SIXTH FRAMEWORK PROGRAMME
PRIORITY [2.5.12]
ICT for Environmental Risk Management
SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT (STREP)

"SCIER"

Sensor & Computing Infrastructure for Environmental Risks

EC RTD Contract no.: IST-5-035164

www.scier.eu

Project Presentation

Deliverable No.: D01

By

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National and Kapodistrian University of Athens(*NKUA*)
DHI Hydroinform a.s. (DHI)
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Abstract

SCIER designs, develops and demonstrates an integrated system of sensors, networking and computing infrastructure, aimed to detecting, monitoring, predicting and assisting in crisis management of natural hazards or accidents at the "wildland-urban interface" (W-UI), i.e., areas where forests and rural lands interface with homes, other buildings and infrastructures. The goal of SCIER is to make the much neglected W-UI zone safer for the European citizens against any type of natural hazards or accidents.

To achieve its objective, SCIER pushes the state-of-the-art by combining and using technologies such as: (1) self-organizing, self-healing re-configurable sensor networks for the detection and monitoring of disastrous natural hazards, (2) advanced sensor data fusion and management schemes capable of deducing the required information needed for accurately monitoring the dynamics of multiple interrelated evolving hazardous phenomena (multi-risk), (3) environmental risk models for predicting the evolution of hazardous phenomena using a robust GRID computing infrastructure. Furthermore, SCIER gives emphasis to the public-private sector cooperation (e.g., house/land owner, security-company) as an "active player" in the W-UI zone protection and the monitoring of hazardous events.

Given the above, SCIER has to be a user-demand driven product, addressing the needs and requirements of the user, public authorities and businesses, yet, at the same time, taking advantage of the latest technological advances.

This Deliverable provides an outline of the SCIER project. The Deliverable was produced as a first result of Work Package 0 “Project Management.

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The SCIER Consortium consists of:

Epsilon International SA	EPS	Coordinator	*Greece*
National Kapodistrian University of Athens – Communication Networks Laboratory	NKUA	Contractor	*Greece*
DHI Hydroinform a.s.	DHI	Contractor	*Czech Republic*
National Agricultural Research Foundation	NAGREF	Contractor	*Greece*
Centre Suisse d'Electronique et de Microtechnique SA	CSEM	Contractor	*Switzerland*
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Greek Research and Technology Network	GRNET	Contractor	*Greece*
Centre d'Essais et de Recherche de l'ENtente	CEREN	Contractor	*France*
TECNOMA S.A.	TECNOMA	Contractor	*Spain*
Associação para o Desenvolvimento da Aerodinâmica Industrial	ADAI	Contractor	*Portugal*

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1 Project Identification Information

1. Contract Number: IST-5-035164

2. Project Acronym: SCIER

3. Project Name: Sensor & Computing Infrastructure for Environmental Risks

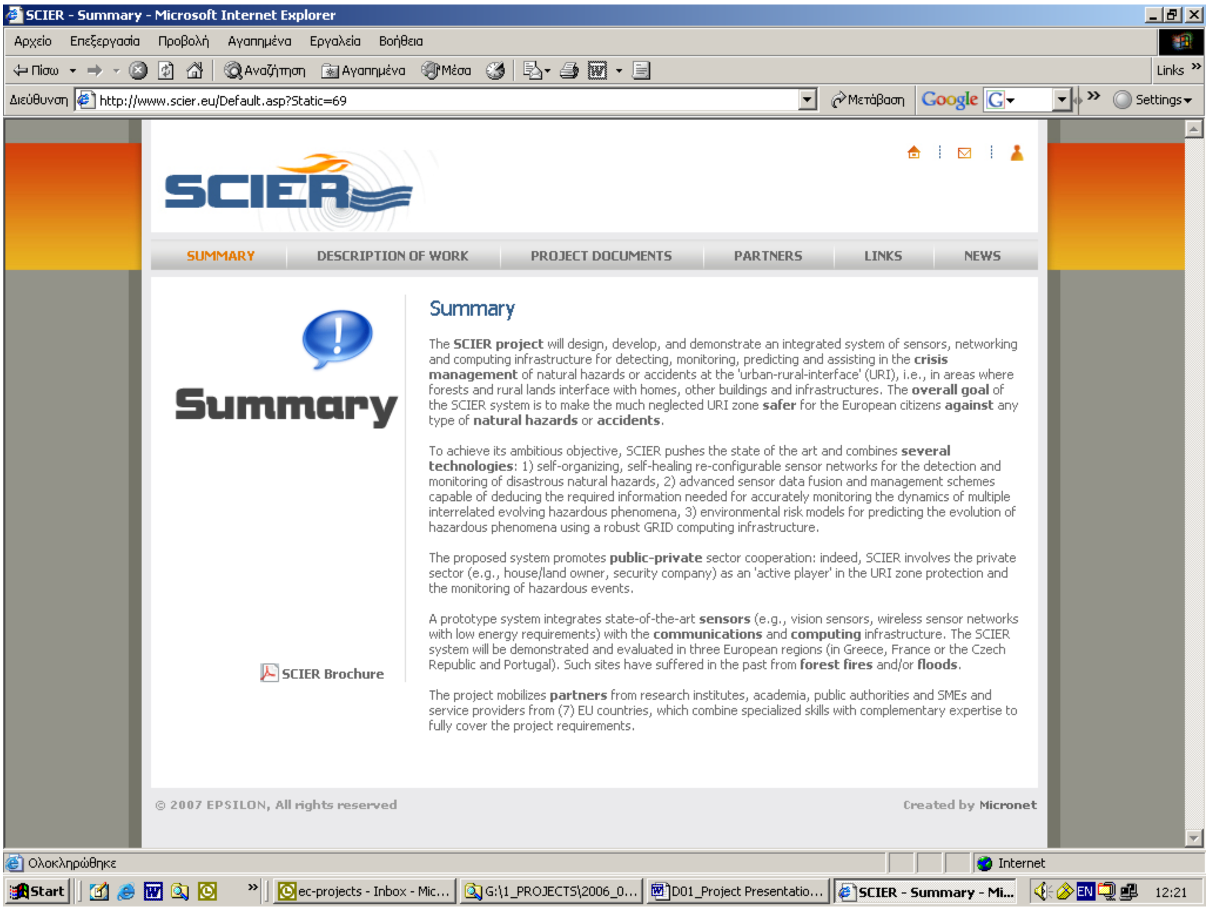
4. Key Action, Action line: 2.5.12 ICT for Environmental Risk Management

5. Project Logo:

(This is a preliminary logo that may change in the near future).

6. Project Website

www.scier.eu



7. List of participants

Participant role	Participant number	Participant name	Country
C	P01	Epsilon International SA	*Greece*
P	P02	National Kapodistrian University of Athens – Communication Networks Laboratory	*Greece*
P	P03	DHI Hydroinform a.s.	*Czech Republic*
P	P04	National Agricultural Research Foundation	*Greece*
A	P05	Centre Suisse d'Electronique et de Microtechnique SA	*Switzerland*
P	P06	Group 4 Securicor Security Services	*UK*
P	P07	Greek Research and Technology Network	*Greece*
P	P08	Centre d'Essais et de Recherche de l'ENtente	*France*
P	P09	TECNOMA S.A.	*Spain*
P	P10	Associação para o Desenvolvimento da Aerodinâmica Industrial	*Portugal*

* C = Co-ordinator / P = Principal contractor / A = Assistant Contractor

8. Total cost (€): 3,266,949.00

9. Commission Funding (€): 2,091,000.00

2 Project Main Goals

SCIER will contribute in the improvement of the safety and minimization of impacts to European citizens through the employment of innovative solutions with significant market value. This refers to types of areas where forests, waterbodies, and rural lands, interface with homes, other buildings and infrastructures, including first and secondary home areas, industrial areas and tourist developments. The tendency for the development of extensive WUI areas is relatively new, whereas the problems, especially in regard to fires and floods, started becoming noticeable only in the 1990s. The SCIER will design, develop, validate and demonstrate an integrated system that will assist the citizens to profit from a better safety against natural or man made hazards, and to respond in time in order to reduce the potential damage to their property. Most important, SCIER introduces an integrated concept that can have a strategic impact in the way citizens view environmental risks, to their well-being.

The SCIER integrated system of sensors, networking, computing, and alerting infrastructure for detecting, monitoring, predicting and assisting in the crisis management of natural hazards or accidents at the "Wildland-Urban-Interface" (WUI), i.e., in areas where forests and rural lands interface with homes, other buildings and infrastructures. The overall goal of SCIER is to make the much neglected WUI zone safer for the European citizens against natural hazards or accidents. Specific scientific and research objectives of the SCIER project involve:

- The integration of various wide and local area sensor network infrastructures for the detection and monitoring of disastrous natural hazards. Specifically, the sensing infrastructure will consist of a static segment (privately owned sensors installed at the perimeter of houses, resorts, and farms) and a dynamic segment (publicly owned sensors dispersed in the WUI prior to, or during, the occurrence of incidents) of different sensors.
- Developing advanced sensor fusion and management schemes capable to deduce the required information needed for accurately monitoring the dynamics of evolving hazardous phenomena.
- Exploiting environmental risk mathematical models for monitoring the evolution of hazardous phenomena into a powerful GRID computing infrastructure, Until know hazardous events management focus either on the urban area, or on the rural area. SCIER aims at filling-up this gap by highly focused activities related to the WUI.
- Real time monitoring of natural hazards: Whereas three types of scientific and operational activities in natural hazards and accidents management exist: (i) Forecasting, (ii) Monitoring, and (iii) Operational Activities, the latter is being considered as the most important. However, Operational Activities require intensive real time information, and such information is both rarely available at the WUI zone and not distributed in real time to important parties (e.g., home owners, fire brigade, police, hospitals etc.). SCIER aims at filling this gap through the deployment of sensor networks.
- Multiple hazards consideration: Most of the research and modelling on real time simulation of natural hazards is focused on single-cause events or accidents (e.g., flood, fire, earthquake, hail, drought, landslide), and there exists no platform which can accommodate multiple (combined & interrelated) hazards as fostered by sensors-fusion technologies. SCIER aims at filling this gap, with a demonstrator for two types of environmental risks (flood and fire at the same time), and the use of existing off-the-shelf models.

- The provision of a GRID-enabled Computing Infrastructure: Most authorities, and institutions operate their models in-house with their own data. They usually operate one-model at a time (e.g., flood model) due to model unavailability or limited processing power. Several events that have occurred this year have shown that this approach is often inadequate: a flood was followed by a landslide in Switzerland, and a flood took place following a forest fire in Greece. Clearly, there is a need of interfacing multiple models, which may not be available at the same authority during the incident occurrence - SCIER aims at filling this gap, by introducing GRID technology with distributed computing features (e.g., different physical location of models, data, computing power the management of which is performed by a single authority) to enable the unhindered execution of different models.
- Public-private sector cooperation: Most of the hazard and industrial accidents are monitored, controlled and managed by the government sector (e.g., civil protection authorities, ministries, agencies). There is little effort known, where the private sector (e.g., house owner, security company) truly participates (e.g., financially) in the monitoring of the events - SCIER aims at filling this gap, by incorporating a large part of the private sector as an “active player” in the WUI zone protection.

3 Key Issues

The SCIER proposal identifies and addresses the following key areas:

(a) The development of a sensor network, which will support the continuous retrieval of information from the WUI areas. The network will comprise various types of sensors depending on the environmental hazards to be monitored. The following types of sensors will be considered for integration:

   i. Fire:

   - Temperature
   - Relative humidity / precipitation
   - Illumination
   - Wind speed/direction
   - Atmospheric pressure
   - Smoke
   - Vision

   ii. Floods:

   - Water Level
   - Rain
   - Vision

(b) The development of the appropriate data fusion mechanisms and algorithms, to be applied to the sensor readings. The data fusion process will produce the indicators that will feed the environmental models running to the core SCIER platform.

(c) The establishment of a GRID-enabled computing infrastructure that will receive the fused data and run the models for the environmental hazards. The computing infrastructure may also be used for storing data coming from the sensors (Data-GRIDs), and for performing the computationally intensive fusion process.

(d) The provision of self-organizing and re-configurable sensor networks for the detection and monitoring of disastrous natural hazard. This will be enabled through the triggering the replacement of lost or failing sensors, switching to alternative sensing means, modifying the network routing to proactively avoid the loss of significant information and adjusting the frequency of the sensor signal feeds.

4 Technical Approach

SCIER aims at developing an integrated platform of sensors and computing infrastructure capable of delivering valuable real time information during the evolution of natural hazards at the “Wildland-Urban-Interface” (WUI, Figure 1).

Sensors spread in the region characterized as the borderline between urban and wildland areas (the WUI) will monitor environmental parameters and feed appropriately fused data to environmental models running in the computing infrastructure. The SCIER infrastructure will monitor an area and detect hazardous events (e.g., forest fires, floods, combined events via simulation), and subsequently provide the information needed to support the planning of actions required to contain the event and its societal impact. As an environmental hazard approaches, or has already reached, the WUI region, SCIER will provide the capabilities of both monitoring and forecasting its evolution based on sensor inputs and predictive models.

The precise dimensioning of the WUI will be determined beforehand according to the opinion of experts. It can range from a few hundred meters to a few kilometres. Longer areas cannot be considered WUIs. The exact layout of the WUI (and the opinion of experts) will also determine the initial sensor spatial distribution. Such distribution may vary after the occurrence of an environmental hazard. WUI segments that call for special attention will be identified by experts. The dynamic expansion/merging/shrinkage of WUI segments is controlled through the evolution of the monitored phenomena.

An innovation of SCIER is that it can receive and fuse appropriately data feeds provided by:

- Citizen Owned Sensors (COS) installed by land/home owners in fixed and registered locations in their URI properties. From now on we will refer to these as “static sensors”.
- Publicly Owned Sensors (POS) which may be networked and are installed by state authorities, either in fixed and known locations (POSF) e.g. forest trees, poles, river banks or on mobile (POSM) entities e.g. fire trucks, police cars, personnel, etc. Since the POSM part of the sensing infrastructure is deployable on a need basis, and will provide data through wireless links, we will refer to it as “dynamic sensors”. The POSF part of the sensing infrastructure is considered part of the static sensor segment.

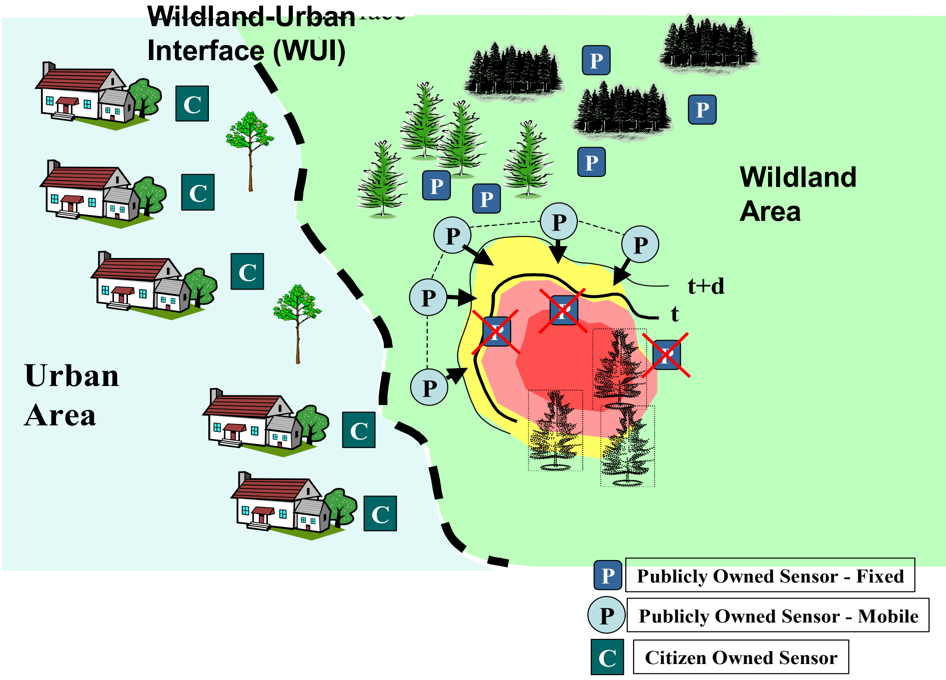


Figure 1: SCIER Sensors infrastructure in the Wildland-Urban Interface (WUI).

The SCIER architecture builds upon existing technical expertise and recent technical progress in the area of sensors, communications, GRID computing, Geographical Information Systems (GIS), data fusion, data modelling, and aims at providing the functionality needed for forecasting environmental hazards, monitoring them and assisting in their fighting. Indeed, the real-time information produced by the SCIER platform, in many cases, will be a key factor in the effective fighting of the hazard. SCIER will predict the evolution of the main phenomenon as well as the risks of any secondary phenomena it may trigger. SCIER will, also, try to interface with existing disaster and emergency management systems (e.g., OASIS, ORCHESTRA, etc.), in order to further extend their applicability to the WUI region. Real time information and forecasts coming from the SCIER platform will feed emergency response systems enabling them to take decisions, taking into account every available detail pertaining to the evolving hazard.

The SCIER architecture consists of three physical distinct, yet cooperating entities:

a) The Sensing Subsystem
b) The Computing Subsystem
c) The Localized Alerting Subsystem (LAS)

A component overview of the SCIER platform is illustrated in Figure 2:

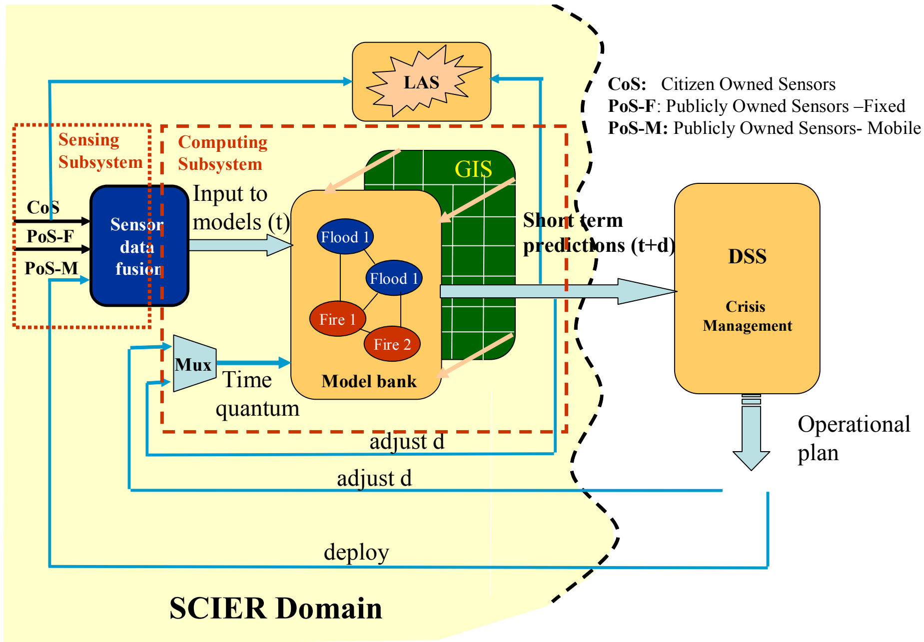


Figure 2: The SCIER platform architecture

The Sensing Subsystem

SCIER will feature a multi-sensor, wide-area infrastructure for the collection of critical sensor readings (e.g., humidity, temperature, wind flow). Such information is fed into the system to be subsequently processed by advanced sensor data fusion schemes (to be developed in the context of SCIER) in order to provide the necessary information for short term prediction purposes contributing to the crisis management effort (Figure 2). Information is fed into the SCIER fusion engine whenever the sensing infrastructure is awake. Energy efficiency reasons dictate that the sensing infrastructure is, normally sleeping and gets awaken whenever certain thresholds are exceeded by the collected readings. The controlling role (trigger the switching from dormant mode to active) is assigned to a subset of the employed sensors. In the dormant mode, sensors do not transmit information to the SCIER back-end infrastructure.

The SCIER sensing front can be divided into a static and a dynamic part:

- The static part consists of Citizen Owned Sensors (COS) that can be installed in the perimeter of houses or farms located in the WUI where communication and power facilities are available. The system feeds the computing subsystem with the required readings (through networks like the PSTN or terrestrial mobile networks) but also triggers a LAS for first level incident handling. Part of the static part of the sensing infrastructure are also, publicly owned sensors (e.g., vision sensors) that can be pre-installed in fixed locations (POSF).
- The SCIER dynamic sensor infrastructure (POSM) features wireless sensor networks (WSN) and vision sensors that can be deployed, on demand. A WSN may consist of several inexpensive diverse sensors, which are distributed in the field at a specific time or whenever an alarming situation arises. The dynamic part of the sensing infrastructure needs to establish ad hoc network connections to exchange information (contrary to the static part where network connections are pre-arranged/configured).

Data from the Sensor Subsystem will feed the SCIER sensor data fusion process , which will combine this information to yield estimates of the parameters needed by the SCIER environmental hazard models in a timely fashion. The data fusion engine processes both data coming from the static and dynamic sensor segments. The functionality of the SCIER data fusion (Figure 3) includes:

- **data collection** from field sensors
- **data assessment** regarding relative importance, quality, proper timing etc., as well as, data spatial and temporal alignment to a common reference,
- **data combination** of compatible representations for the estimation of suitable metrics and parameters needed by the hazard evolution models, and,
- **assessment** of the fusion process quality, with the purpose of evaluating and refining the overall data fusion process..

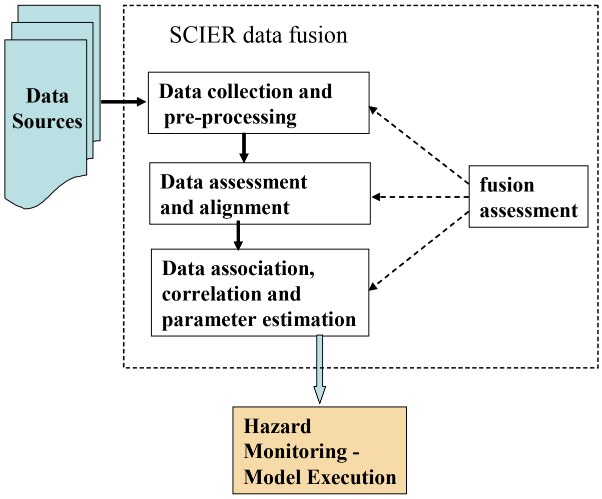


Figure 3: SCIER Data Fusion Process

The Computing Subsystem

The Computing Subsystem is the heart of the SCIER architecture. It is based on GIS where the fused sensor information is systematically "pinned". SCIER also incorporates GIS-enabled mathematical environmental models of different time scales for predicting the evolution of tracked phenomena and related risks. Multiple models for each phenomenon (e.g., fire, flood) are used in order to establish a globally acceptable, highly accurate tracking of the phenomenon. The output of the models will, in certain cases, re-feed the sensor infrastructure, which will be capable of reconfiguring itself to adapt to the dynamics of the observed phenomenon and allow its best monitoring (see Figure 2).

The integration of some environmental models will be necessary at some situations, especially for flood hazard evaluation the coupling of distinct physical phenomena will be necessary in order to evaluate and quantify the impacts of flooding on urban and rural infrastructure.

The sensing infrastructure will be coupled with a GIS platform for assessing the spatial distribution of the sensing components. Whenever, an alarming situation is detected (crisis conditions), the sensor density in the field will be thoroughly evaluated. Depending on the type of the observed phenomenon and the general condition of the sensing components, sensor density will be re-adjusted to obtain the required quality in the data feed. Lost or failing sensors will be identified and replaced/complemented as needed. The re-adjustment of sensor density will also rely on known rules of thumb (e.g., some fire sensors provide adequate coverage when placed 50 meters apart). The discussed management/monitoring of the sensor subsystem are performed whenever an alarming situation is detected and the whole system becomes fully operational.

The computing subsystem incorporates two entities:

1. The Computation and Storage Subsystem (CSS), which performs the following tasks:
   (a) receives and stores data coming from the sensor subsystem, possibly processing it in order to comply with the format needed by the models,
   (b) performs the calculations needed by each environmental model (i.e., run the model), in order to predict its evolution,
   (c) renders models output on the GIS model, thus creating a visual representation of its evolution, as well as of any emerging related risks, and,
   (d) iteratively performs tasks (b) and (c), using a possibly different time quantum in each iteration.

2. The Models for Environmental Risks, which run on the CSS and include:
   (a) Forest Fire models, principally based on the BEHAVE model but other models can be considered as well.
   (b) Flood Models, principally based on the MIKE – series flood models, but other model types can be considered as well.

The Localized Alerting Subsystem (LAS)

The LAS is a part of the static segment of SCIER sensor infrastructure and consists of sensors that can be purchased and installed by the landowners in the geographical areas addressed by the project. LAS will integrate a variety of sensors in a single structure (i.e., MSD: Multi-Sensor Device) that can be installed in the perimeter of houses or farms where communication and power facilities are easier to secure. The MSD is a rugged structure that is installed outdoors, and relays its readings continuously to a Local (house) Area Controlling Unit (LACU), installed indoors. The LACU is implemented as a mini Set-Top Box (m-STB), very similar to the residential gateways encountered in multimedia applications.

The LACU incorporates simplistic business logic for receiving the sensor readings, assessing them and forwarding them to the wider SCIER infrastructure (i.e., the Computing Subsystem). Such logic can be easily integrated in the STB using the OSGi technology. LACU will receive the sensor readings through an m-STB network interface, e.g. IEEE 802.11.

The LAS upon receiving the report provided by the SCIER Computing Subsystem based on the data it has submitted will alert the LACU Owner on the seriousness of the evolving incident. Notification will be performed using pure audio equipment (e.g., a siren) or audiovisual equipment (e.g., a monitor). Remote notification can also be considered using the SMS technology.

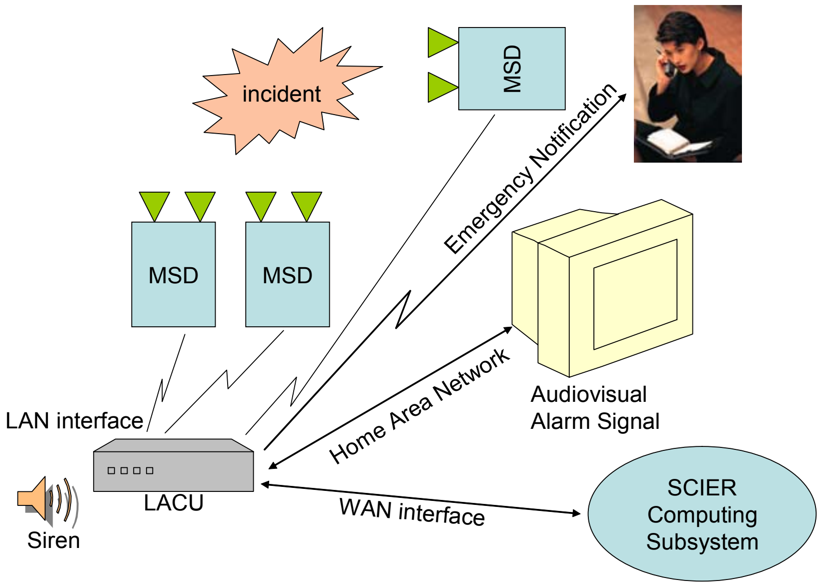


Figure 4: LAS Architecture

5 Trials

The functionality of the SCIER platform on forest fire and flood hazards will be demonstrated through a series of trials. At this moment the deployment in four (4) test sites around the Europe is foreseen. However, final decisions on the selection of test areas will be done throughout the lifespan of the project, as natural hazards at prone areas cannot be forecasted so much earlier. Current candidate areas include:

- A Portuguese test-site at Gestosa, where experimental and controlled burns will take place in order to assess fire monitoring capabilities of the SCIER system. Considering that in Gestoza burns are controllable, the selection of this site is finalized from the beginning of the project. The site will be used for testing SCIER's functionality both the first and the second year of the project.
- A French test-site at the south of France, which will be carefully selected with the help of CEREN, aiming to assess, if possible, SCIER's functionality in both forest-fire and flood hazards.
- A Czech Test-site near the city of Brno, the capital of Moravia, which will be used for flood testing.
- A Greek Test-site, near the small town of Stamata, a suburb of Athens located 25 km north of it, where several forest fires have occurred in the last years. The test will be used for fire testing.

6 Expected Achievements and Impact

SCIER has the mission to contribute in the improvement of the safety of the European citizens through the delivery of an integrated ICT platform capable of monitoring environmental hazards in specific areas. The areas targeted by SCIER are those located at the WUI, a term which refers to all types of areas where forests, waterbodies, and rural lands, interface with homes, other buildings and infrastructures, including first and secondary home areas, industrial areas and tourist developments.

The tendency for the development of extensive WUI areas is relatively new. The problems, especially in regard to fires and floods, started becoming noticeable only in the 1990s. This is the result of pollution and overpopulation of the centres of the cities that grew in the 1970s. The people moved away and developed new homes in the WUI, because of this problem but also with the help of the development of roads and other transportation infrastructure. In many cases the rapid development of such WUIs was unplanned or poorly planned. Settlements were built without efficient road networks, and homes and other building were built in or near areas that form the flood plain of water catchments. Often there is no provision for escaping in case of a disaster. Many recent events in the last twenty years highlighted these problems and brought death and disaster to large numbers of citizens. In the area of Rafina, 25 km east of Athens, about 150 homes were destroyed or heavily damaged in a single fire event, in July 2005, within 4 hours, and homes in Stamata, Greece were under severe risk in 2003. Similar cases appeared in 2005 in Portugal (fire) and Switzerland (floods) and in 2004 in Austria (floods).

The direct achievements of the SCIER project include:

- Bringing together the latest advances in sensor technologies and computing with the knowledge of specialists about these environmental risks, for the development of a very efficient and capable system.
- The SCIER platform, which is expected to assist the citizens to profit from a better security against natural or man made hazards, and to respond in time in order to reduce the potential damage to their property. This will be accomplished directly, since the citizens will obtain direct access to information about hazards, or they will be notified immediately through sophisticated alarms (LACU).
- The participation of a high profile security company in SCIER is not coincidental. The consortium of SCIER believes that the user installed (and funded) sensor systems on her/his property, specifically targeted in each WUI area for the potential risks facing that area, will be the equivalent of the introduction of smoke detectors inside homes, a few decades ago. Such detectors have become a necessity where there was a real problem (e.g., where houses are made of wood), whereas have not been used widely where the threat is low.
- The SCIER consortium believes that wherever there is an obvious potential risk in WUIs, systems like SCIER, once proven will become a necessity for the citizens. Furthermore, SCIER adds to this the usefulness of the data and the overall system for the authorities and intervention mechanism, which further benefits the safety and security of the citizens.

The abovementioned achievements are expected to have significant impact in the following areas:

Industry

The benefits stemming from the realisation of SCIER for the strengthening of European ICT industry are multi-fold. SCIER will contribute innovative solutions with significant market value to the wireless sensor domain. In this domain, numerous commercial players have appeared during the past years.

Energy efficiency is of critical importance to SCIER; therefore, particular attention is given to this aspect of the pursued system. Another option with profound impact on the ICT industry is the autonomous, self-healing operation of the wireless sensor network and the robustness of the network-internal mechanisms (e.g., routing). Such aspects of the sensor technology (that will be thoroughly studied in the course of SCIER) are also of great market value since the commercial solutions required in different business domains (e.g., on tele-monitoring, telemetry) need to support such characteristics.

Great market impact is expected from the SCIER residential component that implements the localized alerting system. Such system will be implemented according the latest standards in the residential computing infrastructure and providing innovative solutions for the industrial players specialising in electronic security components for houses and industrial facilities.

A very important part of the SCIER architecture, the multi-sensor device that implements the static segment of the sensor infrastructure, is expected to be welcome as a highly innovative solution by the security industry. Similarly to the localized alerting system, the static segment sensors will easily penetrate the security market as they present a missing component that is crucial to the protection of lives and properties. In the Services sector, SCIER will enable the expansion of the activities spectrum of security companies through the deployment and operation of the localised alerting system.

Universities/Research Centres

The SCIER project will bring together experts and researchers from different domains (geo-sciences, computer science, electrical engineering, etc.) in an effort to deliver an integrated platform for environmental risk management. The Universities and Research Centres will significantly benefit from this collaboration context, as they will expand their activities spectrum beyond their current research fields and improve their adopted processes and tools (e.g., by means of advanced computing infrastructure). The SCIER outcome is expected to strengthen the current ties between European academia and research institutions and the European industry.

Employment

As discussed in the previous paragraphs, SCIER will improve the current status of EU industry in the product and services domain. News, advanced products will surface the high-technology market and new services will be delivered by security companies. This mobility is expected to improve EU-wide employment levels by developing new working opportunities with a long time perspective. SCIER is expected to generate employment of at least 2-5 person/year/WUI in Europe. If, for example, we consider the 98.000 towns and municipalities in EU-15 the employment impact of SCIER is quite important.

Citizens

SCIER features a unique localized alerting system that improves the response time of individuals to serious incidents like local fires. Such a cost-affordable, privately owned system is expected to significantly improve the current status with respect to the targeted regions (i.e., the URI) and the occurrence of natural disasters. Recent incidents (similar to the ones attacked by SCIER) resulted to loss of human lives and properties. SCIER is expected to entail quantifiable results in the considered problems though a novel synergy of state-owned and privately owned infrastructures working together for the common welfare. The death toll and property loss indicators associated with the attacked problems are expected to diminish.

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