World Academy of Science, Engineering and Technology
International Journal of Industrial and Systems Engineering
Vol:17, No:08, 2023

A Human Factors Approach to Workload Optimization for On-Screen Review Tasks

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Abstract : Rail operators and maintainers worldwide are increasingly replacing walking patrols in the rail corridor with mechanized track patrols -essentially data capture on trains- and on-screen reviews of track infrastructure in centralized review facilities. The benefit is that infrastructure workers are less exposed to the dangers of the rail corridor. The impact is a significant change in work design from walking track sections and direct observation in the real world to sedentary jobs in the review facility reviewing captured data on screens. Defects in rail infrastructure can have catastrophic consequences. Reviewer performance regarding accuracy and efficiency of reviews within the available time frame is essential to ensure safety and operational performance. Rail operators must optimize workload and resource loading to transition to on-screen reviews successfully. Therefore, they need to know what workload assessment methodologies will provide reliable and valid data to optimize resourcing for on-screen reviews. This paper compares objective workload measures, including track difficulty ratings and review distance covered per hour, and subjective workload assessments (NASA TLX) and analyses the link between workload and reviewer performance, including sensitivity, precision, and overall accuracy. An experimental study was completed with eight on-screen reviewers, including infrastructure workers and engineers, reviewing track sections with different levels of track difficulty over nine days. Each day the reviewers completed four 90-minute sessions of on-screen inspection of the track infrastructure. Data regarding the speed of review (km/ hour), detected defects, false negatives, and false positives were collected. Additionally, all reviewers completed a subjective workload assessment (NASA TLX) after each 90-minute session and a short employee engagement survey at the end of the study period that captured impacts on job satisfaction and motivation. The results showed that objective measures for tracking difficulty align with subjective mental demand, temporal demand, effort, and frustration in the NASA TLX. Interestingly, review speed correlated with subjective assessments of physical and temporal demand, but to mental demand. Subjective performance ratings correlated with all accuracy measures and review speed. The results showed that subjective NASA TLX workload assessments accurately reflect objective workload. The analysis of the impact of workload on performance showed that subjective mental demand correlated with high precision -accurately detected defects, not false positives. Conversely, high temporal demand was negatively correlated with sensitivity and the percentage of detected existing defects. Review speed was significantly correlated with false negatives. With an increase in review speed, accuracy declined. On the other hand, review speed correlated with subjective performance assessments. Reviewers thought their performance was higher when they reviewed the track sections faster, despite the decline in accuracy. The study results were used to optimize resourcing and ensure that reviewers had enough time to review the allocated track sections to improve defect detection rates in accordance with the efficiency-thoroughness trade-off. Overall, the study showed the importance of a multi-method approach to workload assessment and optimization, combining subjective workload assessments with objective workload and performance measures to ensure that recommendations for work system optimization are evidence-based and reliable.

Keywords : automation, efficiency-thoroughness trade-off, human factors, job design, NASA TLX, performance optimization, subjective workload assessment, workload analysis
Conference Title : ICEMUE 2023 : International Conference on Ergonomics Modeling and Usability Evaluation
Conference Location : Vancouver, Canada
Conference Dates : August 03-04, 2023