

# SILC - SUPPORTING INDEPENDENTLY LIVING CITIZENS: AN INNOVATIVE PERSONAL EMERGENCY ALARM SYSTEM WITH INTEGRATED BIOMETRIC SENSORS

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## 1. Introduction

Personal Emergency Response Systems (PERS) were introduced in Italy in the eighties, in response to the need of an ever-growing number of independently-living elderly people to be granted safety and help in their daily life at home.

In 1987 the Veneto Region established the Homecare and Personal Emergency Assistance Program, the first case in Italy of such an institutional action on a regional level.

The basic concept is the use of the public switched telephone network (PSTN) to automatically convey alarms from the users to the rescuers. A low-cost electronic device installed at the user's home receives radio impulses from a small transmitter constantly worn by the user, who can trigger it in case of need or emergency. The device immediately starts a process of telephone calls to a network of operation centers, working 24 hours a day, 365 days a year. At the alerted operation center the caller's data automatically pops up on the monitors of personnel with specific training, who then analyse the situation and manage the emergency by following strict, highly-tested, operative protocols.

The current developments in information and telecommunication technologies (ICT), computer-telephony integration (CTI) and bio-medical engineering have been transforming a PERS company such as Tesan S.p.A. into a contact-center-based homecare and telemedicine service provider, capable of handling and processing a variety of transtelephonic voice and data flows. The mission is to supply an integrated mix of home care service solutions to both the citizens (elderly people, disabled people, patients suffering from chronic pathologies, ...) and the health and social service operators (practitioners, specialist physicians, hospitals, social institutions, public authorities, ...).

In this framework, the Veneto Region and Tesan are participating in the SILC project ("Supporting Independently Living Citizens"), an R&D project within the IST Programme (5<sup>th</sup> Framework Programme) of the EU, involving universities, industrial companies and service providers from Austria, Great Britain and Spain.

## 2. The SILC Idea

The SILC project is aimed at developing an innovative alarm system (itself referred to as SILC in the following) based upon a wrist-worn electronic device with integrated innovative biometric sensors (Figure 1).

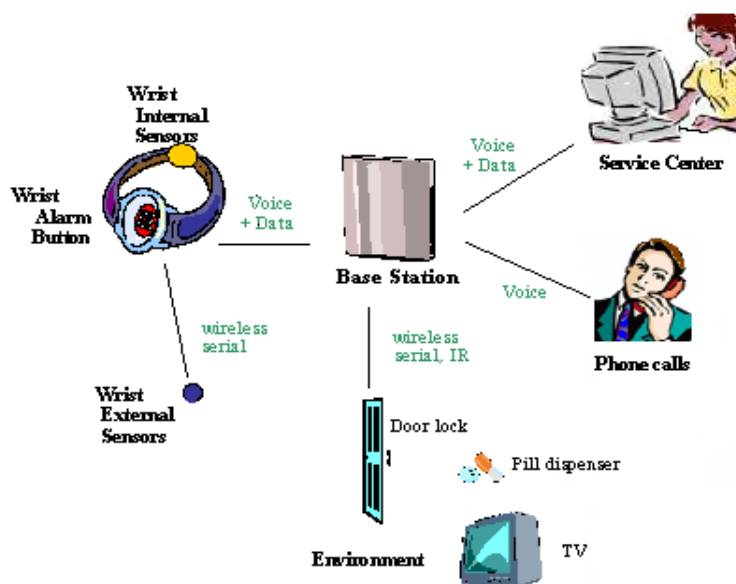


Figure 1 – The SILC concept

SILC is a modular system including a wrist unit and a base station for communicating to the operation center.

The main innovation of SILC with respect to similar alarm devices is the inclusion of a set of biometric sensors together with additional features to make the device even more indispensable for the every day life of the future users.

The system will be usable by elderly people with a variety of disabilities, including short-term memory loss, low vision and deafness.

The recognition of combined "derailing" body parameters is the unique feature of SILC, which at present is not provided by similar devices offering only limited possibilities of detecting such events.

SILC combines the latest sensor technologies with innovative decision taking strategies, to allow, inside a wrist worn device, monitoring of critical body functions and reliable alarm triggering. When critical conditions are detected, an alarm telephone call will be triggered and the user's biometric data will be made available to the operation center and to the call-out rescue team.

The integrated biometric sensors is designed to monitor:

- the pulse rate, including the variation of the pulse;
- the body temperature;
- the user's movement (through the spatial orientation and acceleration of the device);
- the ECG signal (with external sensor);
- possibly, the glucose level by means of an innovative non-invasive measuring method.

To make SILC an indispensable device for everyday life a variety of additional features will be incorporated:

- built in cordless telephone;
- clock and alarm clock shown on the display;
- simple Personal Digital Assistant (PDA), especially as a reminder for medication;
- programmable remote control for various household appliances (TV, VCR, door lock, lamps ...).

SILC will also offer the possibility of upgrading the device with others sensors as soon as they become available. By using a cordless RF-link external sensors will be connected with the SILC system.

### **3. Project Overview**

The first prototypes of the SILC system (wrist unit and base station) will be ready in July 2002 for laboratory evaluation. This testing will focus on monitoring of critical body functions and alarm triggering, but it will also include the evaluation of the first release of the user interface aboard the wrist device. A second set of prototypes will be released in the second half of 2002 and will permit full testing of the final functionalities. Sizes and weight will not be optimal yet. A user test is planned to start in January 2003. A redesign will follow and will lead to the final prototype in miniaturized form.

### **4. User needs and requirements**

At the basis of the project design is the set of user requirements that have been systematically collected since the beginning of the development. Adherence of the designed features to the user requirements is ensured by continuous assessment of intermediate design stages by means of user tests.

The SILC-Target User is defined as follows:

- elderly, older than 65,
- living alone,
- in health conditions that restrict usual daily activities, up to including possible disabilities,
- under increased risk of falling or other possible accidents.

Following these indications, primary users for a user panel were selected by the SILC user partners. Rehabilitation professionals and service providers supplement this panel, which represents the advisory body for the project, in charge of assessing and approving the project results. Questionnaires and interviews were used to collect the user requirements. Possible usage-scenarios were developed to define probable real-life situations for the tests. In priority order, the common core usage areas will be:

- (1) Health status and fall detection (automatic monitoring)
- (2) Check call services and periodic contacts (personal communication)
- (3) Reminders for medication or periodic business (automatic reminder)
- (4) Remote control of door lock or household appliances (remote control).

To detect a variety of risky situations, the SILC device is designed to identify the following conditions:

- (1) falls,
- (2) pulse rate and variation,
- (3) user activity,
- (4) body and environment temperatures,
- (5) removal of device.

All applications require the user to permanently wear the SILC device in order to provide maximum benefit.

## 5. User Interface

The User Interface (UI) of the SILC device is fundamental to the success and usability of the system. Mock-ups and PC-based simulators of the UI were used in the first design stages. Early prototypes employ a special User Interface Evaluation Hardware which communicates to a hand-held computer (palm top) worn by the user on his/her belt. A BlueTooth module is used for testing the SILC communications system. The UI design is driven by the ergonomic requirements of the elderly: a wide (25mm x 50mm) central LCD screen is employed, showing a clock as default, telephone numbers and related information during telephone calls, system values only for maintenance and test purposes. A large SOS button is located on the strap of the wrist device. For navigating the menus, 4 navigation buttons are currently available, which might reduce to 2 only, in response to the demand for further user-friendliness.

## 6. Base Station and Operation Center

The base station (BS) plays two main roles in the SILC system:

1. it is the communication gateway between the wrist unit and the operation center through the PSTN (public switched telephone network);
2. it is the core of the Environmental Control functions. Whereas an infrared transmitter for TV and/or radio remote control will be mounted directly in the wrist unit, an EIB interface (home automation network) and peripheral control modules (e.g. for door intercom) will be embedded in the base station.

The environmental control link is bi-directional: environmental alarms are received (i.e. from the gas or smoke detectors), whereas control commands are transmitted. A control panel for the whole SILC system will be available on the BS. A configuration interface allows rescuers, nurses, social workers, as well as the operation center via PSTN, to change settings and preferences of both the base station and the wrist unit. No software for the Operation Center is developed within the SILC project. Nevertheless, care is taken to make the interface to existing service providers as easy to implement as possible.

## 7. Sensors

Measurement of the event can be represented as a 2-dimensional matrix as shown in Figure 2, which covers correct measurements of events and incorrect measurements of events. It also includes correct measurements of non-events and incorrect measurements of non-events.

With a perfect measuring device, there will be only “true positives” and “true negatives”. A confusion matrix showing possible results would look like as in Figure 3.

100% (TP)	0 (FN)
0 (FP)	100% (TN)

**Figure 3 – Confusion of a perfect measuring device**

In practice, e.g. for the variable “falling out of bed”, it will differ from severe non-event and some falls will be incorrectly classified as non-events, i.e. false negatives. Similarly, measuring the occurrence of “falling out of bed” will vary because of measuring errors etc., thus some of the non-events will be incorrectly classified as falls, i.e. false positives.

Thus, in a less than perfect system, the “confusion matrix” might look like as shown in the next Figure 4.

To reduce false detections as shown in the confusion matrix, multiple sensor signals are necessary in order to make the correct decision to send an alarm. A complex software package is necessary to handle the priority of single sensor signals. To improve the efficiency of the system, external sensors might be necessary. Figure 5 shows the signals from a 3-axis accelerometer and compares them to the ECG signal and to the signal from a pulse sensor.

The 3-axis accelerometer sensor was fixed on the wrist, whereas the pulse sensor was fixed on the tip of the middle finger. The ECG signals was taken as reference. It can be seen that, while sleeping, the signals taken with an accelerometer can be used to compute the heart rate, the heart rate variability as well as the signal from pulse sensor. Figure 6 shows that accelerometer signals are no longer usable to detect the heartbeat if the user moves while sleeping. However a moving user is alive, thus high significant signals will result from the accelerometer sensors.

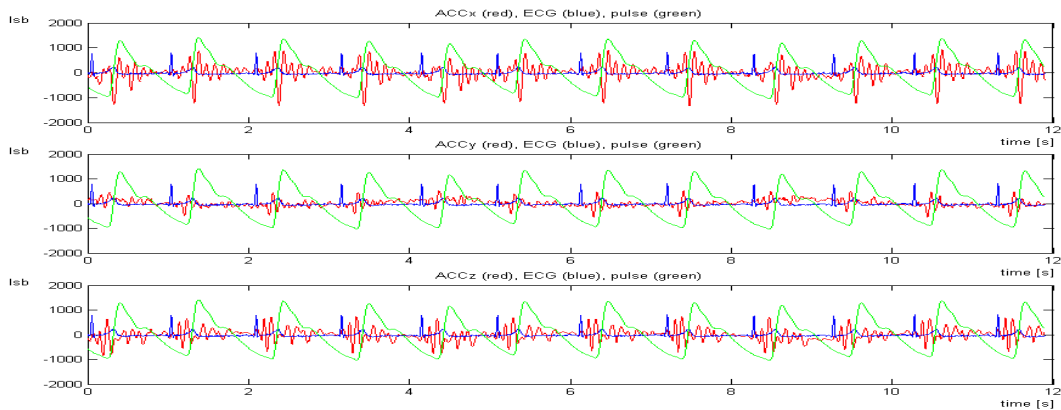
Measure OK (TP) “true positives”	Measure wrong (FN) “false negatives”
Measure wrong (FP) “false positives”	Measure OK (TN) “true negatives”

**Figure 2 – Confusion Matrix**

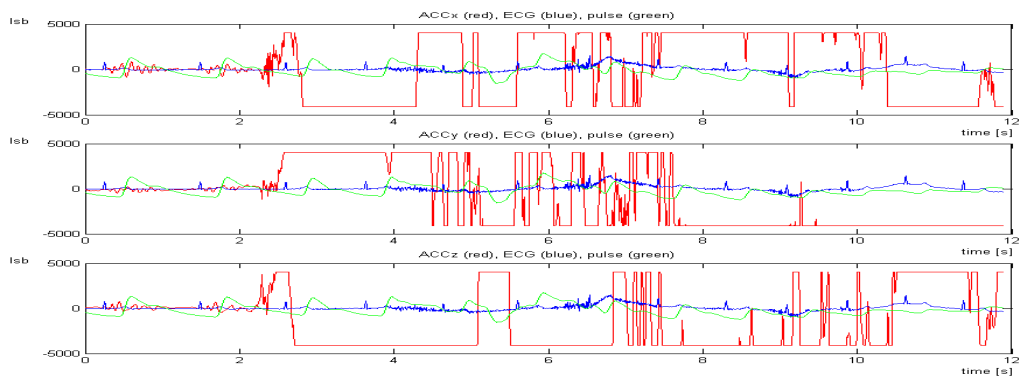
Figure 2 – Confusion Matrix

95% (TP)	5% (FN)
5% (FP)	95% (TN)

**Figure 4 – Confusion Matrix of a less than perfect system**



**Figure 5 – 3 axis accelerometer in comparison with pulse and ECG**



**Figure 6 – Signals from a moving user**

Combining evaluation of short time events as well as analysing long-time activities will help to perceive a good overview on the status of the user. Several sensors and sensor arrangements have been tested until now but only the tests with the full prototypes will show which sensors or sensor combinations will deliver satisfactory results.

## 8. Conclusions

Actually, the SILC wrist modules are under evaluation in laboratory. After the laboratory tests and the refinement of the software, a number of prototypes will be prepared for a first user test in January 2003. The main innovations of the SILC project are: 1) the use of combined sensors information to detect the user status before generating an automatic alarm; 2) the capability of the System to add new features by adding/connecting external devices; 3) the use of the wrist for telephone calls and for household appliances control, which will make the device even more indispensable for the every day life of the future users.

## 9. Disclaimer

The SILC project is partly funded by the European Commission within the IST (Information Society Technologies), which is part of the Fifth Research and Technological Development Framework Program. Information in this paper is provided as is and no guarantee or warranty is given that the information is fit for any particular purpose. The user thereof employs the information at its sole risk and liability. The content of these pages in no way represents the view of the European Commission or its services.

## 10. Project partners

**Austria:** Fortec Institute of Ind. Electronics and Material Science, Rehabilitation Technology; TECWINGS Industrialisierung und Elektronikproduktion GmbH; Joanneum Research, Institute of Noninvasive Diagnostics; Municipality of Vienna, Health Planning Department; Johanniter-Unfall-Hilfe;

**Italy:** Regione Veneto, Direzione Servizi Sociali; TeSAN S.p.a.

**Spain :** Ajuntament de Callús ; CHC Vitae, S.A

**United Kingdom:** Cardionetics Limited; Cloudworld Limited; Knowsley Metropolitan Borough Council Social Services.