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What other recent innovations have been implemented or should be implemented to improve the safety of OHTL workers?

As shown in Q3.2 safety improvements in OHTL works over the last 10 years have been mainly due to the following reasons:

- Continuous training of workers and lessons learned feedback from accidents and incidents
- Personal Protective Equipment (PPE) design improvement and easiness to use
- Preventive attitude and cultural change: increased awareness and participation of all stakeholders in health and safety matters, developing behaviors and attitudes that consolidate the commitment to a preventive culture of "zero accidents".

However, with the advent of Industry 4.0, new technologies have become available, and we can foresee a new era with regards to Health and Safety management.

More and more companies are using drones (UAV/RPA) or robots for tasks such as maintenance inspections or bird flight diverters installation. Safety of workers is improved as works are carried out at ground level, eliminating fall risks.

We have seen before the importance of continuous training of workers. Virtual Reality (VR) techniques can be used to complement conventional training. In the example shown below VR training is applied to train the safety procedure of safety rope and temporary anchors installation needed for works at height in overhead line construction and maintenance activities. In this particular training, haptic gloves were also used to provide workers with more realistic feedback from the type of work being carried out.


VR techniques enable training in a simulated environment and at the same time avoiding the own risks from training at heights in real situations.
To sum up, by this VR simulations, workers can increase the number of trainings and consolidate theoretical concepts and all of that in a safe environment.

Finally, the development and use of IoT or IoB wearables may allow us to reach a new level in safety management, in which data and anticipation are key factors.
One of the main objectives of IoT deployment with regards to safety considerations in overhead line works is to move from conventional continuous training based on accidents or incidents towards an adjusted training based on actual data on safety deviations from the established procedure.
This idea is depicted in the following graphs.
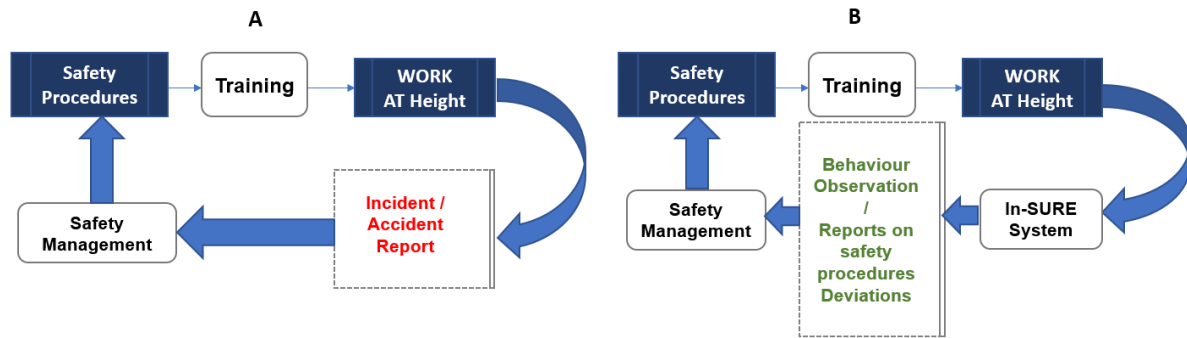
To achieve this goals, the In-SURE system is currently being developed by the Spanish TSO with a technological start-up, as described in Session paper B2-10915 "A wearable system for Work at Height Safety Management". Research is now in stage TRL-5 "Technology validated in relevant environment".

As explained in Q3.2, works at heights in overhead lines are carried out according to very detailed and defined safety procedures.

By using wearables attached to PPEs (Personal Protective Equipment) the proposed system can determine whether the worker expected behaviour is following the safety produce or in contrast if there is any deviation from it.

Wearable main sensor is using IMUs although there are other sensors included.

In the next figure sensor deployment in a relevant scenario is shown.

Sensor attached to safety body harness

Sensor attached to temporary anchor device

Sensor attached to mobile fall arrester

Sensor attached to safety rope

From the figure shown below, we can observe the other main objectives from the proposed wearable system: real time detection of misuse of PPEs or any other deviation from safety procedures and, consequently, alarm generation in real time to alert overhead line workers.

In the example shown in the figure below, a worker climbs and installs a first intermediate anchor point following the safety procedure. After that, the worker continues climbing but the safety distance from the first anchor point is exceeded before a second anchor is installed. As a consequence, the system raises a real time alarm and also registers all the relevant data for further offline analysis.

NOTE:
During testing, the worker remains safe installing an anchor at the required altitude which is artificially hidden to the system to allow for the test to be carried out.

In a real scenario this violation will not normally lead to an accident so it will not be given any attention unless the proposed system is used. An unattended deviation that becomes an everyday practice can lead to serious injury at the time a real fall from height actually happens.
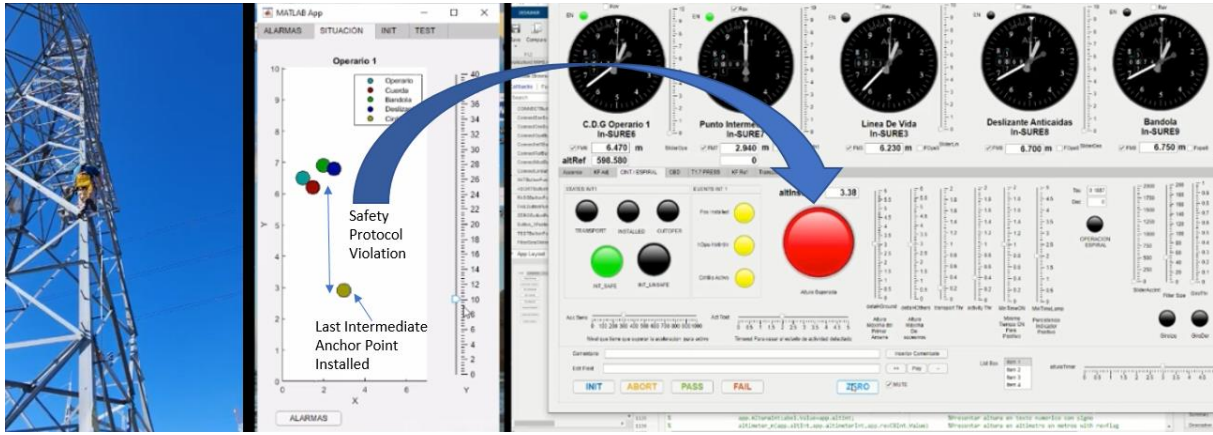
As a conclusion, the proposed wearable system will improve the safety of OHL workers in the following areas:

1. Continuously monitors Safety behavior and correct use of PPEs
2. Provides real time alarms for workers to immediately correct a safety deviation or violation
3. Enables Health and Safety managers with a new tool to adapt training, making adjustments based on system detection of safety violations or deviations not easily detected at ground level

Once the system is deployed, a huge amount of behavioral data will be available. This rises the opportunity of leveraging big data and analytics techniques to further improve decision making in the safety management process.