# Wearable System for Human Safety in Harsh Environment

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*In several European projects (Proetex, eSponder) dealing with human safety in a harsh environment, CSEM is involved in the development of wearable electronics for smart garments. The greatest challenges concern textile electrodes and their contact with the skin, effects of sweat, motion artifacts, and sensor connections. Another sensitive point is the communication with the sensors disseminated in the garment, because interoperability implies careful compliance to standards. All these issues require a high safety level to cope with the harsh environment.*

Wearable systems aim at improving the safety and efficiency of emergency workers by empowering them with wearable sensing and transmission systems that monitor their life signs, activity, and position, as well as their environment during risky situations such as:

- Rescue operations
- Water rescue
- Operations requiring ventilation
- Firefighting in urban and industrial settings
- Large area bush fires
- Earthquake and building collapse

The main constraints to be taken into consideration while developing such systems are ease of use, maintenance and reliability. To be used by rescuers, these systems must not impede them, not interfere with their mobility, nor add to the weight of the overall protection clothing (which is already heavy and bulky). Therefore they must operate as a 'second skin'. Textile-based smart wearable monitoring systems are the natural option to enable this.

Advanced eTextiles integrate the sensors with their connections to the embedded electronics as shown in Figure 1.

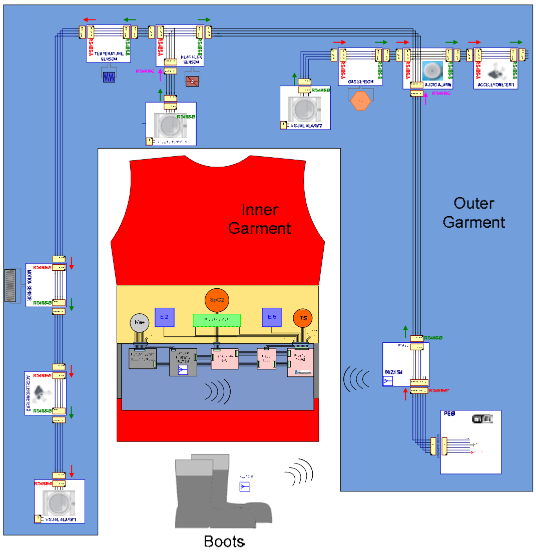


*Figure 1: Wearable electronic system overview*

A set of application-specific sensors is necessary to get information about the emergency workers and their environment in order to take the right decisions. First of all the sensors provide the vital signs of all crew members. Onboard microcontrollers automatically process the signals from the sensor accelerometers to classify the rescuer activity and to estimate the energy expenditure. Other information, such as pace rate, is also extracted from the accelerometer signals. A multi-parameter approach is used in order to enhance the quality of the signals. The most relevant information of the users and their environment is extracted from the set of heterogeneous signals.

Textile integration of smart sensor systems is the key technology for sensing garments protecting emergency workers. The challenge offered by emergency situations is mainly to acquire data in harsh environment, during intense physical activity, i.e., conditions that increase the occurrence of signals artifacts, as well as the presence of positive and negative false events. The body sensing platform requires a direct contact with the skin leading to the implementation of a sensing inner garment. At the same time the environment sensing platform, the alarm system, as well as the electronic unit for data processing and transmission can be embedded in standard uniforms.

Continuous monitoring ensures the capture of relevant events and their associated physiology during routine working activities. The systems are personalized according to the risks inherent to the different emergency scenarios like fire, earthquake, flooding, explosions, gas leakage, or more simply, any situation at risk. Collected data will have a double use: first an immediate alert to optimize the emergency operations, and second, statistics for learning purposes. Long-term monitoring has the potential to help in the creation of new models of behaviors at risk both for the emergency workers and for the supervisor. Compared with existing systems, these new systems offer a view over larger time spans as well as over more human vital signs and environmental information.

First Responder Unit (FRU) Local Network system has to be used non-obtrusively into the routine working activity of the user. Additional sensors are integrated in the on-body electronics for the detection of movements, as well as for the detection of context information (e.g., GPS location). The core of the electronic system is based on a scalable low-power processing unit that can be designed according to different application needs. The system not only allows the acquisition and storage of data, but also the online analysis of the data. Moreover, the system has to provide sufficient processing power to diagnose the health status. Ad hoc signal and data processing procedures have to be developed for each scenario in order to provide personalized and synthetic parameters related to emergency status and its deviations from a "reference" situation. On top of that, wireless technology is used to seamlessly connect the system to wired and wireless communication infrastructures and to acquire data from external sensors and from a centralized control unit.

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