with:
  - Monash University Faculty of Art and Design
  - Accident Research Centre
  - PJB (OEM)
  - KADE Development (Maintenance)
- Methodology:
  - Used the “Redesign Guidelines and Specifications” previously developed
  - Allowed for: Safety, Comfort, Transport of auxiliary equipment,
  - Use as a work platform
  - Review by Industry Group including ACARP monitors
- Two final concepts have been proposed for further consideration

Concept Vehicle Models

Concept 1: Bi-directional Vehicle
Concept 2: Tray Vehicle
Concept 3: Flat Bed Vehicle
Concept 4: Short-Wheel Base Vehicle
Bi-directional Vehicle

A purpose built vehicle to carry twelve mining personnel (including driver), accommodate a stretcher and a diverse amount of tools and ancillary equipment.

Main Features:

- Vehicle height: 1980 mm
- Excellent visibility and manoeuvrability
- Elevated safe raised central work platform and limited storage of equipment
- Modularity of design
- Ergonomic design providing a high level of passenger and driver comfort
- Effective restraint system
- Option of a sealed air conditioned cabin
- All wheel drive utilising hydraulic motors
- Reduced emission levels (DPM)
Concept Vehicle: Final Model 2

**Short-Wheel Base Personnel Carrier**

The objective of this design is to create a conceptual package for a purpose built vehicle capable of carrying 4-5 mining personnel (including driver), accommodate a stretcher and ancillary equipment.

Four man Version  

The principle repercussions of making the four-man vehicle into a five man capacity is an increase in overall length (including wheelbase) and the width of the vehicle will grow to the maximum permissible dimension (i.e. 2100mm).

Moulded Side and rear Doors

Concept Vehicle: Final Model 2 (Cont)

**Short-Wheel Base Personnel Carrier**

Bumpers

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Concept Vehicle: Final Model 2 (Cont)

Short-Wheel Base Personnel Carrier

Features:
- Vehicle height: 1800 mm
- Ergonomic design
- Side and rear access
- Common components – bumpers, wheel arch panels, front and rear doors
- Forward curving bonnet for safe front sightlines
- Monocoque construction
- Use of moulded components to reduce vehicle weight

Summary and Conclusions

- The current situation of PTV safety and comfort aspects were discussed
- Poor ergonomics in cabin layouts and seating is a major aspect that need to be improved to provide adequate safety and comfort for the users.
- In addition, there is potential to improve the engineering in relation to: weight, power, emission, etc.
- The Kestrel project has very successfully retrofitted a current vehicle model to improve ergonomics, safety and comfort
- In the current environment the industry deserves a new generation of vehicles that provide higher levels Safety and Comfort with improved engineering
- The proposed Concept vehicles demonstrates the potential to achieve these objective.