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Safety in the use of portable olive harvesters

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AIM OF THE RESEARCH

The mechanization of olives harvesting is very important both to reduce the costs of production and to assure the oil quality.

The manual harvest does not allow to operate at the right time and also need a long period to be completed.

AIM OF THE RESEARCH

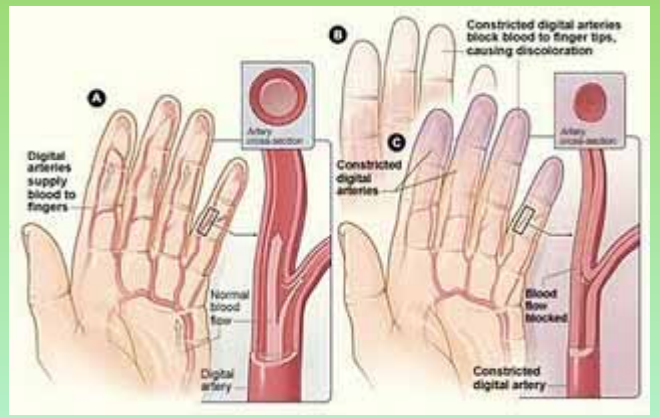
The use of portable shakers, that are spreading more than others typologies, can give a solution to the problem.

However, the use of such equipment may involve risk of exposure to hand-transmitted vibration.

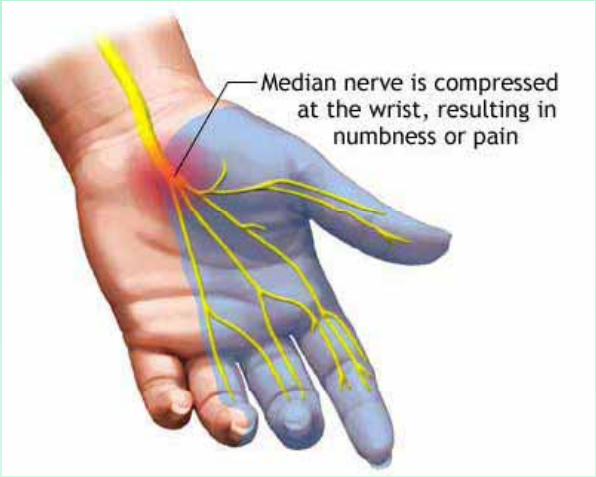
HEALTH RISKS ORIGINATED BY VIBRATIONS

The exposure to prolonged vibration is a potential cause of pathologies such as muscular/skeletal pains in hand-arm system, or specific pathologies such as:

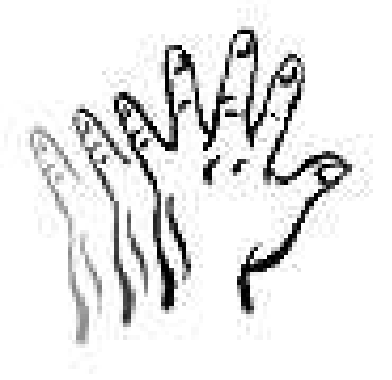
Vibration-Induced White Finger (VWF)



Carpal Tunnel Syndrome (CTS)

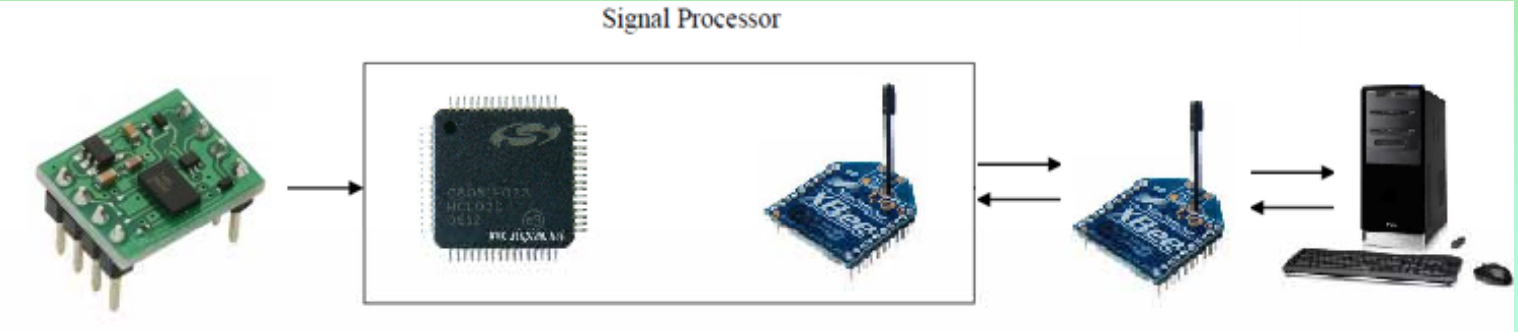


Hand-Arm Vibration Syndrome (HAVS)



AIM OF THE RESEARCH

The research involves the definition of the hardware components of the system and the related software development activities, as well as an experimental test in real operating conditions.



The experimentation allowed to gather and characterize the vibration data, in terms of frequency spectrum and intensity. Such information has been subsequently exploited for real-time vibration monitoring and subsequent health hazard assessment.
The transmission was performed via wireless network to a station where the data were stored and analyzed.

REFERENCE STANDARD

EN ISO 5349-1:2004 and 5349-2

Measurement and evaluation of human exposure to hand-transmitted vibration
Part 1: General requirements
Part 2: Practical guidance for measurement at the workplace

They give the characterization of the vibration transmitted to the hand and a guide to the health effects.

EXPERIMENTAL TESTS

The experimental tests were performed in 2010 using the hand held shaker Cifarelli SC 800 commonly employed in olive harvesting operations in Italy.

Cifarelli SC800 technical features

Engine	Cifarelli C5
Engine displacement [cm^3]	52
Strokes [n]	2
Cooling	air
Tank capacity [l]	1.7
Total weight (filled up) [kg]	18.0
Length except the bar [mm]	1050
Bar length/total length ratio	0.66
Length of the bar [mm]	2000
Stroke of the bar [mm]	60.2
Hook width [mm]	40.5

EXPERIMENTAL TESTS

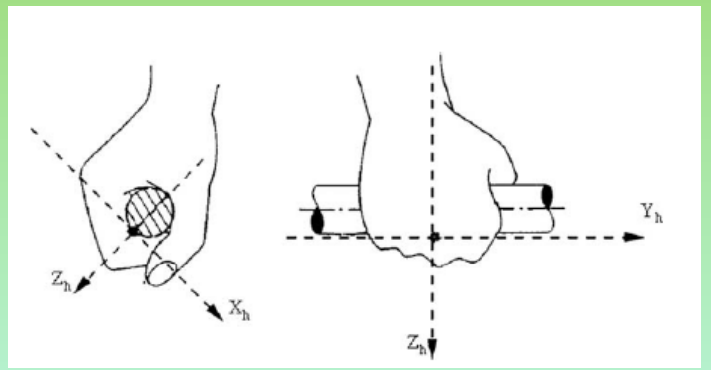
Accelerometer position and directions

Fixing process of the accelerometers on the auxiliary and command handles to have each axis oriented in the directions imposed by the provisions of EN ISO 5349-1 (basicentric coordinate system):

y_h axis parallel to the axis of the handle;

x_h perpendicular to the axis of the handle oriented by the back towards the palm of the hand;

z_h axis perpendicular to the plan formed by the two previous axes.



For practical measurements, the orientation of the coordinate system may be defined with reference to an appropriate basicentric coordinate system originating in vibrating handle gripped by the hand.

EXPERIMENTAL TESTS

Lab tests

The vibration tests have been performed inside the lab in simulated operating conditions with a fake branch constituted by a bar with one end fixed to a solid structure and the other end free to shake.

EXPERIMENTAL TESTS

The proposed system is based on Micro Electro-Mechanical Systems (MEMS) technology and involves the design of a compact wearable unit to be attached to the waist of the operator, and a fixed station for storing and analyzing the measured data.

The wearable sensor unit has been designed taking into account that the unit must be lightweight, small and as compact as possible in order not to hamper the operations and the movements of the worker .

According to such specifications, the Freescale MMA7455 triaxial accelerometer device has been selected.

EXPERIMENTAL TESTS

Each test consisted in 3 trials of 40 seconds each with a polling frequency of 120 Hz.

The acceleration data collected by means of the previously described sensor are fed into a microcontroller and sampled via an analog digital converter.

In the ISO 5349 standard recommendations, the most important quantity used to describe the magnitude of the vibrations transmitted to the operator's hands is the root-mean square (rms) frequency-weighted acceleration, expressed in m/s^2.

$$a_{hw} = \sqrt{a_{hw(x)}^2 + a_{hw(y)}^2 + a_{hw(z)}^2}$$

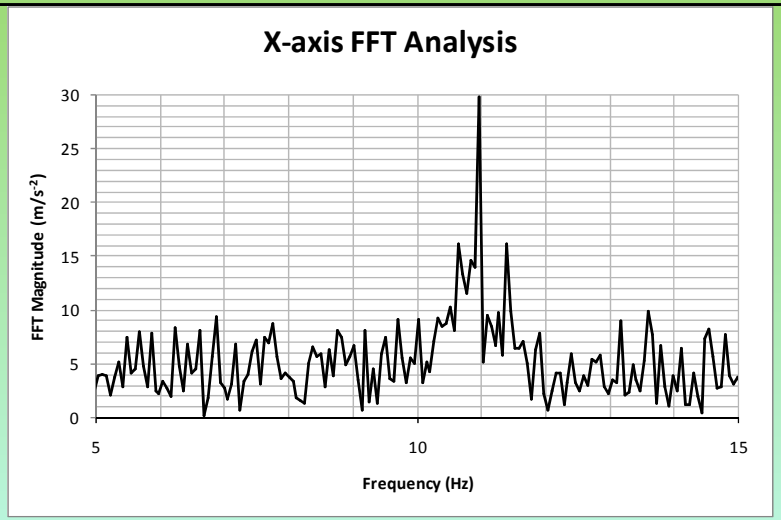
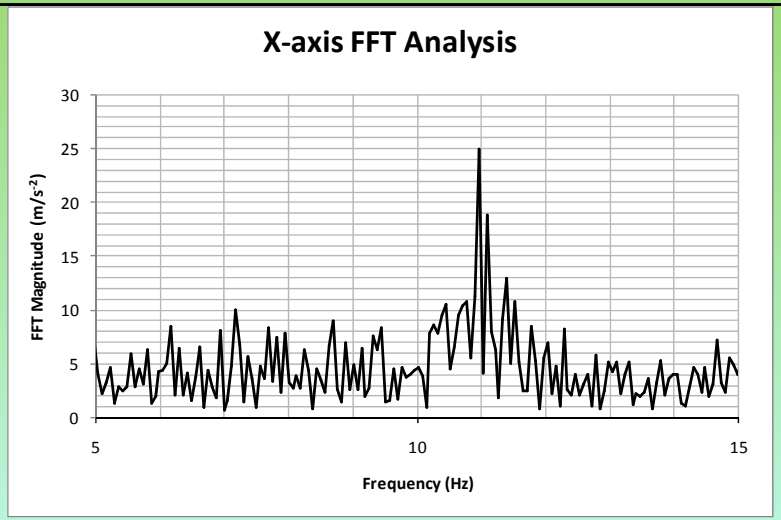
The system was used during the operator's activity. The data were subsequently transmitted via wireless network to a station where they were stored and analyzed.

EXPERIMENTAL TESTS

Field tests

The experimental analysis involved the real time acquisition and processing of the acceleration data gathered by means of the monitoring device developed while the machine is employed in field by a human operator.

RESULTS

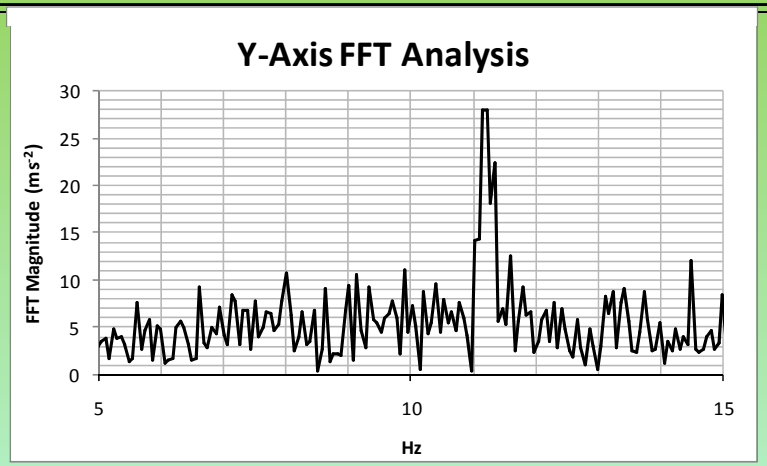
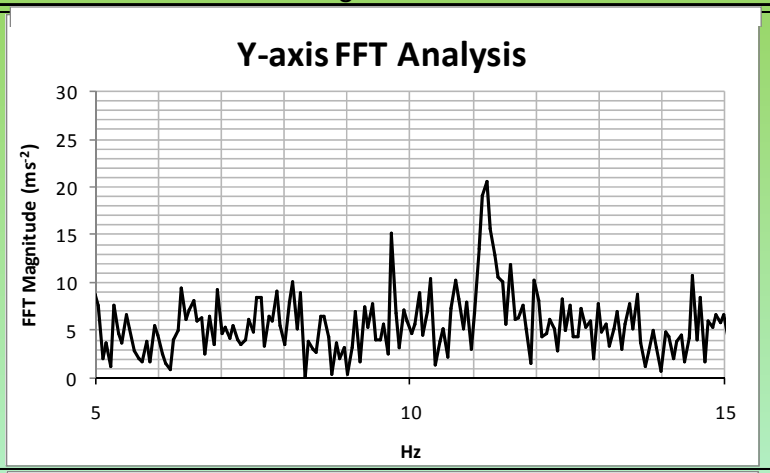
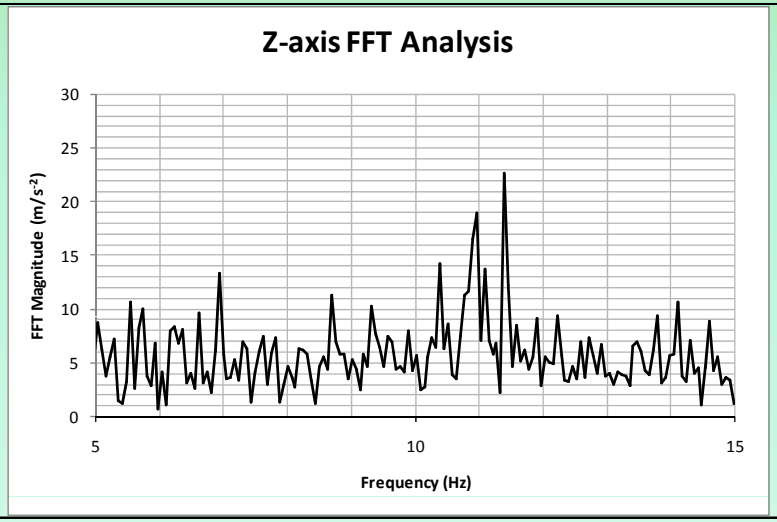
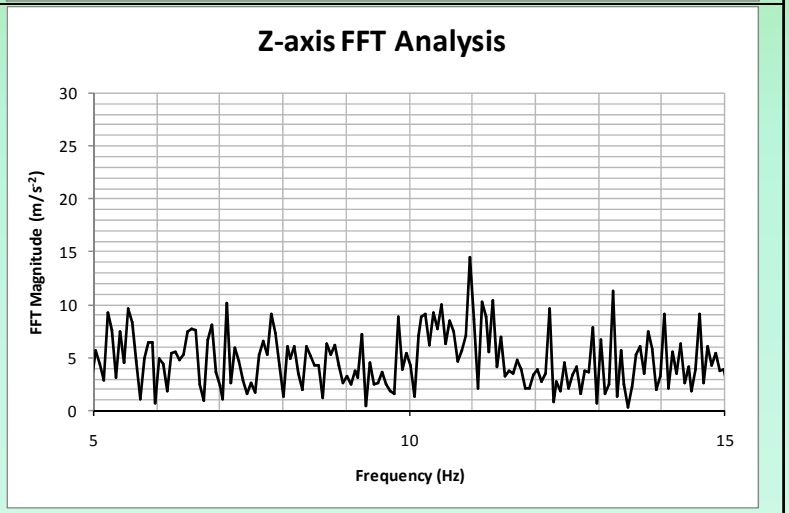
Left Hand	Right Hand
	

FFT spectrum for the X axis for both hands.

For the left hand, the peak vibration acceleration was approximately 30 m/s^2 on the x axis, at the frequency of 11 Hz.
For the right hand, again the FFT spectra show the same peak in the x axis.

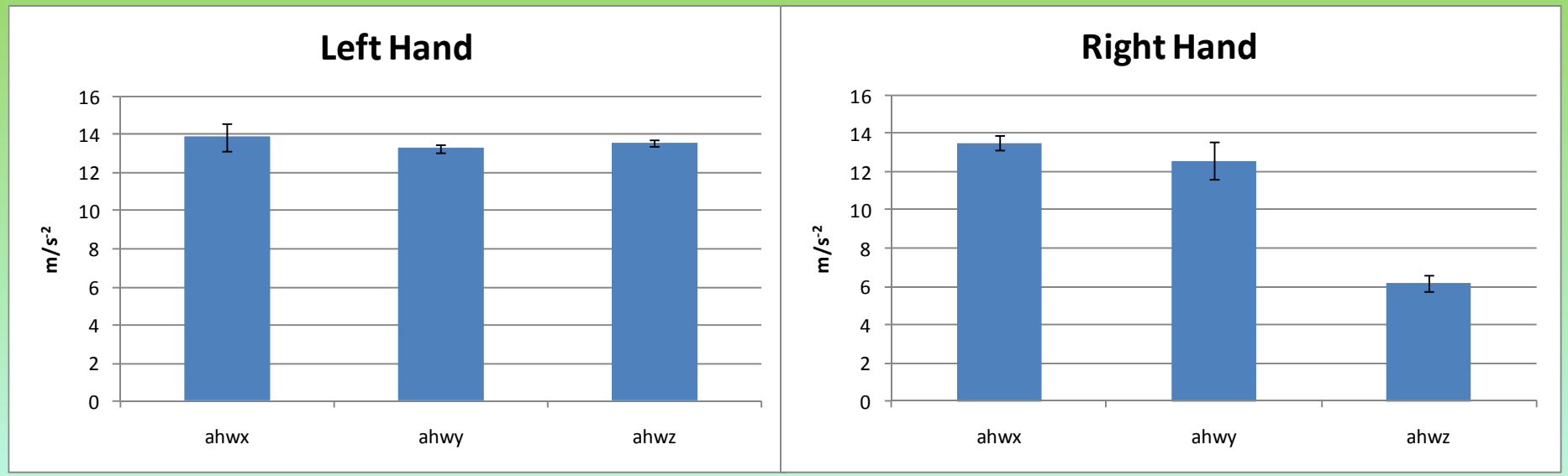
The measurements show that vibration acceleration in the X-axis, is more prominent than the other two directions.

RESULTS

Left Hand	Right Hand
	
	

FFT spectrum for the Y and Z axes for both hands.
The same harmonic can be distinguished in y and z directions.
For the right hand, on y and z axes again the FFT spectra show a lower vibration level than the left one.
In particular vibration on the z axis of the right hand is significantly smaller than all others.

RESULTS

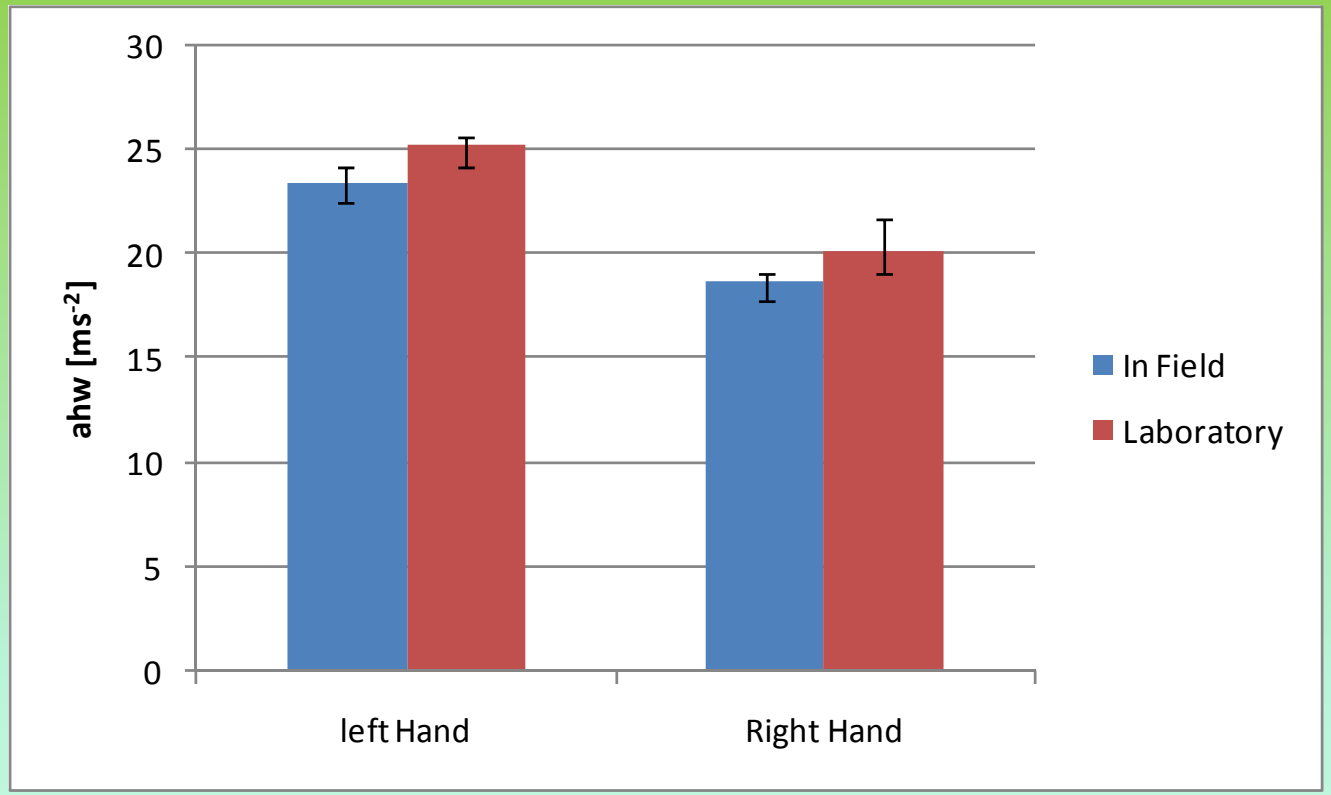


The resulting weighted vibration level for each axis

$$a_{hw(x,y,z)} = \left[\sum_{j=1}^{n}\left(W_j \cdot a_{w,j(x,y,z)}\right)^2\right]^{1/2}$$

where aw,j is the acceleration measured in the one-third octave band in m/s², and Wj is the weighting factor for the one-third-octave band.

RESULTS



Comparison of a_{hw} values for both hands in laboratory and in-field tests

Although the experimental field tests generally lead to a underestimation of the vibration exposure, the error is generally lower than 10%.

This demonstrates a fairly acceptable compromise between performance and ease of operation of the monitoring system.

CONCLUSIONS

The research involved the development of a novel device for assessing the health risk caused by hand-harm vibrations in real worker operating conditions in olives harvesting.

- Recent emerging technologies such as MEMS accelerometers and wireless networking allow a revolutionary approach to safety management, by promoting the development of cheap devices for real time monitoring and risk assessment.

- The device developed can easily be integrated into workers' standard equipment employed in outdoor operations, since it is involves a lightweight wearable device with on board power supply and wireless communication module.

- The experimental field tests demonstrated the effectiveness of the research proposed; in fact, the results show little differences between data obtained in field and measurements carried out in the lab under standard conditions.

- This allows to effectively evaluate health risk caused by hand-harm vibrations in laboratory also testing different machines.

Thank you