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LEARNING TO TRANSITION ACROSS ELEVATED WORK PLATFORMS: VIRTUAL CONTROL TRAINING VIA MOBILE TECHNOLOGY

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Abstract

An estimated 120 variations of elevated-work platform (EWP) control panels are currently in use across Australian construction worksites. Transitioning across dissimilar control panels is highly problematic. As a way of mitigating the issues caused by transitioning between control panels, many regulatory and coronial recommendations suggest that operators should pay particular attention to reading and comprehending EWP model-specific manuals. Yet, many EWP operators may have either a low level of literacy or be unable to take the required time off a busy job site to do this effectively. This paper reviews current issues faced internationally with regard to operator transference between EWP control panels and discusses these in relation to current theories from aviation human factors on the risk arising from control variations. In particular, categorisations of controls that are used to differentiate between aircraft flight deck variations are applied to contribute to current knowledge on control variation issues that continuing education in EWP competency need to consider. The development of a control simulator which can be deployed on worksites via mobile technology is discussed in terms of new approaches to the ongoing training and assessment.

Keywords: Simulation, Continuing Education, Elevated Work Platform, Controls, Transitioning.

1. Introduction

Over the five years from 2008-2012, a total of 211 construction workers died in Australia from work-related injuries, nearly twice the national rate, with serious injuries occurring at more than 1.5 times the national average (SWA, 2013). The social and economic cost of falls from heights costs approx. $5.6 billion annually (SWA, 2014) impacting injured workers, employers, the construction industry and the nation. To reduce the number of deaths from falls, Elevated Work Platforms (EWP) ranging from simple scissor-lifts and telescopic-lifts, to more complicated knuckle-booms are increasingly being used. Although the number of fatalities caused by falling from height has decreased, fatalities and injuries associated with EWP use is now a significant cause of death for construction workers with EWP fatalities and serious injuries occurring during incidents involving overturning, entrapment, falling and collisions (White Card EDU, 2014).

Crush injury in particular is a silent killer, in most cases with the operator caught in a crush accident with little or no warning. Operators working at heights in unfamiliar and changing environments are increasingly exposed to crushing events for both experienced and novice operators. Commonly identified situations where crushing hazards are present are; 1) driving the EWP at height around and under structures; 2) manoeuvring into or around a confined area; 3) rough operation of controls; 4) distraction while operating. It can be argued that these hazards exist on every work site and operators are aware. But the fact remains that operators have continued to fall victim to crush injuries (Middleton, 2016). The complexity of workplace activities means that EWP modifications undertaken to address the dangers (e.g., protective rails and shrouds) are sometimes ineffective; and in some cases are the causes of accidents (White Card EDU, 2014).

Significantly, accidents and fatalities during the operation of an Elevated Work Platform (EWP) are increasing both nationally and internationally with design issues and the adequacy of training now under scrutiny. A 2015 study undertaken with 460 Australian EWP operators by Workplace Health and Safety, Queensland (WHSQ) found 80% of operators reported their biggest concern was the array of differences apparent in the control panel presentation and layout across the wide variety of EWP types and brands (Geinitz, 2015). That is, as seen in Figures 1 to 3, the arrangement of switches, levers and dials used to manipulate the EWP are not consistent. Several EWP brands and types can often be found in the use on the same construction site and across Australia, it is estimated more than 120 variations of the EWP control panel are in use (Tichon, et al., 2016).

Figure 1. Multiple Joysticks, fewer switches

Figure 2. One Joystick, multiple levers

Figure 3. Multiple switches, no Joysticks

In Australia, the construction industry, aware of this issue, requires those involved in work using EWPs are familiar with their operation and the use of emergency controls. The Occupational Health and Safety Regulation 2001 (Clause 264B), recommends a EWP is operated by a person who follows the EWP manufacturer's manual. Yet in Australia, it is recognised that many workers holding EWP licences have low levels of literacy. As a consequence, they are not required to read training materials but must only 'be able to understand and communicate to the trainer' (EWPA, 2015). Internationally, it is also recognised, because of model variations, training needs to be specific to the type and model of equipment being used (Build Safe UAE, 2010).

In summary, operators are currently required to read EWP manuals prior to transitioning to another model of an EWP in order to understand any differences in controls specific to each model, yet many workers are recognised as not possessing the reading skills to do so nor is time on busy job sites adequate to read a full manual. They receive training for their operating licence on only one EWP control panel. This paper outlines current issues faced internationally with regard to operator transference between EWP control panels. In order to understand these issues, this paper first explains current theories from control and applied human factors knowledge in aviation. These theories are then applied to the author's filed research experiences in an Australian construction training site in order to reconceptualise the current issues confronting EWP practice.

2. National and International Progress on EWP Safety

EWP accidents and fatalities appear to be occurring at similar rates internationally, with recommendations from inquests focusing on training. A New Zealand fatality resulted in a recommendation that 'all operators of EWPs must be suitably trained' (Transpower, 2011). In the United Arab Emirates (UAE), for instance, the recommendation following a double fatality of operators who had generic EWP training was, 'training should be specific to the type and model of equipment being utilized' (Build Safe UAE, 2010). The International Powered Access Federation (IPAF) a not-for-profit organization owned by members including manufacturers, rental companies and contractors aiming to promote safe and effective use of EWP recommend operators check directional movements with direct reference to controls before moving a EWP (IPAF, 2014).

Some EWP manufacturers have responded to the high risk by providing anti-entrapment devices such as a frame fitted to the basket that provides a 'safe zone' (SWA, 2014). Physical barriers have a large presence, which may limit the operator's ability to carry out work and in some cases in advertently create a crush situation (Middleton, 2016). In 2014, an Australian worker using a EWP was crushed between the so-called protective rail of the EWP workbasket and an overhead steel beam (White Card EDU, 2014). Not surprisingly, a British study has concluded machine control covers are a major concern and some fatal incidents could have been prevented if machines had not been fitted with covers (White Card EDU, 2014). Another common type of guarding is pressure sensitive pads. These pads remove the bulkiness of anti-entrapment devices; however, the operator must be crushed between the sensors and the structure, before it will activate (Middleton, 2016).

Physical safety devices alone are; therefore, insufficient to prevent accidents. Currently, as a result, the management of crushing has been left to sit firmly with the operator. To minimise the risk of a crushing injury, the operator is required to remain vigilant, stay wholly within the basket, never lean over the control panel and make use of a spotter among other requirements (Middleton, 2016). If responsibility for managing crushing risks is to be left with the operator, whose main focus is the efficient completion of their tasks, the number of crushes may continue to grow unless the problem of control variations across EWP models are addressed as a priority.

In other sectors, the problem of control selection errors during heavy equipment operation has been highlighted as a serious issue and investigated. Of particular interest is work that was undertaken in the Aviation sector investigating the issue of pilots flying similar, but not identical aircraft. This work demonstrated that pilots had significant issues both at an operational (Mavin, et al., 2015) and cognitive level (Roth, et al., 2014) when required to transition between the controls of different aircraft types.

3. Transitioning Between Aircraft Types

The mix of aircraft required to meet the specific needs of an airline vary dramatically. Airlines that fly long international sectors may require aircraft such as the Boeing 777 or Airbus A330. As routes become shorter, small jet aircraft can be used such as the Boing 737 or Airbus A320. In fact, turboprop aircraft rather than a jet aircraft can more effectively service shorter sectors with fewer passengers. Here, the Airbus ATR72 or Bombardier Dash-8 aircraft transporting 30 to 70 passengers in smaller airlines around the world.

To maintain a competitive edge, aircraft manufacturers must continuously be involved in testing and development of aircraft systems, fuselage and wing design, as well as engine advancements in both thrust and efficiency. When a new aircraft is designed, major aircraft manufactures have generally updated current models rather than go for a complete redesign. These newer designs which are based on older models are referred to in aviation as "variants". For example, the Boeing 737-100 series was introduced in 1965; the 737-200 series in 1967, the 737-300, 737-400 &737-500 series from 1984 onwards and in 1996 Boeing began manufacture of the737-600, 737-700 and 737-800. This updating process allows airlines to operate two aircraft at the same time during the replacement period. Pilots are required to be trained to fly the newer aircraft and in many cases, the newer variant is similar enough to the older variant to allow both to be flown at the same time by the pilots. This has a great effect on reducing pilot numbers during such a transitioning period, and in most cases, is one of the key reasons an airline will retain a similar aircraft type for many years (Soo et al. 2016).

Over time, this practice has continued, though research into aircraft variants has generally been limited to investigating issues where pilots experienced performance difficulties when 'forward' transitioning onto new variants (e.g. Wiener, 1989; Sarter & Woods, 1992; Sarter et al., 2003). For example going from the 737-200 to the newer 737-300. The majority of these studies tended to focus on pilot issues going from older analogue flight instruments to newer flight instruments replicated by computer screens. Further issues investigated included problems pilots experienced with both the increased use and complexity of automation in the flight deck (Parasuraman, 2000). Yet little if any research had been conducted on how pilots transition (a) back to an older variant, or (b) between variants during a time when the airline moved from an older version to the new aircraft.

4. Recent Investigations into Transitioning Between Two Aircraft Types

In recent years, a new aircraft type the ATR72-500 was updated to the ATR72-600 series. Here, the major change was with the flight deck (arrangement and types of controls, switches and instruments) of the aircraft. Pilots would be required to transition back and forth between the two aircraft types. This procedure is referred to as Mixed Fleet Flying (MFF) and is an approved practice (Soo et al., 2016).

A study was undertaken to ascertain if the practice of Mixed Fleet Flying was feasible with these aircraft variations. Pilots with previous extensive experience on the ATR72-500, but had transitioned onto the newer ATR72-600 were asked to return to and fly the ATR72-500 simulator. The aim was to identify possible issues that occurred in moving back and forth between different control types and layouts. It was discovered that pilots had numerous difficulties with the task. Each issue or problem was categorised under areas such as (a)flight instruments, (b)presentation, position and functionality of secondary instruments, switches and dials, (c)automation, (d)flight management computer, (e)electronic checklists and (f)general issues (Mavin, et al., 2015).

The most concerning finding from the study was that often the pilots were unaware of the issues and problems. Moreover, the cognitive study revealed that delayed actions and missing or misunderstood calls that had serious implications for performance were more serious than flight crews realized. Importantly this study developed a two-by-two table based on the heuristic model of analysis used to assist the categorisations of the control issues addressed above (see Figure 4).

Even though the problems identified in this initial study revealed issues, the way in which they had been initially categorised (via systems such as automation) did not fully encompass the difficulty pilots had encountered. As a way of enhancing the categorisation, a two-by-two table was used (see Figure 4). Here, the issues were looked at in two ways. Firstly, the actual presentation of the switch, dial, lever or instrument was investigated. If there was no difference between the two variants, then it was considered "same".

If however the switch, dial, lever or instrument was moved to a different place, changed in presentation, or had a completely new presentation, then it was considered "different". This was used even if the difference was slight. For example, the engine instruments in the new variation of the ATR72-600 had slightly changed (less then 10cm) position. However, the impact of this 'slight' difference was great. The pilots' eyes were found to initially go to the wrong location during the engine start procedure. In one case, for example, the pilots required four engine start procedures before they became familiar with the position of the instrument and their eyes began to automatically shift to the new control location (Mavin, et al., 2015).

It became evident when transitioning between aircraft variations that a period of time was needed to build a level of automaticity in which pilots' eye movements follow an automatic scanning pattern learned from repeated operation of the same controls. The theory of automatic processing postulates that certain task components can be 'automatized' and performed with little demand on cognitive resources (Cannon-Bowers & Salas, 1998). This is particularly critical in using controls for heavy machinery whether an airplane or an elevated work platform. Most likely, operators eyes and hands follow an automatic pattern of movements built by on a previous control panel prior to being required to transition to a new, different layout.

Figure 4. Function versus Presentation/look of Eelevated Work Platform controls

Physical Presentation/look	Function: Same	Function: Different
Same	Risk Level 1. Same/Same (Looks and functions the same)	Risk Level 4. Same/Different (Looks the same but function is different e.g. light switch in USA vs Aust).
Different	Risk Level 3 Different/Same (Looks different but functions the same eg. Joystick replacing up & down levers)	Risk Level 2. Different/Different (Looks different and functions differently e.g. IBM versus Apple computer operating systems)

Once a switch, dial, lever or instrument had its presentation or 'look' categorised, it was further categorised for functionally. If a switch, dial, lever or instrument functioned exactly the same, it was categorised as the same. If however there was a change in the functionality, it was seen as different. For example, the airspeed indicator of the ATR72-600 initially looked like the traditional speedometer of a car, whereas the new version presented the speed moving up and down a vertical tape, with airspeed presented as a digital number. However, while different in its presentation/look, it actually functioned in the same way. Hence, it was given an overall clarification of different/same. In some cases a system looked exactly the same though had different functionality. For example, a single automatic pilot switch did look the same, but had a different function altogether. It was categorised as same/different. All systems were categorised in this way and placed in Figure 4 (Soo, et al., 2016).

What was striking was that this categorisation approach allowed degrees of difficulty to be anticipated. In the *same look/same* function category, there were no issues identified. This makes sense, as these will be treated by the pilot or operator as usual and prior to transitioning. In the scenario of *different look/same* function, while initial issues of interpretation were made, the pilots quickly adjusted to the situation with no further issues. With the *same look/different* function scenario, the pilots found themselves in trouble. Here, with controls or switches presenting or looking the same, there were assumptions made on its function. That is, once a switch was pushed or turned on, the pilots went on with other tasks in the belief the systems would act in a particular way. Pilots were unpleasantly surprised when the system acted differently to what was expected.

What this means for Elevated Work Platforms

With reference to the two-by-two table in Figure 4, the authors applied examples from EWP filed studies (see Tichon, Diver, Kikkawa & Diver, In review) to further understand the impact of transferring between control variations. The heuristic model indicates degrees of risk in the following ways:

Risk Level 1: Same/ Same

Similar to aviation studies, in the same look/same function category, there were no issues observed in EWP operations. This makes sense as these controls will be treated by the EWP operator as prior to transitioning. Therefore, the level of risk resulting in a control error in this category is low.

Risk Level 2: Different/ Different

When an operator learnt to use a new control with different look/different function, the process of learning is similar to one of a new student who is gaining their initial licence to operate a EWP. That is, both the operator and novice will pause their actions to assess the situation in order to make the correct control selection, instead of selecting controls without an underlying cognitive evaluative process. During observations of novice operators, the cognitive process of assessing and deciding on each control was frequently observed (Tichon, Diver, Kikkawa & Mavin, in review). As the operators were taking extra time and care to familiarise themselves with controls in this category, the level of risk was low.

Risk Level 3: Different Look/ Same Function

When a control looked different, but functions the same there were initial hesitancy in interpretation but there followed no further issues. The following example highlighted that different look with same function helped the novice operator to understand the initial movement required to operate the control (RIT2_14-20):

Novice referring to controls of a Boom-type EWP: 'The controls seem like the ones on the scissor lift too.'

> Researcher: 'Okay, is the scissor lift the same as this?
>
> EWP Instructor: 'The actual joystick is the same joystick, more or less, that we use to steer.'

However, as discussed earlier, the slight change in control look made a possible error more likely when learning and using the new controls. Therefore, the rick level is considered to be higher than the previous two categories.

Risk Level 4: Same Look/Different Function

With the same look/different function category, similar to the pilots, the EWP operators experienced difficulties. When controls looked the same, there were immediate assumptions that their function would be the same too. That is, the operators would push the joystick forward or backward in the belief the systems would act in their anticipated manner. In one example, even an experienced instructor was surprised when the EWP reacted differently to what he expected when he was demonstrating EWP operations on a machine he was unfamiliar with:

EWP Instructor: 'The joystick on our machine that I normally use, takes the boom up and down. What I did there, was I went to bring the boom up, pushed the joystick forward and actually travelled forward....so actually I pushed a wrong control here. (Instructor comments in RIT1-32)

If EWP safety is to be improved, there are lessons to be learned from the both the aviation experience and the field observations of EWP operators using varying models of equipment. Some key points to be considered in construction and for other industry users of EWP are:

Use of controls on EWPs, as in aircraft, can lead to high degrees of automaticity in operators. In stressful situations, operators react using these early learned physical responses, which can involve incorrect responses for the current piece of equipment being used.

Operators using varied control panels create risk. Interestingly, the more complex and different a control panel, the less the risk caused by automatic processes, as the automatic response is to 'stop' due to the requirement for new cognitive processes to be formed in order to work the system. For example in Figure 4, the different/different category usually led to a pause in operation while the new configuration was assessed.

The two areas of greatest risk were found to be: when controls look the same but have a different function, and when controls look different but have the same function.

All levels of variability of control panels may lead to an incorrect response.

Time spent familiarising operators with different control panels to build new and relevant automaticity is essential and should be documented.

The aviation experience demonstrated that expecting pilots to work with variations across control panels led to increased risk of errors. Likewise, EWP operators working across variations in control presentation and function combinations will continue to experience increased risk of error unless dedicated transitioning training, and documentation become part of the construction landscape.

5. Training Via a Portable Control Simulator

While EWPs provide an effective fall prevention measure, national and international data reveal the number of deaths from EWP have increased considerably all around the world (White Card EDU, 2014). Despite this, there appears to be no current research investigating the issue of operators being required to transition among multiple control panels or how to solve the problems this creates.

At least 30% of construction workers are immigrants and almost 50% of the Australian construction workforce does not have the literacy skills to use or understand typical work force documents (Breslin, 2011). EWP manuals are usually in English with some providing limited pictograms, however explanations of pictograms are in English (Breslin, 2011). Yet understanding the layout and role of controls is generally addressed via directives requiring 'if the operator is not familiar with the specific make and model, instruction are to be provided using the Manufacturer's Operators Manual' (Genie Safe Work Method Statement, 2012).

Despite the international requirement for operators to have knowledge of an individual EWP operations manual specific to make and model prior to operation, no formal evaluation has been undertaken to determine how a training curriculum or supportive training technology such as simulation could deliver this requirement. As part of a larger research program of which the project described here commenced, we are investigating innovative training technologies that have the potential to significantly impact the effectiveness of EWP training by spurring further development of new theory and methods for curriculum inclusion of safety-critical circumstances. Focus is on how to design and deliver effective transitioning training to address the problems the lack of emphasis of competency on specific EWP control layouts creates.

Of key interest is automatic processing theory. Automatic processes are fast and effortless and are not easily altered by a person's conscious control and, once initiated, tend to run through to completion (Kirlik et al., 1998). This can be problematic when transitioning across controls if a new muscle memory has not been built through training to account for a control variation. The ideal target for transitioning training is to achieve new automatic processes for operators for each control layout before use. Automatic processes may be developed only through extensive practice under consistent conditions which is typical of many skill acquisition situations. On the basis of automatic processing theory, many other industries particularly the military have successfully used simulated part-task training to improve performance in manipulating new control panels (Kirlik et al., 1998).

Recent developments in light weight, mobile virtual reality (VR) and augmented reality (AR) devices are readily adaptable for training to support transitioning familiarization and automatic processing on differing EWP control panels without the need for reading literacy. In the larger project, we are testing such visualisation based training to bridge the language gap between manuals produced by international companies. Currently, work is underway on the development and testing of a prototype. This technology also supports the recording of user's actions and results where over time individual work history on specific models of EWP and hours of use on each model can be quickly ascertained prior to determining transitioning training requirements.

At the individual operator level the database records the type and models an individual has experience with and how many hours of training he/she has received on each. This is important as it can take 3 times longer to inhibit old operating habits for new ones when developing an automatic process. How recent or not an operator has been exposed to a specific model and results from previous tests on these models provide quality information to enhance safety outcomes. On site a mobile control simulator provides immediacy of assessment playback of the training session with trainer in addition to a record of training provided and competency level achieved for any third party verification purposes required by the employer.

The technology supports the incorporation of a number of other performance evaluation innovations onsite for the employer. For example, the recorded performance data can guide decisions on which EWP models/types to hire and may be indicators of safer combinations to require staff to transition between. It can do this by offering new insights on how to safely support use of multiple control panels through comparison data across any two consoles – which transfers result in fewer errors? Which transfers result in the highest number of errors? In develop and analyze of this data in future work, we will be seeking to add to current knowledge on how best to safely support multiple ticket holders. By comparing data across any two machine types, such as EWP and excavators, we will be able to ascertain which transfers and in what direction result in less errors?

Scenarios on the prototype have been designed to raise awareness of new configurations on a EWP currently in use by giving direct comparisons with any models previously used by an individual operator. Once the user is familiarised with the new console layout and EWP operation they are taken through demanding tasks which test their ability to adapt to changing environments that underline the importance of also being spatially aware of the both the console layout and movement of the machine parts. The EWP transitioning trainer is not just a EWP simulator, but rather a training application that educates the user about potential dangers when incorrect assumptions are made regarding a console layout and trains the operator to think about the console controls before use. It is intended for use immediately prior to transitioning from one EWP model to another.

Conclusion

How Aviation came to understand the problems inherent in transitioning between control layouts is compelling for Elevated Work Platform training and work practices. What appears at first to be a relatively straight forward two-by-two categorisation of similarities and differences in control function and appearance reveals an important relationship between automatic processes and their impact when there exist even limited unexpected variances in controls. The greater the expectation of operators that a panel will perform the same as a previous one, usually through the existence of some level of similarity, the greater potential for errors when even one or two controls do not conform to expectation. In conclusion, any level of variability of control panels may lead to an incorrect control selection.

It is an economic reality that many industries require workers to complete tasks using different types of equipment but this only increases the imperative that issues arising from this practice are addressed appropriately. The current problematic practice of issuing EWP operators with a generic license for multiple EWPs is currently being further examined via mobile, visualisation-supported transitioning training targeted to the model specific level. This portable control simulator targets control errors by preserving a temporal map of each control location and function. Repeated exposure to the training modules builds automatic processing specific to the type and model of EWP being operated.

Conflicts of Interest None.

References

i. Breslin, P., 2011. Eliminating Falls from heights in the Australian Construction Industry: How effective are elevating work platforms? *Australian Construction Safety Journal* 1(2), pp. 0-17.

ii. Build Safe UAE, 2010. *Man Lift Fatalities,Safety Alert #413*. [Online] Available at: http://www.ewpa.com.au/uploads/Safety%20Guidance%20Notes/Safety%20Alert%20413%20-%20Man%20Lift%20Fatalities.pdf

iii. Cannon-Bowers, J.A., Salas, E., 1998. Indidivual and Team Decision Making under stress: Theoretical Underpinnings. In J Cannon-Bowers & E Salas, eds.*Making decisions under stress*. American Psychological Assoc: Washington, DC.

iv. EWPA, 2015. *Yellow card participants with inadequate reading and writing skills.*[Online] Available at: https://www.ewpa.com.au/resources/information-sheets

v. Geinitz, B., 2015.*CTC Safety Series – EWP Safety. March 4. Queensland Construction Strategy Unit, Workplace Health & Safety Queensland*.[Online] Available at: http://www.ctc.qld.edu.au/ctc-safety-series-ewp-safety/.

vi. Genie Safe Work Method Statement, 2012.*Job Safety Analysis Worksheet. Reference # SWMS-Electric-Slab Scissorlift*. [Online] Available at: http://genielift.com.au/site/assets/media/Service/Safe-Work-Method-Statements/Genie-E-Series-Slab-Scissor-Lift-Operation.pdf

vii. International Powered Access Federation, 2014.*IPAF Guidance for Instructors and EWP Operators: Important do's and don'ts to avoid trapping/crushing injuries while working in a EWP platform*.[Online] Available at: http://www.ewpa.com.au/uploads/ Information%20 Sheets/AvoidingTrapping.pdf.

viii. Kirlik, A., Fisk, A., Walker, N., Rothrock, L., 1998. Feedback Augmentation and Part-Task practice in training dynamic decision making skills. In J. Cannon-Bowers & E Salas, eds. *Making decisions under stress*. American Psychological Assoc: Washington, DC.

ix. Mavin, T.J., Roth, W-M., Soo, K., Munro, I., 2015. Towards Evidence-based Decision Making in Aviation: The case of Mixed-Fleet Flying. *Aviation Psychology and Applied HumanFactors*, 5(1),pp. 52-61.

x. Middleton, P., 2016.*Managing Crush, wearing of harnesses in scissor lifts and complinace around VOCs, Elevating Work Platform Association of Australia*. [Online] Available at: http://ctc.qld.edu.au/ctc-safety-series-ewp-safety/

xi. Parasuraman, R., 2000. Designing automation for human use: empirical studies and quantitative models. *Ergonomics*, 43(7), pp. 931-951.

xii. Roth, W.-M., Mavin, T.J, Munro, I., 2014. How a cockpit forgets speeds (and speed-related events): toward a kinetic description of joint cognitive systems. *Cognition, Technology and Work*, Volume 17, pp. 279-299.

xiii. Sarter, N. B., Woods, D. D., 1992. Pilot interaction with cockpit automation: Operational experiences with the flight management system. *The International Journal of Aviation Psychology*, 2(4), pp. 303-321.

xiv. Sarter, N., Wickens, C., Mumaw, R. J., Kimball, S., Marsh, R., Nikolic, M., Xu, W., 2003. Modern flight deck automation: Pilots' mental model and monitoring patterns and performance. In *12th International Symposium on Aviation Psychology*, 2003.

xv. Soo, K., Mavin, T. J., Roth, W.-M., 2016. Mixed-fleet flying in commercial aviation: A joint cognitive systems perspective. *Cognition, Technology and Work*, Volume 18, pp. 449–463.

xvi. SWA, 2014. *Work-related fatalities associated with unsafe design of machinery, plant and powered tools, 2006 – 2011*.[Online] Available at: http://www.safeworkaustralia.gov.au

xvii. SWA, 2013. *Work-related injuries and fatalities involving a fall from height*. [Online] Available at: http://www.safeworkaustralia.gov.au

xviii. Tichon, J., Diver, P., Kikkawa, Y & Mavin, T., n.d. *How students learn to operate an elevated work platform: The practice of 'trying out' controls*, s.l.: s.n.

xix. Tichon J., Mavin, T., Diver, P., Dyer, K., 2016. *Part-task training for safe operation of elevated work platform (EWP) controls.Poster Presentation at HFESA 2016 Conference, Gold Coast*.[Online] Available at: https://www.ergonomics.org.au/resources/hfesa-conference-proceedings/conference-proceedings-2016-conference [Accessed31 Aug, 2017]

xx. Transpower, 2011. *First Alert: Use of Elevated Work Platforms Update number 2*. [Online] Available at: http://www.ewpa.com.au/uploads/Safety%20Guidance%20Note s/Alert% 20rom %20NZ%20July%202011.pdf

xxi. Weiner E.L.,1989. Human Factors of Advanced Technology (Glass Cockpit) Transport Aircraft, *NASA Contract Report 1989*.

xxii. White Card Edu, 2014. *Elevating Work Platform Safety Alert Issued after Worker Fatalities*.[Online] Available at: http://www.whitecard.edu.au [Accessed Oct 5, 2014]