An integrated approach to forklift safety

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The use of mobile equipment such as forklift trucks to transport goods within industrial premises is widespread. Pedestrian operators may often work in close vicinity to this equipment. Unless mobile equipment traffic is appropriately managed there can be serious safety implications. As such, safe forklift operations are a major issue in many industrialised countries. Until recently, this topic was largely neglected by traffic psychologists. A long-term research program being undertaken at the Monash University Accident Research Centre (MUARC), Australia is seeking to redress this by working towards an integrated approach to forklift safety. The overall aim of the work is to develop improved systems of safe forklift management, and to help contribute to a substantial long-term reduction in forklift related injuries. It is asserted that this can be reached through the development of integrated forklift transport environments, particularly where the potential conflicts between forklift trucks and pedestrian workers are frequent. This requires a comprehensive site logistics and safety analysis, with particular emphasis on forklift driver behaviour, as a basis for countermeasures that focus on issues such as industrial facility design, improved operator training, clear and efficient traffic management and greater use of intelligent vehicle safety systems. This paper will outline key parts of the research program, especially focusing on the forklift driver behavioural components.

1. Introduction: plant and mobile equipment hazards

Industrial accidents and incidents involving plant are still commonplace in the developed world. For example, each year in Australia 200 deaths and 70,000 compensation claims involve workplace machinery, tools, appliances and equipment (National Occupational Health & Safety Commission (NOHSC), 2003).

Mobile equipment used in heavy industry is the specific class of plant of particular concern in this paper. Such mobile equipment includes forklift trucks, mobile cranes, trains and other rail vehicles, road vehicles such as cars and trucks, motorised hand trucks and other specialised industrial vehicles powered by electric motors or internal combustion engines (Occupational Safety and Health Administration (OSHA), 2003).

Perhaps the most commonly used type of mobile equipment is the forklift truck. The use of various types of forklifts has increased in recent years. Such vehicles are now essential tools in many manufacturing, logistics, retail and transport operations. They offer many economic benefits, such as a reduced need for manual handling of materials and improved operational productivity. Despite this, such vehicles pose a significant occupational hazard. For example, the National Institute for Occupational Safety and Health (NIOSH) estimated that each year nearly 100 workers are killed and 20,000 seriously injured from forklift use in the USA alone (NIOSH, 2001). Likewise, forklift deaths between 1980-1994 in the USA resulted in the loss of over 27,500 years of productive life; manufacturing and transportation being two of the worst offending industries (Collins, Landen, Kisner, Johnston, Chin and Kennedy, 1999).

Many workplaces in sectors such as manufacturing, logistics, transportation or retail have pedestrian workers operating in close proximity to mobile equipment. Such pedestrian workers are typically either moving to or from workplaces at times of shift commencement, shift termination or during breaks, or they are undertaking tasks in the workplace that cannot be conducted by mobile equipment or automation, such as maintenance or quality control. Most industrial mobile equipment such as cranes or forklift trucks are heavy, relatively fast-moving and powerful, and in comparison to cars used on public roads they are not explicitly designed to be crash tolerant if they come into contact with pedestrians. It is not surprising, then, that pedestrians account for a significant proportion of the fatality/injury figures. Pedestrian workers were involved in 45% of crashes involving such equipment (Larsson and Rechnitzer, 1994) and, of 48 mobile equipment related deaths between 1985 and 2003 in the Australian state of Victoria, 56% were pedestrian fatalities (WorkSafe Victoria, 2003).

In recent years, researchers have argued that many industries using mobile equipment have generally relied on controls that focus on operator training or the use of Personal Protective Equipment (Larsson and Rechnitzer, 1994; Horberry, Larsson, Johnston and Lambert, 2004). Such a strategy largely depends on a low incidence of operator errors; in view of the high accident rates it seems an untenable assumption. A more systematic and comprehensive collection of engineering and administrative controls appears needed.

2. Overview of mobile equipment safety countermeasures

As observed above, mobile equipment safety should progress beyond a primary focus upon operator training and Personal Protective Equipment. This approach is being increasingly accepted; for example, OSHA state that reducing the risk of forklift and other mobile equipment incidents requires systematic traffic management, comprehensive worker training, a safe work environment, a safe forklift and safe work practices (OSHA, 2003).

Other agencies around the world have made similar recommendations. For example, NIOSH produced a publication entitled '*Preventing injuries and deaths of workers who operate or work near forklifts*' (NIOSH, 2001). It covered the steps that workers should take to protect themselves. The publication also moved beyond focusing purely on front line operator behaviour to consider safety systems including training, the factory environment, and vehicle maintenance and operation. Likewise, WorkSafe Victoria recently produced guidance that considered both active and latent failures in mobile equipment usage (WorkSafe Victoria, 2003). This guidance covered traffic management advice (especially for the separation of pedestrians from mobile equipment), forklift selection, training, forklift speed and stability, incident reporting and legal requirements.

Similarly, suggestions, guidance and advice can be found in the open literature. For example, recommendations for greater use of seatbelts, better separation and systematic traffic control have appeared in academic journals (Collins, Landen, Kisner, Johnston, Chin and Kennedy, 1999). In a similar vein, an entire book about preventing powered industrial truck incidents and injuries has been published (Swartz, 1999). This included practical advice covering the costs of incidents, forklift design features, pre-use inspections, general safety rules (eg training) and pedestrian safety matters.

Standards in this area are also in place in many industrialised countries. For example in the USA, OHSA Regulation 1910.178 (Powered industrial trucks) contains safety requirements for the design, maintenance, and use of forklift and related mobile equipment (OSHA, 2003). To touch upon a few areas, this covers the lighting of operating areas, road surface conditions, pedestrian separation, traffic management principles and training.

A framework for operational safety that is becoming increasingly important (especially in larger organisations) is the use of Safety Management Systems. Such systems are integrated collections of work procedures and practices for examining and improving an organisation's safety and health (Civil Aviation Safety Authority, 2002). In part they often involve proactive hazard identification (through audits or other means), devising countermeasures, documenting procedures, identifying responsible people and integrating health and safety documents with operational documents. Thus in many progressive organisations mobile equipment safety is managed as part of an overall safety management system.

3. Overview of MUARC's research program

3.1. Undertaking problem assessments

Due to the diverse nature of industrial sites it is important that such sites are individually assessed to help develop appropriate countermeasures. Such assessment methods used have included:

- Empirical assessments, eg familiarisation tours, vehicle-pedestrian interaction quantifications and interviews with forklift drivers.
- Reviews of company documents. Useful information includes site maps, incident data, existing traffic flow management systems, examples of relevant risk assessments, a statement of the safety

policy, schedules for audits, the OH&S safety management system, site risk registers, codes of practice, and details of both new and ongoing operator training.

- Reviews of relevant previous research, standards and other literature.

3.2. Developing auditing tools and conducting industrial site audits

Conducting regular audits is an essential part of an effective Safety Management System. However, few mobile equipment audit tools used in industry are available in the open literature. In many ways this is understandable, given that such tools are usually developed in-house and it would serve no commercial benefit for an organisation to release them externally.

One mobile equipment safety audit used in the USA available for public scrutiny (University of Oregon, 2003) has a checklist of 24 items, however, it only covers basic issues concerning a safe environment, such as no electrical cords on the floor. WorkCover NSW in Australia produced a similar checklist that covered forklift pre-operation, operation, work environment, work processes and the operator (WorkCover NSW, 2002). Again, although a potentially useful document, it does not penetrate the safety issues very deeply; most of the questions are simply of a general 'yes/no' type (e.g. is there efficient workplace layout?).

Despite the dearth of comprehensive mobile equipment audit tools available in the open literature it is argued that auditing can be invaluable to assess if an industrial site has a potential safety problem. Audits are more proactive than relying solely on learning lessons from injury/incident records (although of course learning from incidents at work is also vital - see Koornneef and Hale, 1997). Likewise, audits can be more reliable and objective than relying purely on expert analysis to judge potentially unsafe acts, situations or procedures. The potentially quantitative nature of audits can be a valuable tool to judge observed safety performance against desired performance. Such quantification allows benchmarking against safety goals (eg 'zero risk'); in addition it allows comparisons to be made between similar sites or within one site at different times.

Given the potential usefulness of an audit approach to assess the safety of mobile equipment, and the lack of a suitable, easily available instrument, one objective of our research program was to develop auditing tools for organisations that use a large amount of mobile equipment in their operations. The audits designed are usually designed as a paper-based tool to take a 'snap-shot' of plant layouts, tasks, equipment, policies and personnel. They are developed from first principles and are intended to be an objective and systematic guide to assess the status of sites regarding mobile equipment safety. They would not uncover all the possible problems involving mobile equipment interactions with pedestrians or other equipment. They would, however, address a large number of factors that are known to affect safety in this area. Building on the stated aims of a semi-related survey instrument (the Work Safety Scale developed by Hayes, Perander, Smecko and Trask, 1998), the main purpose of such audits are to identify potential problem areas regarding mobile equipment interactions with pedestrians or other equipment. Potential problem areas identified in this way require more detailed investigation and possible correction using risk assessment techniques already established by an organisation.

3.3. Evaluating the use of Intelligent Transport Systems for mobile equipment operations

Work was undertaken by MUARC to assess the safety benefits of Intelligent Transport Systems[1] (ITS) for organisations that use mobile equipment. This work ranged from problem/issue identification and quantification, through to reviewing suitable ITS products. Technologies considered included purely in-vehicle systems, such as vehicle speed limiters and access controls, as well as systems that take into account the environment in which the forklift is operating, such as pedestrian proximity sensors.

[1] ITS is a broad term to describe developments in electronic, communications and computing technologies applied to transport services and infrastructure.

3.4. Developing generic safe forklift systems design concepts

In this work, relevant principles of traffic safety and information ergonomics were applied to some typical areas of logistics and transport management design. For example, a full literature review was undertaken; this included a review of international trends in research and development in relation to logistics, transport, and safe forklift management. Based on this, architecture /design blueprints, where systems and logistics parameters were defined, were produced. Two generic blueprints were produced for a transport terminal and a distribution centre.

3.5. Producing a guidebook of industrial traffic management and forklift safety

A guidebook was developed and disseminated to major mobile equipment using organisations in Victoria, Australia. It provided practical advice and commentary regrading logistics and forklift traffic management. It examined and illustrated a number of key issues with respect to industrial traffic management and forklift safety, this included:

- Logistics, design & safety
- People and tasks
- The site and building
- Management of the traffic system
- Forklift features
- Forklift accessories

The guidebook contained a large number of specifically produced 3D graphic images that were created by professional 3D graphic designers working with the MUARC team. Figure 1 below shows an example of the images created.

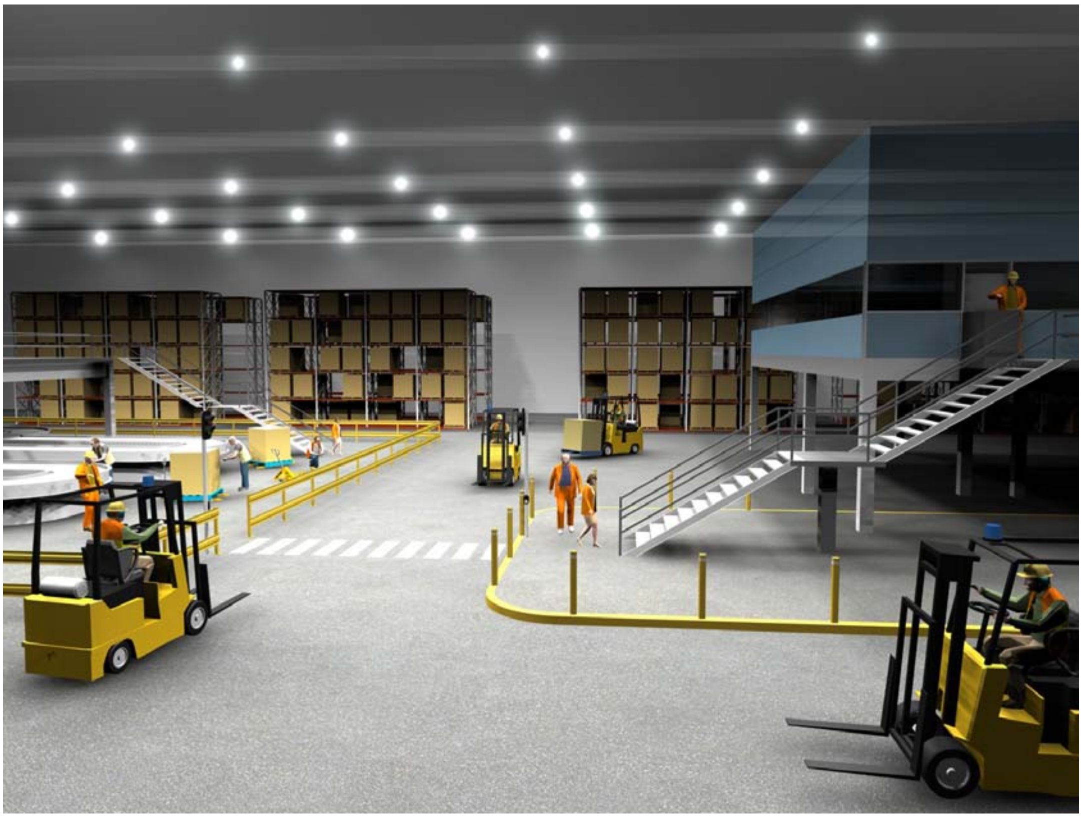

Figure 1: 3D image (computer generated) of a possible operating environment for forklifts.

3.6. Undertaking forklift stability tests

Extensive empirical testing and modelling work was performed by the project team, especially to assess forklift stability. The results of this work were disseminated to organisations in Victoria, Australia by the State occupational health and safety agency (WorkCover Victoria).

3.7 Conducting a demonstration project

A forklift safety demonstration project was undertaken at two manufacturing sites in Victoria. The design was a '*before*' and '*after*' case study, in which behaviour of forklift and production staff at two sites was assessed both before and after a series of traffic and vehicle engineering interventions were implemented. This work was published by Horberry, Larsson, Johnston and Lambert (2004). That paper describes the background to the demonstration project and briefly introduces the methods used to assess operator behaviour with regard to the forklifts. Thereafter, it describes the overall nature of the safety interventions proposed. It then summarises the results of the actual interventions upon operator behaviour and opinions. Finally, it discusses these results and draws conclusions based upon them.

A guidance note about methodology was also disseminated to Victorian organisations by WorkCover Victoria. It was designed to be an aid to organisations that use forklifts or similar vehicles in their workplaces, and gives advice regarding how to assess the effectiveness of safety changes to workplaces. It describes a way in which the actual behaviour of forklift drivers and pedestrian workers can be easily recorded and objectively quantified.

4. Conclusions: impact on research, practice and policy

As seen above, a large number of different activities have been undertaken as part of this overall work program. Where possible, the researchers have disseminated the results in academic journals, at conferences, in industry trade shows and through guidebooks. The project team has worked with a range of stakeholders, such as large organisations using mobile equipment and government agencies responsible for occupational safety, to gain maximum impact from the work.

It is expected that such activities will help improve systems of safe industrial mobile equipment management, and contribute to a substantial long-term reduction in severe forklift related injuries. Likewise, it is anticipated that our information, methods and results will help develop further scientific research in this area. Finally, it is hoped that forklift safety will be seen as a legitimate part of transport psychology in which behavioural scientists can have a valuable role to play.

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