

## **Dynamic Armrest Prototype to Reduce RSI's in Hydraulic-Actuation Controller Users**

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Hydraulic-actuation controller users are subjected to long, highly fatiguing static muscular loads in the shoulder and neck regions (Attebrant et al., 1997). Low level static or consistent loading of muscles can pose a greater threat to the development of repetitive strain injuries (RSI) than less frequent, larger muscle contractions (Jensen et al., 1993; Veiersted et al., 1993; Westgaard & Aaras, 1984; Winkle & Westgaard, 1992). Of particular concern for joystick operators is the upper trapezius (UT), a large muscle used for stabilizing the neck and shoulders. Excessive UT loading, particularly in the forward and backward movement directions, is likely the result of inadequate arm supports (Attebrant et al., 1997; Northey, 2004).

The objective of the dynamic armrest (US Provisional Patent #: 60/827086) is to increase the stability of the shoulder by supporting the forearm throughout the entire joystick range of motion. The external support contributes to stability and thereby reduces muscular loads of the shoulder complex that are essential in stabilizing the forearm.

Six Vicon® M2 cameras were used to capture the true arm and shoulder movements from five, 50<sup>th</sup> percentile sized male unskilled operators during unrestricted forward/backward joystick manipulation using a right-hand-side joystick. Resulting kinematic data were then used to produce trajectories that represented the “natural motion” of the operator’s wrist and elbow. The captured trajectories were then incorporated into a dynamic armrest design that replicated the “natural motion”.

The efficacy of the newly designed dynamic armrest was then tested against a stationary armrest as well as no armrest through electromyography (EMG) and a subject questionnaire (Murphy, 2006). Peak, mean, and total muscle activation from twenty-one subjects were compared between the three armrest conditions for both forward and backward motions. Immediately following the testing, subjects completed a brief questionnaire regarding their opinions of comfort, effort, and efficiency of the various armrests.

EMG comparisons among the three armrest conditions revealed that muscle activation for all muscles tested (upper trapezius, anterior deltoid, and posterior deltoid) was significantly lower when the dynamic armrest was implemented in comparison to the typical stationary armrest ( $p=0.001$ ). Similarly, muscle activation under the no armrest condition produced significantly lower activation levels than the stationary armrest condition, highlighting the fact that the stationary armrest fails to provide adequate support.

The questionnaire revealed that subjects significantly preferred the dynamic armrest design over all other types ( $p=0.002$ ). Ratings from the questionnaire indicate that subjects felt that the dynamic armrest required less effort, was more comfortable, and more effective than either of the other two armrest conditions. In agreement with these findings, subjects preferred the dynamic armrest over the other two armrest conditions in 17 of 21 cases.

The overwhelming user preference of the dynamic armrest, accompanied with the evidence of decreased muscle activation in the shoulder indicates that dynamic arm supports are an important ergonomic consideration for hydraulic-actuation controller users. Future work will focus on design iteration and developing an armrest to account for side-to-side motions of the controller as well as retrofitting options for existing cabs.