VALIDATION OF THE VICON 460 MOTION CAPTURE SYSTEM™ FOR WHOLE-BODY VIBRATION ACCELERATION DETERMINATION

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INTRODUCTION

With mobile equipment operators experiencing root mean square (RMS) average accelerations (A_{rms}) ranging from 0.1g to 0.3g [3], the ultimate goal of this research program is to recreate and monitor in a laboratory environment the whole-body vibration (WBV) exposure levels experienced by forestry equipment operators in a field setting. Since the research questions being asked are concerned with investigating the transmission of WBV for frequencies up to 20Hz, coupled with the fact that the body can have transfer functions approaching 2 [2], the ability to measure an A_{rms} of 0.6g up to a frequency of 20Hz is required.

To better understand the body's response to WBV more detailed studies need to be conducted, where vibration levels are monitored at many levels of the spine in concert with muscle activation and posture measurements. This requires many markers, accelerometers, and electrodes to be placed on the subject. If multiple measurement systems are used, subject preparation is time intensive, large amounts of memory for data storage and processing are required, and results can be affected by skin artifacts and the encumbrance of the subject. Using a high sample rate/high resolution camera system to determine accelerations can reduce some of these problems. Thus, the purpose of this study was to determine if a VICON camera system could measure WBV acceleration levels within the range established above, eliminating the need for accelerometers.

METHODS

A Bruel and Kjaer™ 4810 electromechanical shaker was used to produce RMS accelerations of 1.09±0.11g, 0.74±0.06g, 0.33±0.06g, and 0.13±0.01g at each of 30Hz, 25Hz, 20Hz, 15Hz, 10Hz, 5Hz, and 3Hz frequency levels. A VICON™ 460 motion capture system (with six M^2mcam cameras) recorded a reflective marker vibrated at each amplitude and frequency combination while a Crossbow™ CXL04LP3 accelerometer recorded the acceleration. Each amplitude and frequency combination was recorded for a 5 second duration at a sampling rate of 250Hz.

The raw digitized VICON and accelerometer data were fourth order zero lag Butterworth filtered (cutoff frequency of 45Hz [1]). The VICON data were then double differentiated using a three point method to provide acceleration values. A 1/3-octave band-pass filter was then applied to the VICON and accelerometer data and the overall A_{rms} acceleration levels were calculated for each combination of the input acceleration and frequency levels using the 3.15Hz to 31.5Hz 1/3 octave bands. The percent difference between the VICON and accelerometer overall A_{rms} acceleration values were compared for all acceleration and frequency combinations.

RESULTS AND DISCUSSION

When comparing the overall A_{rms} acceleration values it was found that the percent difference between the VICON 460 motion capture system and the accelerometer was 4.43±8.23% for frequency and acceleration combinations ranging from 5Hz to 25Hz, and 0.33g to 1.09g (Table 1). Larger errors were observed at the 3Hz and 30Hz frequencies, as well as the 0.74g accelerations (Table 1). While errors were greater than 10% for some acceleration frequency combinations, for the most part, these errors resulted from the shaker having small displacements (<1mm) which are probably within the error of the VICON system. Field measurements indicate that displacements at all frequencies of interest are in excess of 1 mm suggesting that the VICON system can be used to predict acceleration in laboratory studies which simulate field vibration profiles.

Results are promising and further validation studies will be conducted using acceleration profiles from actual field data.

REFERENCES

1. International Organization for Standardization. IS0 2631-1, 1997.
2. Jack RJ, et al.. *Int J Ind Ergon,* (In Revision).
3. Neitzel R, et al.. *Department of Environmental Health*, Seattle, Washington, Unpublished Manuscript, 2001.

Table 1: Percent difference between overall RMS accelerations measured with a VICON™ 460 Motion Capture System and a Crossbow™ CXL04LP3 accelerometer

Frequency (Hz)	Overall RMS Acceleration (g)		
	VICON System	Accelerometer	Percent Error (%)
5	0.38	0.32	19.58
	0.77	0.75	3.95
	0.97	0.94	2.83
10	0.46	0.39	16.38
	0.82	0.78	4.79
	1.22	1.19	2.67
15	0.40	0.36	9.84
	0.85	0.82	3.69
	1.18	1.15	2.55
20	0.33	0.33	-1.99
	0.68	0.74	-7.58
	1.23	1.14	7.72
25	0.21	0.24	-10.05
	0.63	0.64	-1.85
	1.15	1.01	13.98