COLLISION AVOIDANCE SYSTEM FOR LARGE MINING TRUCKS

Rusty Mark, CSIRO
Henk Verhoef, AMT

SUMMARY

Since the advent of large mining trucks there has been an ongoing problem with collisions resulting from poor external vision and limited manoeuvrability. Over the last 10 years in New South Wales and Queensland open cut coal mines 147 collisions have been reported involving large mining equipment. It is likely that many more collisions with stationary plant and other objects have occurred and not been reported.

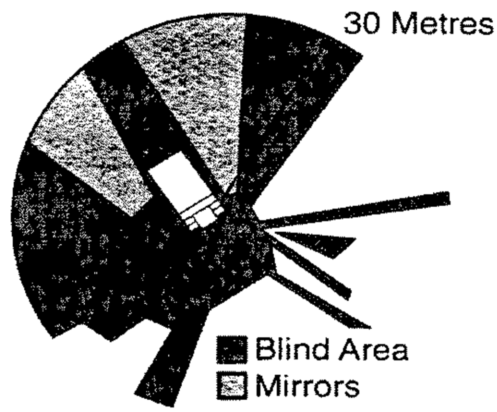
The only protection against collisions in the blind areas of a truck are procedural or "soft" barriers, such as no go zones for light vehicles, standard parking and start up procedures, and reversing alarms. Reversing alarms have recently come under review in the Hunter Valley as surrounding residents have begun complaining about the noise these alarms cause.

CSIRO Exploration and Mining together with Advanced Mining Technology are nearing completion of an ACARP funded research and development project aimed at eliminating the need for reversing alarms while greatly improving vehicle safety.

The research team has developed a system to address these requirements utilising the latest technology in miniaturised radio transmitters and receivers, video cameras and LCD video displays. Final system design modifications and production prototyping are now under way and the projected date for completion of the pre-production prototype system is August of this year. A provisional patent application for the system is pending. The design and operation of the system will be discussed in this paper

INTRODUCTION

Large mining trucks have been plagued with the problem of poor driver visibility (Figure 1). This has resulted in a very high incidence of accidents where large mining trucks collide with other vehicles, items of plant and occasionally people.



Typical Heavy Equipment Visibility Diagram

Figure 1 (QMITAB 1998)

This problem is addressed by procedural controls and noisy reversing alarms but these have not eliminated the problem.

Ideally additional sensing could be implemented to give the driver of the truck 360 degree unlimited vision around the truck. Even this would not be adequate as the truck is so large that the driver would only be able to "look" in a limited number of directions at once. The next step is to provide an automatic sensing system which looks in all directions at once, identifies potential problems and attracts the drivers attention to those areas where potential collisions could occur.

The ultimate collision avoidance system includes not only unlimited visibility for the driver, but also an "automatic co-pilot" which never gets fatigued and has enough smarts to identify problem areas so that it can alert the driver to take appropriate action.

ACARP has identified collision avoidance as a priority for research and has funded two consecutive projects to address this issue.

The first of these was focussed primarily on reversing and eliminating the need for reversing alarms and is nearing its successful completion. The second project is underway and is focussed on expanding collision avoidance capabilities to all directions of travel.

PROJECT OBJECTIVES

The project aim as stated in the original ACARP proposal is:

"...to develop and demonstrate a collision prevention system prototype that eliminates the noise problems caused by the current reversing alarm system and improves safety."

While the primary objective is to improve safety, the issue was accentuated by the noise complaints arising from reversing alarms in the Hunter Valley. Bengalla Mine is very close to urban development and has spent considerable effort to reduce its noise impact on the Race Course community at Muswellbrook. Bengalla Mine therefore had a close interest in the success of this project and agreed to be the host site for initial trials and have had a very important role in forming the project requirements.

As the industry need was urgent, the solution had to utilise an adaptation of readily available technology.

A risk review meeting in Singleton which involved representatives from the New South Wales Department of Mineral Resources, Truck Drivers, Maintenance Engineers, Environment Officers, and the Project Team, defined a set of key performance objectives:

- Delivery of a warning to the driver of the large vehicle.
- Delivery of a warning to the person.
- Improved vision for the driver. (eg video cameras).
- Mechanism for driver acknowledgment of alarms.

Overriding these four is a requirement for the solution to be unaffected by weather, darkness or other adverse conditions.

Following this meeting a conceptual system design for the ultimate objective (a comprehensive collision avoidance system) was established which formed the basis for further technology identification and development (Figure 2)

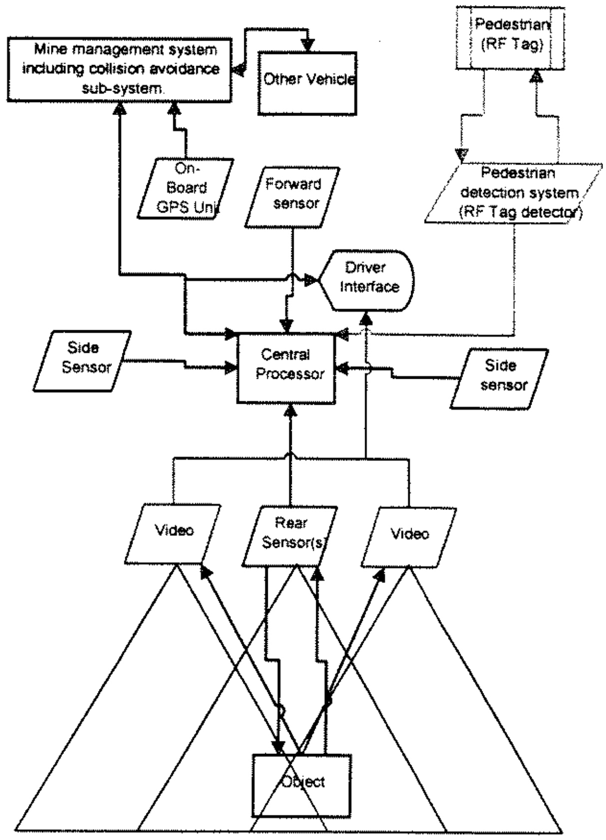


Figure 2

TECHNOLOGY IDENTIFICATION

The basic approach to this project is one of relative risk reduction. The criteria for success is essentially a system which provides a reduction in risk over the current system while achieving the primary goal, which is the removal of reversing alarms.

During the Singleton meeting it was decided that a fundamental component of the system should be that it gives the vehicle operator the ability to make informed decisions. In other words the driver should have more information about what is behind the truck. The driver, once inside the cab has no vision at all behind the truck and therefore no ability to alter his/her course of action.

Therefore the fundamental approach for collision avoidance is to give the driver better information and then to hold him/her responsible for making the decisions.

With all of this in mind a technology review was conducted.

Any prospective technology had to meet the following criteria:

1. It must be readily available.
2. It must be proven to be reliable.
3. It must fulfil at least one of the four key performance objectives.
4. The technology should be unaffected by adverse conditions.
5. It must provide a mechanism of positive identification (in order to avoid false alarms).

A thorough technology review was conducted using the internet, patent, searches and literature reviews. Two broad types of technologies appeared to be prospective. RF tags and Doppler Radar. Upon further analysis Doppler radar failed on Criteria 5 and was doubtful on criteria 1 for mine site application. Very good doppler radar systems are available in the USA for highway truck application but adaptation to mine use would be costly and positive identification remains a problem.

While radar systems have advantages in range finding and positive location, RF was chosen as the most likely to meet the critical objectives within the time and budget constraints.

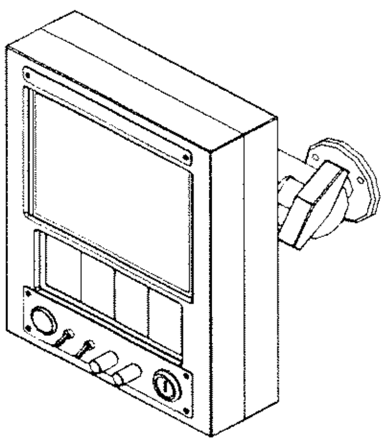


Figure 3

Video cameras were perceived by the DMR and some operators as being a crucial part of any truck system and were agreed in the Singleton meeting to be included as a mandatory part of the system. Some trucks are already fitted with video camera systems so these systems were not considered initially as part of the project. As the project progressed it became apparent that the video systems currently in use could be improved, so the latest video technology was included in the final system.

Radio Frequency tagging and high resolution colour video became the basic technological building blocks for the collision avoidance system.

CONCEPT DEMONSTRATION

RF test units were constructed and tested in controlled conditions. The test units consisted of off the shelf transmitters and receivers in the 433 MHz band which is currently used for remote controls. The test units were designed to give a 30 meter detection range and they performed to that specification consistently in a wide variety of conditions thereby proving the concept.

PROTOTYPE SYSTEM DESIGN

The pre-production prototype has been designed and constructed to include all of the functionality of the commercial system.

In practice the system positively identifies any tagged object within 25 metres of the rear of the truck (180 degree coverage) and provides a warning to the truck driver and the tagged object when the truck is engaged in reverse gear. The driver can then acknowledge the alarm by pushing a button. The rear mounted video camera gives visual coverage over a 90 degree arc to the rear of the truck.

The driver display unit (Figure 3) features a high resolution 7-inch colour TFT LCD monitor, a large four digit LED display, an alarm confirmation button and video monitor controls. The "smarts" of the system are also housed within the display unit.

The RF unit mounted on the rear of the truck features a transmitter and a receiver on independent frequencies and is connected by heavy duty shielded cable to the display unit (Figure 4).

The prototype system is designed to accommodate up to three cameras which can be placed anywhere on the truck.

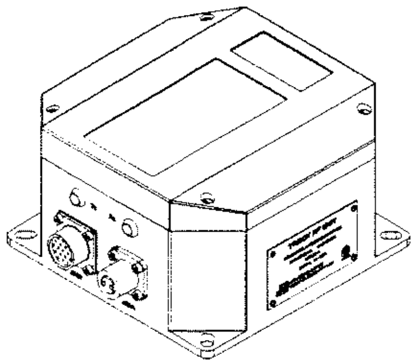


Figure 4

The high resolution colour cameras are housed in water proof housings with a high pressure air lens cleaning nozzle (Figure 5).

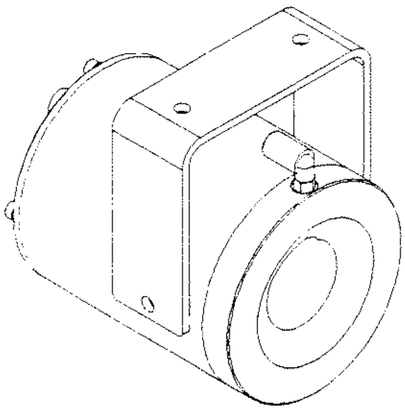


Figure 5

Two types of tags have been designed and built for the prototype demonstration, a light vehicle unit which is retro fitted to a roof mounted flashing beacon (Figure 6),

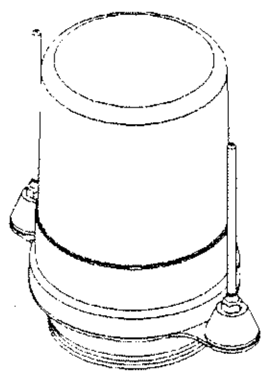


Figure 6

and small helmet mounted personal tag (Figure 7).

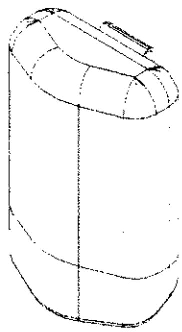


Figure 7

Both tags contain the same circuitry except the vehicle unit has externally mounted antennae and the personal tag antennae are mounted directly on the printed circuit board. The personal tag prototype weighs about 120 grams with a battery life of 24 hours (the batteries are most of the mass).

SYSTEM FUNCTION

The truck system will detect any tagged object within 25 metres of the back of the truck. The tags transmit an identification code which is deciphered by the truck mounted system and classified into three classes, eg light vehicle, person, fixed plant. The number of tags detected in each class is displayed on the LED outputs. The truck unit also conducts initial and continuous self checks to detect cable damage or any other malfunctions which are reported to the driver as EEEE across the LED outputs.

As the truck is placed in reverse gear it transmits a signal which is detected by the personal and light vehicle tags which then display a warning to the wearer or passengers. The personal tags flash high intensity LEDs through the visor of the hardhat. The light vehicle tags flash lights and sound an audible alarm in the cab.

All systems are independent in power supply and transmission frequency so that the failure of any one component does not compromise the other components.

A diagram of the system function is shown in Figure 8.

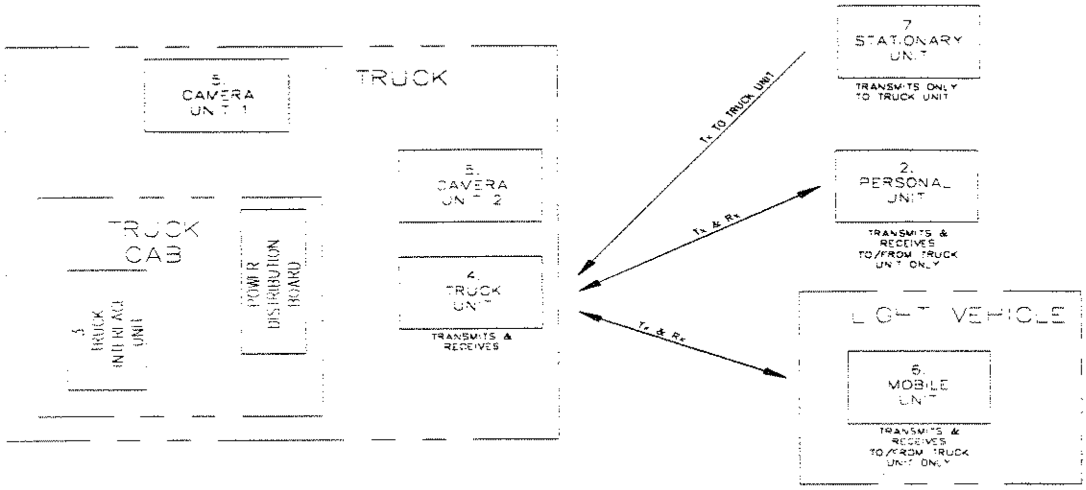


Figure 8

CONCLUSIONS

The four key performance criteria which were established at the initial risk review have been met. The RF system provides warning to the driver and to the person at risk. The video system improves driver vision and the driver interface provides for driver acknowledgment of alarms.

In addition, the system has been designed with redundant systems and the flexibility to accommodate various applications. In many cases where reversing alarms are not a noise problem this system will provide an advantage in that it can be used to protect light vehicles, items of plant and/or any other items of value from damage by truck collisions. The design is fully modular and thus can be easily modified to suit a variety of applications.

The system is currently being tested at Bengalla Mine. At the conclusion of this test a final risk review will be conducted. Once a reduction in risk over the current system is demonstrated, DMR approval should be given for the reversing alarms at Bengalla to be turned off.

Peripheral systems are in development including site access control systems, battery charging system, and systems for integrating with current mine management. Work is also currently progressing to extend the capabilities of the technology to cover forward movement and other types of collision risks.

ACKNOWLEDGEMENTS

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Grant Farrar, Maintenance Manager,
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REFERENCES

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