Grant: AFC316-61
Title: Systematic Evaluation of Multi-axial Suspension to Reduce Whole Body Vibration Exposures in Heavy Equipment Mining Vehicle Operators

Organization: Oregon State University

Principal Investigator: Jeong Ho Kim

Partnerships: Northeastern University, University of Washington, Bose Corporation

Topic: Injury and Disease Exposure and Risk Factors
Priority Area: Musculoskeletal Disorders

Problem Statement and Justification: Mining vehicle operators suffer from a high prevalence of musculoskeletal disorders (MSDs). These operators are exposed to multiple risk factors for MSDs, including whole body vibration (WBV) and sedentary work (prolonged, static sitting). Mining vehicle operators are exposed to high levels of WBV exposures, one of the leading risk factors for the development of MSDs (especially, low back disorders) in professional vehicle operators. Current engineering controls to reduce WBV exposures rely on a passive vertical (z-axis) suspension system. However, in off-road vehicles such as mining vehicles, WBV exposures are multi-axial in nature, meaning that the predominant WBV exposure axis is not necessarily limited to the vertical (z-axis) but can be either fore-aft (x-axis) or lateral (y-axis). Therefore, the current industry standard seats with single-axial (vertical) passive suspension may be less effective in reducing the multi-axial components of WBV exposures among mining vehicle operators. Furthermore, because of the substantial mass of the torso and head, such multi-axial components of WBV exposure can not only substantially increase shear forces in the back and neck, but also muscle loads to counterbalance the inertia of the torso and head. Given the extended vehicle operation hours (i.e. prolonged exposed to multi-axial WBV), the increased muscle loads can cause overuse and damage to the low back and neck muscles. Therefore, mining vehicle operators exposed to multi-axial WBV are at even greater risks for MSDs, especially in the low back and neck as compared to on-road drivers whose WBV exposures are predominantly on the vertical axis (vertical-axial WBV).

Impact of the Research: With the high prevalence of injuries and MSDs in the mining industry, this research will have direct impact on mining vehicle operators by reducing WBV exposures through engineering interventions (evaluation of multi-axial active suspension and alternative seat suspension systems); we will in turn improve their musculoskeletal health. Aim 1's impact will be the reduction of multi-axial WBV exposures and the associated biomechanical loading on the low back and neck through an engineering intervention, a multi-axial active suspension seat for mining vehicles. Aim 2's impact will be to identify other affordable alternative engineering controls (seats) to reduce WBV exposures for mining vehicle operators. The knowledge gained during this project will be translated into practice with the short-term objective of providing mining vehicle operators and industry stakeholders with effective seating recommendations for reducing WBV exposures and the long-term objective of reducing MSDs affecting mining vehicle operators.

Objectives and Research Approach: The primary objective of this study is to determine whether there are differences between a single-axial passive suspension seat (current industry standard) and a new multi-axial active suspension seat in reducing the mining vehicle operators' exposures to WBV and the corresponding biomechanical loading. This primary objective will be achieved by Aim 1 & 2: Determine the efficacy of different engineering controls (mining vehicle seat suspensions) in reducing the multi-axial WBV exposures in mining vehicles and the associated biomechanical loading on the musculoskeletal system. Using a repeated-measures design, we will evaluate the WBV attenuation performance of the two main engineering controls (Aim 1) and two lower-cost alternative engineering controls (Aim 2) in a laboratory setting. Using actual field-measured mining vehicle WBV exposures played back into a large scale motion platform for four hours, we will collect and compare WBV exposures (per ISO 2631-1 and 2631-5 standards), muscle activity, and joint torques in the neck and low back between a single-axial passive suspension and multi-axial active suspension seat (Aim 1). Lower-cost alternative passive seat suspension technologies will also be evaluated in the similar manner (Aim 2). The expected outcomes of Aim 1 & 2 will be identifying effective engineering controls to reduce WBV exposures in mining vehicle operators and associated biomechanical loading.