as "posture with some harmful effect on the musculoskeletal system – corrective actions required in the near future" (the second lowest of four risk categories).[22] OWAS scores take no account of the relatively brief duration of this trunk posture as a proportion of the overall delivery process. On the other hand, the *frequency* of this posture is in fact higher with SBD than with the current process, so the associated risk cannot be dismissed as necessarily trivial.

Another potentially hazardous aspect of retrieving mail from a pannier bag could be the velocity and accelerations/decelerations of lateral and twisting back movements ... that is, the *dynamic* aspects of this trunk posture. This source of risk is not addressed by any of the above methods, but its potential importance has been clearly established by researchers using a highly specialised piece of equipment – the Lumbar Motion Monitor. Using this equipment they have shown that risk of back injury is significantly affected by the velocities and accelerations of lateral bending and twisting movements of the trunk. In the present case, it seems likely that such velocities and accelerations would be influenced by the extent to which PDOs felt subject to time pressures during the delivery process. Unfortunately, it was not feasible within the present project to measure these task parameters.

From the above, it was concluded that the posture entailed in reaching and extracting bundles of mail from the pannier bags is potentially hazardous, but current methods do not support quantification of the extent of this risk.

Additional biomechanical calculations

Another possible source of increased risk with SBD versus the current delivery process was first identified by some of the interviewed PDOs, who attributed increased levels of aches/pains in their legs or lower back during the SBD trial to the greater time spent supporting the motorcycle with their lower body when stationary at delivery points. According to data supplied by Australia Post, total time spent supporting a stationary motorcycle would be longer with SBD than with the current process, by something of the order of 15 to 20 minutes for a standard round.

[22] As with RULA and OCRA, the wording of OWAS risk categories should not be taken literally.

This was a plausible source of increased risk, but it could not be assessed by any of the existing risk assessment methods. Therefore, some biomechanical loads were measured to estimate the required supporting/ restoring forces exerted by PDOs when astride a stationary motorcycle on level ground.

It was found that for a PDO of around average height, standing astride a stationary motorcycle causes one leg to be more heavily loaded than the other. According to analyses for the shortest of the three Subjects, whose height was 169cm (69^{th} female percentile), the more heavily loaded leg supports a force 26% higher than in a normal upright stance. In addition, it was found that a significant *lateral* force must be exerted through the lower body to support the motorcycle. This posture and associated forces would subject the lower back to asymmetrical loading, which is known to be hazardous.

This finding is important in light of the longer expected time spent supporting a stationary motorcycle with SBD. Little or no associated increase in MSD risk for very tall PDOs would be expected due to SBD, but for those of average or short stature, the increased time spent with legs astride and supporting a stationary motorcycle may increase risk – particularly for the back and perhaps also the hips/legs.

However, it must be emphasised that the above calculations were necessarily based on some assumptions which, while reasonable, are subject to error. Also, the *extent* to which risk might increase is not predictable.

4. DISCUSSION OF POTENTIAL EFFECTS OF SBD ON OHS

The initial focus of this project was on OHS impacts of the SBD process, looking mainly at those due to changes in PDOs' *mental workload.* Subsequently, the project was expanded to include OHS impacts due to changes in the *physical demands* experienced by PDOs using the SBD process, focussing particularly on MSD risk. Any other foreseeable sources of risk were also to be addressed.

It was shown that PDO mental workload was substantially higher during the SBD trial (Figures 1 and 2, Section 3.1). Further, it was found that some of the physical demands imposed by the SBD delivery process are higher than with the current system. In the following sections, potential OHS implications of these increases are discussed.

4.1 How does mental workload affect OHS risk?

First, it is important to remember that high levels of mental workload are not *necessarily* risky. Mental workload levels should be sufficiently high to maintain some challenge and interest. OHS risks can increase when mental workload levels are excessively high, but also when they are too low with resultant boredom and lack of job satisfaction. In the present context, OHS risks would be expected to relate mainly to the possibility of mental workload being too high rather than too low.

Mental workload should not be so high that:

- workers are overloaded to the point where **error rates** increase, particularly if these can result directly in injury. In the present case, the most obvious resultant OHS risk related to an increase in PDO error rate is that of ***road accidents***;
- many workers experience increased **stress** due to the perceived consequences of their failing to cope adequately with their work demands. In the present case, predictable OHS risks include:
    - increased risk of ***MSDs***[23]

[23] For summaries of the causal role of stress in the development of musculoskeletal disorders, see Macdonald (2004); Macdonald & Evans (2006); National Research Council and Institute of Medicine (2001)

- increased risk of errors, and hence ***road accidents***[24]
- increased risk of various ***other stress-related diseases*** (e.g. cardiovascular disease).

- **fatigue** accumulates to an extent that workers' ability to cope with work demands decreases, with consequent increases in error rates and the risk of ***road accidents***,[25] possible stress and associated OHS risks (see dot point above), and further increases in mental workload – which can become a downward spiral.

Section 4.2 below discusses whether implementation of SBD might be unacceptable on any of the above grounds.

4.2 Will mental workload due to SBD result in unacceptable OHS risks?

Mental workload levels for the SBD delivery process (outdoor work) were higher than with the current delivery process. However, there are several likely reasons for this finding, most of which would *not* be expected to be relevant following the full implementation of SBD.

First, mental workload levels would be higher during the trial because PDOs had not had time to 'get up to speed' on the new process. Adapting their existing skills to the new delivery process requires a considerable amount of re-learning, and mental workload levels would be expected to decrease with practice over a much longer period than that of the trial, because many months, if not a year or so, are needed for such re-learning.[26]

Second, participants in the trial were having to cope with systemic 'teething' problems related to introduction of the new system, many of which were related to programming of machines sequencing the mail.[27] There were many comments from PDOs about difficulties during SBD delivery due to mis-sorts – problems that with the current work process are

[24] For summaries of the causal role of stress in road accidents, see Rowland et al (2007)
[25] For a summary of how fatigue increases the risk of injury due to occupational accidents, see Swaen et al (2003).
[26] Evidence that re-learning is complete would be evidence that skill level is no longer improving with practice, as indicated by measures such as performance time when people at their maximum capacity, and the attention required to maintain performance at that level.
[27] Based on advice from a Centre Manager.

detected and corrected prior to the delivery phase. It is assumed that such problems would be largely eliminated prior to general implementation of the SBD process.

Third, given the above conditions during the trial (incompletely developed skill levels; problems due to mis-sorts), there were probably higher levels of PDO tiredness and/or stress than otherwise, with resultant reductions in their cognitive capacities and consequent increases in their mental workload. For all three of the above reasons, mental workload levels during the trial would be higher than those expected following full implementation.

On the other hand, it is expected that the inherently greater mental complexity of the SBD delivery process compared with the current process will continue indefinitely, with some associated increase in mental demands. However, since several factors contributing to higher mental workload levels during the trial would be expected to decrease over time, it is concluded that the most effective means of determining whether or not higher mental workload presents an unacceptable risk will be future monitoring using the scales from this project.

4.3 How do the physical demands of work performance affect OHS risk?

As already discussed, *mental* workload has potential effects on many different aspects of OHS risk, but of course *physical* demands can also be important – particularly in relation to MSD risk, which is the main focus here. These physical demands are listed in Section 1.3 above.

In fact, MSD risk is a product of a great many factors, including but not confined to the physical demands of work performance. These factors include stress, as noted in Section 4.1 above, and therefore the wide range of work-related hazards that can affect workers' stress levels. These other hazards include overall workloads, working hours and shift systems, practices related to rest breaks, work organisation and job design, along with a wide range of other 'stressors'. Assessment of MSD risk is therefore a complex and inexact process – particularly because different aspects of physical demand act both interactively and cumulatively in their effects on risk. For a more extensive discussion of factors affecting

MSD risk, see the diagrammatic representation of these factors in Appendix E, from the review by Macdonald and Evans (2006, p.24 – downloadable from address in references).

In this section, however, focus is just on the role of physical demands and related hazards, as specified in Sections 1.3 and 2.2 above.

4.4 Do the physical demands of SBD delivery cause unacceptable OHS risks?

Because of the various limitations of available risk assessment methods, as discussed in Section 2.2 above, the differences in risk associated with the varying sets of physical demand hazards assessed by these various methods indicate only *ordinal* differences in risk, rather than the absolute *size* of such differences.

Further, it should be clear that judgements concerning cut-off points beyond which risk is "unacceptable" usually cannot be made *only* on the basis of risk assessment methods that focus on particular types of hazard, because this takes no account of the workplace context. Using this kind of hazard-focused risk assessment method, overall MSD risk *might* be judged as unacceptable (depending on other factors) if the method categorises risk at the highest possible level. However, none of the conditions observed or analysed in the current case approached the highest end of any of the risk scales used, which is fairly typical for most Australian workplaces nowadays (although such conditions are still common in some industrially developing countries).[28]

In this context, with multiple and diverse, interacting hazards, the importance of 'secondary prevention', based on monitoring of the first signs of increasing injury risk, becomes an important risk control strategy. To this end, it is suggested that PDO perceptions of the demands of their work, how tiring it is and their physical aches/pains should be monitored and used to assess MSD risk more directly, as discussed in the following section.

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[28] Also, judgements of acceptability need to take account of the availability of 'reasonably practicable' risk reduction measures for identified hazards. The increase in risk might be relatively small, but if there is an easily practicable means of reducing that risk, it should be implemented. Development of a range of possible risk reduction measures and assessment of whether it would be practicable to implement them was beyond the scope of this project.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Management of OHS risks due to increased physical demands of SBD

The main hazards related to the physical demands of work performance are those affecting MSD risk. Three aspects of the SBD process relative to the current delivery process were identified as presenting an increased risk – although the extent of such increases could not be determined. These three aspects, and some related options for risk reduction, are outlined below. The three aspects of SBD that were identified as *possibly* increasing MSD risk are as follows.

(1) Relative to the present process, SBD requires more time to select mail at delivery points. Because of this, SBD requires more time to be spent with the head bent forward and hands/wrists manipulating items of mail. To some degree, this increased time spent in 'hazardous' manual handling activities at the delivery point might be offset by less time spent in such activities during mail sorting prior to delivery, since both tasks entail a high level of hand/arm activity. However, the extent of any such offset effect could not be assessed from the data available for this project.

Potential Risk Reduction Strategies

- One kind of strategy would be to limit the *time* for which PDOs are exposed to the adverse postures described in the above paragraph. For example, perhaps it would be possible to design PDO jobs so that the total time any individual spends in such hand/arm activities (selecting mail from the front letter carrier; mail sorting) is not significantly greater than with the current process.
- Another kind of strategy would be to consider design changes to the motorcycle or its equipment in order to modify PDO postures so they are closer to a 'neutral' (risk free) position – for example, further changes to the design and/or positioning of the front letter carrier.[29] In practice, however, such modifications might be precluded by the need to comply with Australian Design Rules (ADRs) for motorcycles.

[29] All of the currently planned design changes had been fully implemented on the motorcycle used for the SBD delivery activities that were video-recorded, photographed, measured and analysed for this project.

(2) The process of reaching back to into a pannier bag to retrieve another bundle of mail to replenish the front letter carrier is potentially hazardous. This occurs more frequently with SBD than with the current process, due to SBD mail bundles being smaller than current ones. Being smaller, the bundles are lighter, which to some extent might offset the increased frequency of hazardous back movements; however, the extent of any such offset effect could not be assessed from the data available within this project.

Potential Risk Reduction Strategies

- One kind of strategy would aim to minimise the velocities/accelerations entailed in this bending/twisting action of the trunk, since higher rates of movement are much more hazardous. To this end, all possible measures to reduce PDOs' motivation to rush through their round would be beneficial in reducing MSD risk (as well as reducing road safety risks as already noted).
- Another kind of strategy would aim to reduce the *extent* of trunk bending and twisting. Based on a biomechanical analysis of the task, this would be achieved by locating the next bundle of mail to be retrieved as far *forward* as possible, and as far *out* from the motorcycle as possible. Such changes would presumably require modifications to the design and/or placement of the pannier bags. If such a change were contemplated, it would be important to ensure compliance with ADRs.

(3) As noted in (1) above, SBD entails more PDO time at delivery points, so more time is spent supporting the weight of the stationary motorcycle. This imposes asymmetric loads on the back and lower body in ways that might possibly increase the risk of back injury. Any such increase in risk would be expected to increase with *decreasing* height (i.e. least risk for tallest people).

Potential Risk Reduction Strategies

- One kind of strategy would aim to eliminate or reduce the need, when the motorcycle is stationary at delivery points, for PDOs (of all heights) to support its weight with their lower body. In principle, this could be achieved by modifying design of the motorcycle so that some kind of stand to support this weight would be activated by an easily executed action of the PDO, and retracted each time by another easily executed action. In practice, however, such modifications to the motorcycle might be impracticable – for example because of constraints imposed by motorcycle ADRs.

- Another kind of strategy would reduce the extent of the forces required to maintain the motorcycle upright by making it a requirement for PDOs to be above average male height. However, in a context where recruitment into this job may be increasingly difficult, such a strategy appears likely to be impractical.

Again it is emphasised that inclusion in this report of the above three sets of potential risk reduction strategies does *not* imply that the SBD process will be unacceptably risky if such strategies are not implemented (although of course any that are reasonably practicable *should* be implemented). This is because it is impossible to draw conclusions concerning *overall* MSD risk based simply on the risk associated with relatively small subsets of physical demand hazards (at least within the range of hazard severity levels found here), because overall risk is determined by a much larger and more varied set of hazards (see Appendix E).

It is therefore suggested that consideration of these three sets of risk reduction strategies could be deferred until further data are available from monitoring of the SBD process when implemented. If monitoring is implemented as recommended in the final section of this report, the resultant data would provide a more reliable indicator of actual MSD risk, and this would constitute a better basis for decisions concerning which kinds of risk reduction interventions, if any, might be warranted.

Some of the ratings documented during PDO interviews are also relevant to assessment of MSD risk. Most obviously relevant are the PDO ratings of *physical demands*. As expected, the average rating level was lower during the indoor component of PDO participants in the trial (3.7 for SBD, versus 4.2 or 4.4 for the current process depending on whether V-sort or Merging was being considered). For outdoor work, however, the average *physical demands* rating was higher for SBD (6.7) than for the current delivery process (4.5), although *physical demand* ratings. And consistent with these *physical demand* ratings, levels of fatigue (ratings of *how tiring*) for indoor mail sorting work were lower for SBD (3.4) than for the current process (4.5), but for outdoor work they were higher for SBD (6.9) than currently (4.8). Similarly, ratings of *aches and pains* related to indoor work were lower for SBD (3.1) than currently (3.5), but for outdoor work they were higher for SBD (6.0) than for the current delivery process (4.1).

5.2 Management of OHS risks due to increased mental workload with SBD

Management of mental workload is important, because if levels are excessive they would be expected to increase the risk of PDO involvement in road accidents, as well as increasing MSD risk. Associated stress is also a possible issue, since chronically high levels are also associated with a range of stress-related diseases (in addition to MSDs).

In the present case, there was evidence that mental workload related to SBD delivery was higher than with the current delivery process, and this was associated with higher levels of stress, of fatigue, and of aches and pains. However, some of the causes for this are probably short-term ones. Specifically, trial participants had not yet had time to 'get up to speed' on the new process, and they were having to cope with what they perceived as high levels of machine-generated mis-sorts, which meant that their levels of tiredness and/or stress were therefore higher than otherwise.

Accordingly, the extent of the increase in mental workload that would be seen following full implementation and 'bedding down' of the SBD process and related job design changes is unclear, so the extent of any increase in any of the above OHS risks cannot be predicted only on findings from the trial. Following full implementation of the SBD process, the inherently greater complexity of the SBD delivery process will continue to require more time per delivery point, compared with the previous process.

A key issue will be how jobs are designed under the new regime – particularly the time spent delivering mail, both in absolute terms and as a proportion of an overall job. The importance of such time-related factors was the subject of widespread comment from the PDOs interviewed. From their viewpoint, total time on the road once SBD is implemented – in terms of time allocated for delivery related to the required *work rate*, as well as the *total time* that people would be required to spend on the road – is an important issue.

It is clear that management to avoid excessive time pressures will be very important, and to achieve this, PDOs will need to perceive 'official' delivery times as adequate. On the other hand, it will be equally important for managers to take all possible appropriate means of

discouraging 'read and ride' behaviours, which may be indicated by some PDOs consistently completing their delivery round in much less than the standard time.

5.3 Recommendations for SBD implementation

(1) *Based on all of the information documented in this project, it is reasonable to proceed with implementing the SBD process, provided this process is managed and monitored in accord with the following recommendations.*

The implementation process will need to be carefully managed, with periodic monitoring of key risk indicators during *at least* the first year or so of the implementation process (depending on how the process is staged), to enable early identification of potential problems and the proactive introduction of appropriate risk control measures if required.

Recommendations re SBD Management

(2) *To maximise the prospect of SBD reducing the incidence of PDO 'read and ride' behaviour sufficiently to deliver road safety benefits*, it will be important to manage the process so that time pressures experienced by PDOs are minimised, and so that the likelihood of PDOs perceiving any possible *advantages* to be gained by reading while riding are also minimised.

(3) *To minimise the risk of PDO fatigue increasing to an extent that negatively affects road safety and/or MSD risk*, it would be desirable for total motorcycle riding time per day to be limited, at least during the early stages of implementation, so that durations do not exceed current levels. The advisability of permitting future increases in this duration should be assessed in light of empirical data gathered during the implementation process concerning the factors that affect PDO fatigue levels and the size of such effects.

(4) *To avoid PDOs being exposed to greater risk of upper body MSDs due to 'manual handling'*, their jobs should if possible be designed so that the *total* time any individual spends performing precise hand/arm activities (i.e. selecting mail from the front letter carrier; mail sorting) is not significantly greater than with the current process, at least during the early stages of implementation. The advisability of permitting future increases

in this total duration should be assessed in light of empirical data gathered during the implementation process concerning the factors that affect PDO physical discomfort/pain, and the size of such effects.

Recommendations re monitoring of SBD Implementation

(5) To support implementation of the above recommendations, it will be important to document and monitor a number of parameters at regular periods during the first year or so of SBD implementation.

Most importantly, rating scales similar to those used in the present study should be completed by regularly surveying PDOs. It is suggested that the most important scales for this purpose will be: time pressure, attention, avoiding errors, frustration/stress, physical demands, how tiring, and physical aches/pains. To facilitate diagnosis of likely causes, ratings of aches/pains should be extended beyond the unitary scale used in this project, following a procedure that has recently been developed and validated by Macdonald and colleagues at La Trobe University.[30] The survey should also collect information from each PDO on the other (indoor) activities they usually undertake during a typical shift (e.g. mail sorting), and total duration of a typical shift.

In addition, some key parameters for each SBD delivery round should be documented so that these can be analysed in conjunction with PDO survey data to support achievement of recommendations (3) and (4) above. This would include, for each round, numbers of delivery points and related mail volumes, duration of the delivery process, and duration of 'dead' riding time.

(6) It would be desirable for key findings from analyses of the above data to be discussed by representative focus groups of PDOs, to help identify and explain likely causes of observed patterns, and to help in generating potential solutions for any problems that come to light.

[30] Publication of this research is in progress; further details can be provided on request.

REFERENCES

1. Bernard, B.P et al (1997). *Musculoskeletal Disorders and Workplace Factors. A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back.* U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. NIOSH Publication No. 97-141. Downloadable from: http://www.cdc.gov/niosh/docs/97-141/

2. Fuller, R. (2005). Towards a general theory of driver behaviour. *Accident Analysis & Prevention,* 37, 461-472.

1. Hart, S.G. and Staveland, L.E., (1988), Development of the NASA-TLX. In P.A. Hancock and N. Meshkati (Eds.), *Human Mental Workload*, New York: North Holland

2. Hoffmann, E.R., Macdonald, W.A. and Almond, G.C. (1993). Quantification of the cognitive difficulty of mail sorting. *International Journal of Industrial Ergonomics*, 11, 83-98.

3. Huey, B.M. and Wickens, C.D. (Eds.) (1993). "Workload Transition: Implications for Individual And Team Performance". Committee of Human Factors Commission on Behavioral and Social Sciences and Education, National Research Council. Washington, DC: National Academy Press.

4. International Standards Organisation (ISO) Standards on MWL. *Ergonomics principles related to mental workload* – ISO Standards (International Standards Organisation) 10075-1 (1991) and 10075-2 (1994)

5. Macdonald, W. (1979). *The Measurement of Driving Task Demand.* PhD thesis, University of Melbourne.

6. Macdonald, W.A. (2003). The impact of job demands and workload on stress and fatigue. *Australian Psychologist,* 38, 2, 102-117.

7. Macdonald, W. (2004). Workload, stress and psychosocial factors as hazards for musculoskeletal disorders. *Journal of Occupational Health and Safety – Australia and New Zealand.* 20(1), 37-47.

8. Macdonald W. (2006a). Workload, Performance, Health, and Well-being: A Conceptual Framework. In: Karwowski W (Ed.) *International Encyclopedia of Ergonomics and Human Factors*, (2nd edn). Taylor & Francis, 2006, pp.2794-2799

9. Macdonald, W. (2006b). Managing Workloads to Optimise Performance, Health and Wellbeing. In W. Karwowski (Ed.) *International Encyclopedia of Ergonomics and Human Factors,* 2nd Edition, pp.2170-2174. Taylor & Francis.

10. Macdonald, W., & Evans, O. (2006). *Research on the prevention of work-related musculoskeletal disorders Stage 1 - literature review.* Canberra: Australian Safety and

Compensation Council. Retrieved December 2009 from: http://www.safeworkaustralia.gov.au/NR/rdonlyres/D0C2EF6D-C027-4BEF-B9A2-D4F76F50A05A/0/WorkRelatedMusculoSkeletalDisordersStage1LitReviewNov06.pdf

11. Matthews, G., Davies, D.R., Westerman, S.J., & Stammers, R.B. (2000). *Human Performance: Cognition, Stress and Individual Differences*. Hove, East Sussex: Psychology Press.

12. Moray, N., 1988, Mental workload since 1979. *International Reviews of Ergonomics*, 2, 123–50.

13. **Nachreiner, F. (1995). Standards for ergonomics principles relating to the design of work systems and to mental workload. *Applied Ergonomics, 26,* 259–263.**

14. National Research Council and Institute of Medicine (2001) *Musculoskeletal disorders and the workplace: low back and upper extremities.* Panel on Musculoskeletal Disorders and the Workplace, Commission on Behavioral and Social Sciences and Education. Washington, DC: National Research Council and Institute of Medicine, National Academy Press, 2001. Downloadable from: http://www.nap.edu/openbook.php?isbn=0309072840

15. Recarte, M.A. & Nunes, L.M. (2003). Mental workload while driving: effects on visual search, discrimination and decision making. *Journal of Experimental Psychology*, 9, 2, 119-137.

16. Rowland, B., Davey, J., Wishart, D., & Freeman, J. (2007). The influence of occupational driver stress on work-related road safety: An exploratory review. *The Journal of Occupational Health and Safety - Australia and New Zealand* 23(5):pp. 459-468.

17. Swaen, G.M.H., van Amelsvoort, L.G.P.M., Bultmann, U;, & Kant, I.J. (2003). Fatigue as a risk factor for being injured in an occupational accident: results from the Maastricht Cohort Study. *Occupational and Environmental Medicine,* 60:i88-i92 *suppl_1.i88*

18. Tsang, P. and Wilson, G.F., 1997, Mental workload. In Salvendy, G. (ed.) *Handbook of Human Factors and Ergonomics* (NY: Wiley & Sons), pp. 417–49.

APPENDIX A. Further information on mental workload

The cognitive ergonomics concept of workload emerged during the 1970s and 1980s from extensive research on the demands people experience as they perform specifically defined tasks. The concept was developed to support analysis and measurement of the workload people experience as they operate various safety-critical systems (e.g. flying aircraft or spacecraft; controlling power stations, etc), and it has been widely applied to improve the design of systems or equipment so that operator workload is optimised and system performance is protected (see Moray 1988).

Level of *mental workload is determined by the margin between someone's perceived level of work demand and their perceived capacity to cope with those demands*. When the margin is perceived as small or nonexistent, high workload will be experienced; when the margin is perceived as large, with demands much lower than coping capacity so that there is plenty of spare capacity, workload will be experienced as low. Various factors can influence mental workload level, including *physical* task demands, along with effort expenditure, perceived (in)adequacy of performance, and feelings of frustration or stress. Consistent with this, Hart and Staveland (1988, p.140) defined mental workload as "a hypothetical construct that represents the cost incurred by a human operator to achieve a particular level of performance", and Matthews *et al* (2000, p.87) noted that "Workload ... refers to people's experiences of cognitive task performance as effortful and fatiguing".

APPENDIX B. Mental workload scale ratings

The following page is part of the data recording template used by researchers when interviewing PDOs, showing details of the rating scales used.

DELIVERY CENTRE: Rating **0 = not at all** Rating **10 = Maximum possible**

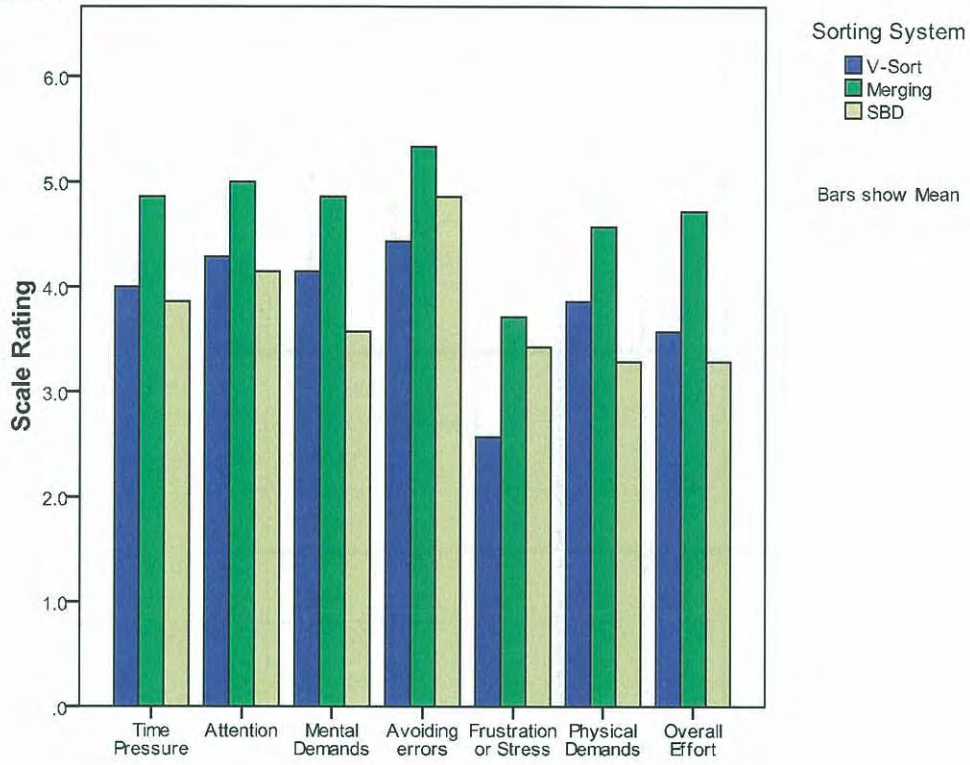
Subject ***Your experience of the 3 work systems – how much …***																				
	VSt	M	SBD	**VSt**	M	SBD	**VSt**	M	SBD	**VSt**	M	SBD	**VSt**	M	SBD	**VSt**	M	SBD	**VSt**	M	SBD
.. *time pressure* – use words below																					
.. frustration or stress … whichever																					
words you like to use … do you feel?																					
.. ***overall*** effort does it take – taking																					
everything into account																					
.. attention – use words below																					
.. *avoiding errors* – use words below																					
.. road safety – use words below																					
How high are the *physical* demands																					
of ..? (comment .. *mental* comes next)																					
How high are the *mental* demands of?																					
How *tiring* is ...?																					
What level of physical aches/pains do																					
you typically have?																					

.. time pressure … how much time pressure do you feel – that's not about *how fast* you work, because you might feel time pressure whether or not you're going fast – it's just about the *time pressure* you *experience*?
… attention
.. do you have to pay careful attention to what you're doing – as opposed to working 'on auto'
… avoiding errors
.. do you have to focus on *avoiding errors* – on how accurately you work?
… road safety
.. is road safety risk higher or lower with SBD? WHY? (lead as necessary to clarify)

APPENDIX C. Results from mental workload ratings for each trial location separately

SEAFORD

Indoor work



Outdoor work