1. PROJECT TITLE

Wireless Sensor Network for Tourist Locating in Emergency Situations

1. TECHNICAL DESCRIPTION OF THE PROJECT

In isolated locations like the mountains area accidents often occur which are more or less serious. This is largely due to the tourists who are unaware of the dangers which lurk, another reason being the tourists who deviate from the hiking trails especially marked for safety reason. Fatigue caused by improper physical training, assuming risks which overcome one's abilities and instable weather conditions are factors which determine the high occurrence of mountain accidents. In order to reduce the number of accidents people can be informed about the existing dangers or they can undertake lessons regarding hiking behaviour (e.g., which touristic route is better to follow) but the most effective way to prevent accidents would be offering continuous support for the tourist throughout all hiking trails. Ongoing support cannot be achieved by providing a specialized guide for each tourist, but could be realized by using mobile electronic devices.

Today's technology allows using mobile phones such as smartphones or tablets for determining the GPS coordinates (Global Positioning System) which are mandatory for establishing an accurate person / vehicle location in case of rescue intervention or in voice calls to emergency stations (e.g. Rescue squad) in case of accidents. But there are some major disadvantages which make harder or even impossible an emergency call:

- Locations in the mountain area are not always directly visible from the satellite for correct GPS determination of coordinates or there is not always radio signal in order to make calls through mobile operators. However, the accuracy of calculating the coordinates, where this is possible, is influenced by the presence of obstacles, which are usually fairly high numbered in the mountain area. The GPS modules use radio signals from satellites or radio signals from the communication equipment of the mobile operators in order to calculate coordinates. The mobile communication masts are installed so that they can ensure radio coverage especially for areas where population density is higher and less in sparsely populated areas.
- Mobile devices, commonly used by tourists, have relatively high energy consumption which limit the period of their usage sometimes just to a few hours. Enabling GPS location service adds significant additional energy consumption. Running time is directly dependent on battery capacity, the degree of charging and the mobile handset features and how they are use.

- Not all tourists have mobile devices such as smartphones or tablets, the cost of buying and maintaining them being high. In addition, they require the installation of dedicated software applications (which are not free) for monitoring and checking the routes taken by the tourist as well as his location.
- If a tourist was seriously injured, he will be unable to make a call to emergency services so its location becomes difficult to determine or it is determined much too late.

The main idea of the proposed project is to design, develop and implement a monitoring system for tourists in order to increase their safety and provide support in case of accident / path lost, if necessary. Being a project that has also a demonstrative purpose, it aims to ensure the monitoring of particular tourist routes integrated within a national park. The existence of administrative checking points at the entrance to the national park favours the implementation of the system and provides the possibility of a well-organized and proper monitoring.

As a key component of the monitoring system - a part of the data acquisition subsystem, we intend to use a wireless sensor networks (WSN - Wireless Sensor Network) for the continuous recording of the necessary information. Its components (devices / network nodes) will be distributed, installed and configured properly in the space subject to monitoring. It is envisaged that the installation of the system will not damage the natural environment or impair the visual landscape therefore network devices will be well camouflaged.

The domain of wireless sensor networks is a research and development area with extensive applicability. One of the main directions of deployment refers to the security and safety of persons. Obviously, these networks can also be used in the case of tourists who go hiking in mountain areas. The main downfall that characterizes network devices is related to energy consumption which has to be as low as possible in order to prolong the up time. Other characteristics which should be taken into consideration in the design and development of network devices are: cost, latency, coverage of the radio signal, data transfer rate, physical size and security. It is desirable that the implementation should be as simple as possible, complying with the requirements for these descriptive characteristics. The most important advantages of wireless sensor networks are the mobility of network devices and their ease of installation.

For implementation of wireless sensor network specific to the monitoring system, two types of network devices are taken into consideration:

- *Fixed*, located in well-defined locations on the tourist route. By default, the installation will keep a certain distance between them, determined on the basis of the radio devices characteristics, but depending on the route and the existing conditions (e.g. presence of obstacles in a small or large number) can decide the decrease of the distance between

them. The installation of fixed network devices will be in trees at a certain height above the ground or on the rocks in protected positions.

- *Mobile*, that will be carried by tourist all along the route. These devices will be made available to tourists by administrators at the entrance to the park; following the tourists to hand them back after leaving the park. Mobile network devices are the most complex which integrates a great number of functions and also an interface for user interaction.

A 3rd type of network device will be developed, but implemented in a single piece: the **master node**, which assures the possibility of forming the network and establishes the connection with the system of processing, storage and distribution of data. A mobile device network can both guide the tourist when he/she deviates from the path and also can generate an automatic alert in case of accident. In the first stage of the project development will take into consideration the detection of falling accidents (e.g. when tourist falls for a longer period of time uncontrollably). Other types of accidents that can be automatically detected will be determined during system testing. When generating an alert it is important to know the location from where it was sent. Locating a person can be made through the fixed network devices whose locations are known. An automatic calibration method allows maintaining accuracy in case of environmental changing conditions.

Most hiking trails are display in a tree form, starting from different points at the mountain base and reaching the areas of interest (e.g., cottage, mountain peak or ridge). Taking this into account, the wireless sensors network will have a similar topology. A simplified example of such a network topology is shown in Fig. 1. The coordinator node will be placed in one of the common points where several trails merge. Here will be installed the central computer responsible for picking up, storage and the distribution of data (the server computer).

The recommended location for installing the coordinator node is inside a cottage or other similar building, where protection of both the master device and the central computer can be provided. Fix devices located at the end of the walking trails connects to computers for recording and alerting (client computers).

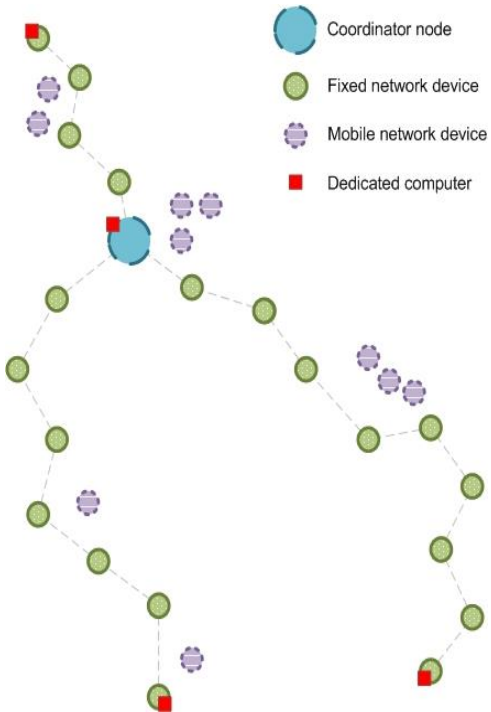

Fig. 1. Network topology

Most hiking trails are display in a tree form, starting from different points at the mountain base and reaching the areas of interest (e.g., cottage, mountain peak or ridge). Taking this into account, the wireless sensors network will have a similar topology. A simplified example of such a network topology is shown in Figure 1. The coordinator node will be placed in one of the common points where several trails merge. Here the central computer responsible for picking up, storage and the distribution of data will be installed (server computer). The recommended location for installing the coordinator node is inside a cottage or other similar building, where protection to both the master device and the central computer can be provided. Fix devices located at the end of the walking trails connects to computers for recording and alerting (client computers).

Network devices, whether fixed or mobile, have a common architecture, similar to that shown in Fig. 2. Their type/format/size may vary depending on optimization solutions implemented later. The main functional modules are:

- *Radio communication mode*: allows the radio communication with other network devices. At the same time it provides the appropriate network topology by establishing logical links between devices. To implement this sensor network the chosen topology is of mesh type (net), where there are several different routes of communication between any two network devices, the data being transmitted on the optimal route. For this type of topology the advantage consists of a self-repair network if some network devices fail or some logical communication links become inaccessible. The disadvantage of this topology is determined by the increase complexity of implementation.

  As a general rule, it is considered that the radio communication module is the component with the highest energy consumption of the network device, the current needed is at its peak during sending/receiving data packets. There are many characteristics that describe radio communication module: antenna type, transmission power, receiver sensitivity, communication protocol used, security, maximum communication distance, rate, the frequency of radio signal, physical size, etc. As a rule a

compromise is established between the characteristics of the radio module and the application requirements, aiming primarily to reduce energy consumption.

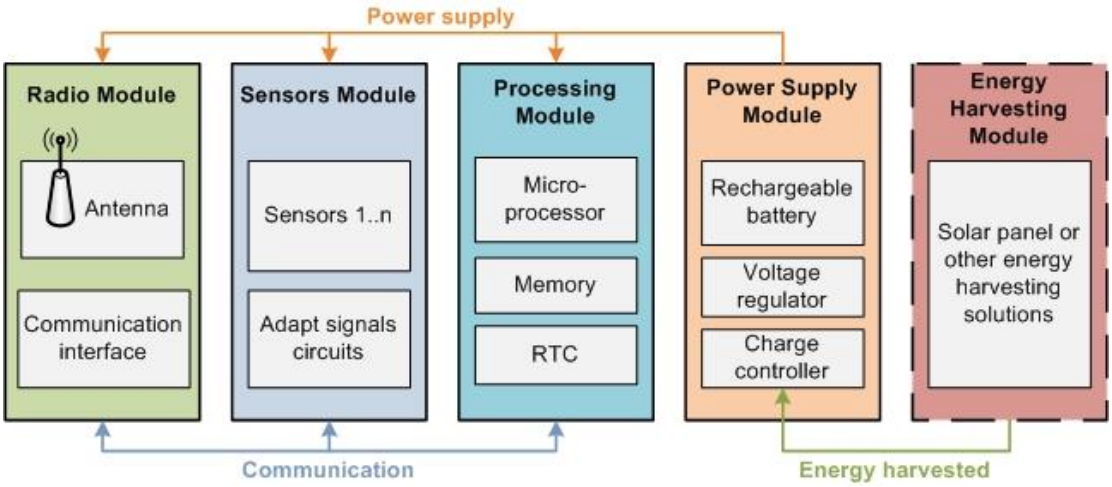

Fig. 2. Network device (node) architecture

- *Sensors module*: includes all necessary sensors to monitories the process. In a first stage an accelerometer-type sensor is attached to the network mobile devices and a temperature sensor for monitoring the environment for the fixed devices. The mobile devices include the following components of the interface which allows user interaction (of the tourist) with the system: pointing / return to the trail button, alert button, button which emits a light signal and a small display showing the direction for returning to the route. For the mobile devices, recording the parameters values associated with the sensors it is performed continuously in order to easily and in a short time detect predefined events. For fix devices the recording and transmission of the parameter values will take place at predefined time intervals.
- *Processing module*: includes the necessary components for processing and storage of information: first, a microprocessor provided with embedded or external memory. An essential component of this module is the component RTC (Real Time Clock). This allows to storage the current information about date and time which is absolutely necessary for any monitoring process. It is important to ensure a good storage / calculation precision of this information simultaneously because certain communication protocols are based on this accuracy. The processing module also includes both a direct programming of the microprocessor connector and additional circuits for its programming via radio communication environment. The need to update the firmware application usually occurs when programming errors need to be corrected or the functionality of the device is changed.

- *Power supply mode*: the source of energy is represented by a rechargeable battery. Its total capacity as well as the way in which energy is taking by this dictates the life span of the network device. It is preferable to extract energy using a low current that vary slowly over time in order to efficiently use the full capacity of the battery. A voltage regulator is necessary to ensure a constant voltage of the electronic circuits, thus maintaining the stability in its operation.
- *Energy recovery mode:* to assure the longest possible period of operation of the network device it is necessary to provide low power consumption and eventually the possibility of recharging the battery during operation time. The maintenance process is significantly reduced as well as the cost of implementation of the monitoring system. Usually, it is considered that the lifetime of a sensor network it is determined by the first node that ceases to function. By implementing one or more energy recovery solutions from the outside, you can extend the lifetime of the sensor network for quite a long period. There are various solutions developed to recover energy from the outside environment. The possibilities of implementation and their effectiveness depend directly on existing conditions.

To reduce the energy consumption we take into consideration some techniques previously determined, following the implementation of similar networks and we will conduct studies and supplementary testing to determine new opportunities:

- The implementations of resource management solution, so only electronics which are needed at a certain time are powered. For example, the sensor module is supplied with power only when information is taken from the sensors, and then it is deactivated. The radio module allows different operating modes with different energy consumption, switching from one to the other can be organized properly. The microprocessor is also a significant component of energy consumption. This can be set in different function modes with different levels of energy consumption. Moreover microprocessor functional modules can be disabled and enabled as needed.
- *The selection of electronic components which allow a reduced energy consumption* - regarding this aspect we will perform studies and tests to determine the optimal components which will be used, components that will embed the latest technologies. Also, we will check the functionality of the electronic components exposed to extreme temperatures, specific for the environment in which the network will be implemented.
- *The use of simulation software models of the network device,* which will be implemented during the project, in order to determine the optimal configuration that allows the lowest possible energy consumption. Software models take into account the most important

functional characteristics of network devices in order that the results to be as precise as possible.

At the same time we want to ensure the modular and general characteristic of the network devices. Modularity requires assembly and easy replacement of the functional modules of the device when it fails or when you want to change its characteristics. The general character assumes that the devices can be adapted without or with minimum effort for other applications too. Least but not last, it aims to achieve a low cost and implementation small physical dimensions.

The electronic circuitry of the network device is assembled and placed in a protective casing designed especially for this purpose.

Most of the research and development activities are dedicated to the wireless sensor network, in order to create new network devices, using the latest field technologies which can provide significant advantages over other existing models of network devices and to become competitive on the market. Besides the wireless sensor network the monitoring system will require the design, development and implementation of the other components which are absolutely indispensable in order to obtain a fully functional system. The monitoring system is divided into two main components, properly integrated:

- *Data acquisition subsystem*: consists of a wireless sensors network and a computer Driver on which runs a specific software Driver application that allows you to configure network sensors and retrieve data from it.
- *Subsystem processing, storage and distribution of data*: includes a computer server, on which runs a server software application that enables the processing of information, their storage in a database and their distribution to the client applications. The subsystem also includes client computers connected to the server computer trough a local network on which the Client software application runs. One client computer must be installed at the entry points of the tourist routes, where a system administrator supervises the recorded data. The Client application allows tracks both the tourists' location in a three-dimensional representation of the routes but also the display of the emergencies.

1.1 THE PROJECT TOPIC AND ITS PRACTICAL RELEVANCE

Subject Area: The main purpose of the proposed project is to make contributions to the development of wireless sensor networks, both by expanding their applicability and by developing new models of network devices (nodes), in an optimized and competitive version on the market, using the latest available technologies. Their general character allows them (without or with minimum changes) to be used for many others types of applications. Also, a large area of applicability regarding the safety of people was intended, but going in a new

direction of applicability, namely: to increase the safety of tourists in mountain areas, where accidents happen quite often and whose location can be achieved quite poorly or too late.

Correlation with the competition requirements: The subject of the research / development of the proposed project is consistent with the research topics prior to the area "Information and Communication Technology", research direction "Technologies for distributed systems and embedded systems - Embedded Systems", research theme "Technologies for embedded systems based on sensor networks" so that it supports the research and development of wireless sensor networks in order to expend their applicability and improve the existing solutions of implementation.

This project proposal will create knowledge by obtaining top scientifically results, globally competitive that will rise the visibility of the Romanian research and subsequently the transfer of the results in socio-economic practice and the rising of social quality growth by finding scientific and technical solutions that support and improve the quality of human condition.

Practical relevance: The need to ensure the safety of tourists in the mountain area is well known, but usually the prevention of accidents is less dealt with, therefore emergency crews are forced to intervene most of the time when various accidents more or less seriously happen. One of the main issues when an intervention takes place refers to the precise location of it, and until this is determined the situation can become much more serious. There are many mountain areas, here and abroad, which requires the existence of methods of prevention and immediately and efficiently response to such events. The project proposal intends to solve this problem by developing a monitoring system which will facilitates the precise location of tourists and will offer support throughout the entire crossing route.

1.2 Project activities:

P1. Experimental network device - implementing ZigBee protocol

P2. Experimental network device - implementing DASH7 protocol

P3. Experimental network device with energy recovery possibilities

P4. Coordinator network device

P5. Fixed network device

P6. Mobile network device

P7. Software model of the fixed network device

P8. Software model of mobile network device

P9. Protective case of fixed network devices

P10. Protective case of mobile network devices

P11. Driver software application

P12. Server software application

P13. Client software application

P14. BackupData software application

P15. Surveillance and assistance service for tourists

2. Expected results (including analysis):

R1. *Experimental device network* - implementing ZigBee protocol at 868 MHz frequency. *Analysis*: studying the proper functioning of the device. *Success criteria*: proper operation in a network of 4 nodes by implementing mesh topology.

R 2. *Experimental device network* - implementing DASH7 protocol. Analysis: studying the proper functioning of the device. *Success criteria:* proper operation in a network of 4 nodes by implementing mesh topology.

R3. *Experimental device network with energy recovery possibilities*. *Analysis*: determining energy recovery methods correctly implemented. *Success criteria*: the number of functional recovery methods are implemented at least 3.

R4. *Network coordinator device*. *Analysis*: The study of data loss in high traffic situations. *Success criteria*: loss of less than 1% of the data transmitted.

R5. *Fixed network device*, resistant to unfavorable external conditions. *Analysis:* study of the operation in extreme conditions of humidity, low temperature and high temperature. *Success criteria:* proper functioning in at least 99% of cases.

R6. *Mobile network device*, functional stable and resistant to shocks. *Analysis*: checking seamless operation of the device and studying of impact shock resistance due to a fall from 1.5 meters onto a solid surface. *Success criteria*: function without failure in at least 90% of cases.

R7. *Software model of the fixed network device*, which allows simulation of functional modes of the network device. For each functional mode, is power consumption is initially determined by measurements. *Analysis*: determining the degree of implementation within the model of functional modes. *Success Criteria*: the degree of implementation surpasses 95%.

R8. *Software model of the mobile network device*, which allows the simulation of the functional modes of the network device. *Analysis*: determining the degree of implementation within the model of functional modes. *Success Criteria*: the degree of implementation surpasses 95%.

R9. *Protective case of the fix network device*, resistant to a prolonged exposure to extreme use conditions. *Analysis*: studying impervious at extreme humidity conditions and the material resistance to prolonged exposure to ultraviolet radiation. *Success criteria*: successful completion of tests in at least 90% of the cases.

R10. *Protective case of the mobile device network*, impact resistant. *Analysis*: studying the impact resistance by falling from 1.5 meters onto a solid surface. *Success criteria*: resistance without damages in at least 90% of the cases.

R11. *Driver software application*, constantly functional. *Analysis:* checking the functionality without any interruptions. *Success criteria*: continuous functionality for at least 1 month.

R12. *Server software application*, constantly functional. *Analysis:* Analysis: checking the functionality without any interruptions. *Success criteria*: continuous functionality for at least 1 month.

R13. *Client software application,* constantly functional. *Analysis:* Analysis: checking the functionality without any interruptions. *Success criteria*: continuous functionality for at least 1 month.

R14. *BackupData software application*, constantly functional. *Analysis:* Analysis: checking the functionality without any interruptions. *Success criteria*: continuous functionality for at least 1 month.

R15. *Surveillance and assistance support for tourists*, constantly functional. *Analysis*: checking the functionality without any interruptions of the service and the correct performance of alert and support functions. *Success Criteria:* continuous functionality for at least 1 month and the correct performance of alert and support functions in at least 99% of the cases.

2.1 PROJECT CONTRIBUTION BEYOND THE STATE OF THE ART

The possibilities for monitoring tourists in national parks have been also previously analysed; most of the proposed solutions make use of the GPS signal in order to locate tourists. However, the GPS signal is not always available due to the presence of numerous obstacles. Other solutions are based on the location of tourists using various other methods that do not involve GPS signal, but there are not precise and therefore interventions may take much longer than is preferable. The inability to precisely locate injured persons significantly impedes the intervention of emergency teams.

Implementing a monitoring system for tourists, which does not require the use of GPS signal for localization; which also provides on-going support for the tourists and can accurate detect location and generate automatic response in case of accident represents a significant

contribution in this area. This is the aim of this project to provide both prevention and intervention of unpleasant situations as quickly as possible. Installation and configuration of such a monitoring system, once developed, would easily be achieved. From this point of view, a wireless sensor network is the most suitable component that can be used to locate and transfer the recorded data, because it can cover a large area which has many obstacles. Implementing wireless sensor networks monitoring systems for tourists was carried out only in a few cases, integrating only basic functionalities.

The field of Wireless Sensor Networks (WSNs) has continuously evolved over time and their applicability grew along with the evolution of technology and the emergence of new types of applications. The main advantage of network devices equipped with sensors is mobility therefore they can be moved from place to place when the application requirements change. The lack of cables significantly simplifies the installation procedure for the sensor network. There are many constraints that currently prevent permanent replacement of wired sensors with wireless ones. These constraints refer to:

- *Cost*: network devices, available on market, have a fairly high cost. Also many of the types of devices available on market do not have a general character, being dedicated to specific types of applications. They also do not evolve along with hardware technology as it would be preferable in order to include the latest solutions which are discovered through the research and development process.
- *Power consumption*: network devices are powered by small batteries, operating time being therefore limited. It is necessary to consider reducing energy consumption and / or energy recovery from the external environment by integrating various available technologies in order to extend life span as much as possible. The project will also have a contribution regarding implementation and promotion of different energy recovery techniques (e.g. using solar radiation, temperature gradient, vibrations, electrostatic charge), implemented through various new ways.
- *Data transfer rate*: communication protocols dedicated to wireless sensor networks are designed to support the transfer of small amounts of data. The most known and used protocol dedicated to this type of networks is ZigBee.
- *Latency*: the delay (until the obtaining of the data recorded by the user) plays an important role in critical applications. Latency is determined both by the communication protocol used and the network security features.

The proposed project is envisaged as the first step in: the development of network sensors, the design of a new type of network in several versions, using both ZigBee protocol, already widely used for the implementation of many sensor networks, as well as a new

communication protocol, which is still developing and tends to become competitive(due to the advantages offered) in the protocols dedicated to wireless sensor networks: DASH7 (Developers Alliance for Standards Harmonization of ISO 18000-7). DASH7 protocol brings a number of significant advantages: greater communication range, low power consumption, greater ability to penetrate and avoid obstacles dedicated to mobile devices, low complexity, etc. The only drawback is that DASH7 protocol has not yet reached a level of acknowledgement as the ZigBee. Establishing the exact optimal protocol to be used in order to develop the final version of network devices will be done in the preliminary stage of the project.

Different from most existing implementations of wireless sensor networks, in this case of a new implementation, we intend to use the frequency 868MHz (for ZigBee), or the frequency of 433MHz (for DASH7); frequencies considered to bring more advantages in contrast to higher frequencies, recommended for environments with many obstacles. Also, the development of new network devices will significantly contribute to their development by: low cost, modularity, general character, new technology of implementation, new development opportunities, optimizing energy consumption etc.

2.2 PROJECT OBJECTIVES AND OUTCOMES

The main project objective (the purpose):

The project aims to contribute in improving safety and offering assistance for the tourists in mountainous areas within national administrated parks, which benefit from an active emergency service based on developing a tourists monitoring system, built on a new model of wireless sensor network which integrate fixed and mobile devices.

Specific objectives:

O1. Design, development and implementation of a wireless sensor network in a unique format, optimized for the space conditions in which the monitoring system will be implemented, while maintaining a general character of the network devices and ensuring: a low cost of development implementation and power consumption, the possibility of recovering energy from the external environment, modularity and simplified maintenance procedure.

O2. Development of tools (software) for registration, transfer and analysis of information provided by the network wireless sensors, ensuring a minimum delay in: data transfer, data integrity and automatic detection of undesirable events (accidents) by correlating predefined emergency situations models with tourists location determined in real or predicted time.

O3. Ensuring the correct functionality of the monitoring system by: ensuring stability during function, accurate detection of tourist locations, correct detection of events and appropriate assistance when necessary.

O4. Conceiving and implementing a management resource system, which aim is to achieve a high level of infrastructure use developed within the project.

O5. Dissemination of project results through scientific articles at national and international conferences, symposia, journals and through the website dedicated to project presentation and by submitting new applications for patents.

Scientific and technical challenges:

- Designing the network device in a unique format, optimized, using the latest technologies in the field;
- Providing general and modular nature of the network device;
- Optimizing energy consumption so that the devices can be functional for very long periods of time;
- Selecting and implementing the best solution for recharging thenetwork devices batteries, taking into consideration the environmental conditions in which the system is to be installed;
- Correctly detect undesired events (accidents);
- Precise location of tourists in the area subject to monitoring;
- Effective tourist locations prognostics in short periods of time when precise location is not active;
- Ensure radio signal coverage, regardless of external conditions;
- Establishing communication methods to ensure a low latency in data transfer and an apportioning of the energy consumption on network nodes;
- Network devices must remain functional even under extreme environmental conditions (e.g. very low temperature or very high humidity).

2.3 ORIGINAL AND INNOVATIVE CONTRIBUTIONS OF THE PROJECT

The proposed project distinguishes by enlarging the scope of applicability of wireless sensor networks towards a new direction of research and development in what the safety of people is concern, moreover it contributes to the development of some versions of network devices, using the latest technologies in the field, thus taking benefit of multiple advantages and offers to possible clients new opportunities for development and implementation.

The applicability of wireless sensor networks in monitoring and assisting tourists when walking in mountain areas has been very little studied; the need for this becomes obvious when large-scale deployment options (and worldwide) of such systems are being possible. Developing of new optimized network devices was also necessary because of the lack of

competitive network devices to be implemented using the latest technologies in the field, which can provide low cost, a modular and general format.

2.4 INTER-, MULTI-, OR TRANS- DISCIPLINARY CHARACTERISTICS

In order to improve the quality of research and development we intended to provide extensive flexibility of the project in order to offer more ways for cooperation and integration, we intend to achieve a proper defragmentation of the knowledge and to establish new challenges and interconnections between various disciplines.

The most important disciplinary components that our project addresses to: (interconnections of which are shown in Fig. 3):

- *Wireless sensor networks* by implementing a data acquisition subsystem, emphasis on a detailed design and optimization of electronic specific circuits for network devices.
- *Information technology:* by developing a subsystem of storage, processing and distribution of data, namely the necessary software applications that together with the acquisition subsystem completes the monitoring system.
- *Tourism* by supporting and encouraging tourism in mountain areas;
- *Safety* by offering support and higher safety for tourists;
- *Geography* by analysing external environmental conditions to achieve effective implementation of the monitoring system;
- *Communication* by disseminating the project results through: scientifically published papers, patent applications and training seminars;
- *Managemen*t by proper management of project activities and resources.

The discipline of *information technology* intertwines with wireless sensor networks discipline by contributing together to the realization of a complex and unitary system. The disciplines *electronic circuits*, *manufacturing engineering*, *networking and algorithms* correlate in order to develop the sensor network.

The disciplines microprocessors, telecommunications, electrical engineering and product design correlates to develop electronic circuits specific for the network devices. The disciplines graphical representation, reliability and diagnostics, software management and algorithms correlate in order to obtain the necessary software system.

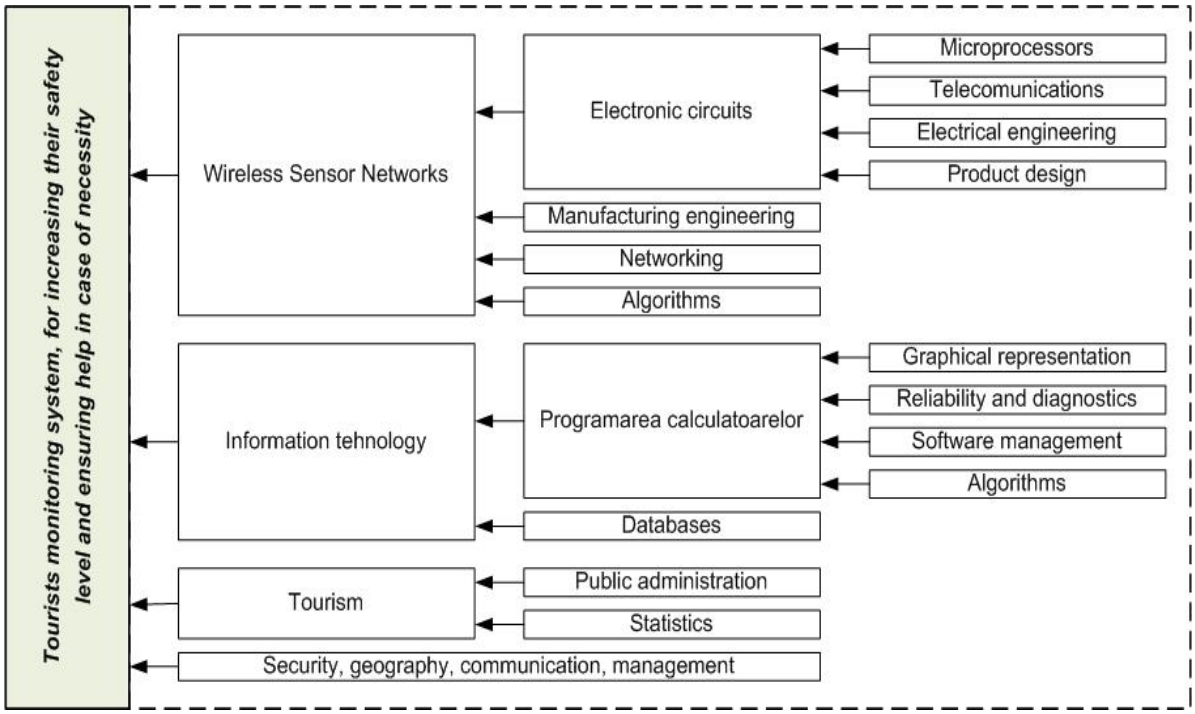

Fig. 3. The connections between the scientific disciplines related to the project

3. IMPACT AND DISSEMINATION OF THE PROJECT RESULTS

3.1 DISSEMINATION AND EXPLOITATION OF THE PROJECT RESULTS

The dissemination and exploitation of the project results is realized by:

- Presenting the products and the results obtained after the accomplishment of the research and development activities, specific to the project, through the website dedicated for the project presentation. On the website are specified and details about the project purpose and the level of fulfillment. On the way of obtaining the products and results, the project coordinator establishes the information which will be presented to the public, and the enterprise integrates this information into the website.
- Publishing scientific papers, of analyze and presentation of the project results, at the national and international conferences and symposiums, and also into dedicated scientific journals. All the partners of the consortium participate at the realization and publication of the scientific articles.
- Sending requests for invention certificates, at OSIM (Oficiul de Stat pentru Invenții și Mărci – The National Office for Inventions and Marks), for protecting the novelty elements resulted after the accomplishment of research and development activities. The requests are realized and submitted by the predominant partner, which have accomplished the main research and development activities for the creation of the novelty elements.
- Realizing educational seminars, for the administrators which use the monitoring system, and also for the tourists, which benefit firstly on the system functionalities. The seminars are organized and held by the coordinator partner together with the enterprise partner P3, immediately after the installation and the preliminary testing of the monitoring system.
- Creating posters and leaflets for presenting the project and for educational purpose. They will be realized by the enterprise P3 and distributed by the coordinator partner, before the education seminars will be held and during the monitoring system usage.
- Promoting the components of the developed monitoring system (by example: the network devices – in different versions, the software applications) at national and international workshops. The promoting is realized by all partners of the consortium.
- Promoting the network devices for commercialization and the development of new applications, similarly, by other engineers and researchers. The promoting is done mainly by the project coordinator, through the project website and it is done immediately after obtaining the complete functional versions of the network devices
- Using the new versions of the network devices for implementing the large scale sensor network, necessary for the implementation of the tourist monitoring system.

The implementation is done into a strong collaboration of all consortium partners after the final version, completely functional, of the network devices.

- Promoting the new developed network devices to other possible consumers from the educational organizations partners or enterprises partners, for the development of new similar monitoring applications. The promoting is done by all partners of the consortium, after the complete implementation of the monitoring system.
- Continuous optimization of the network devices and the creation of new versions completely functional, during the technology evolution, for responding at the new requests of the applications. The project coordinator will sustain the continuous development of the network devices.
- Planning new research activities using the created network devices. All partners of the consortium will be directly involved for accomplish this goal.

3.2 POSSIBLE APPLICATIONS WITH MARKET POTENTIAL

The monitoring system, obtained after the project development, could be multiplied and implemented with minimum of effort into other mountains areas, where it exists also the necessity of increasing the security level of the tourists and for offering continuous support to them, all the time during the trips. The architecture of the system remains the same, being modified only the number of network devices necessary for the implementation. The utility of such kind of systems is obvious, at national and international level. Further it could be done an interconnection of all these monitoring systems, obtaining a central storage of data. New requests and new possibilities for expanding the facilities offered to tourists and administrators of the parks could appear in time, once with the technological and scientific evolution into the area.

The domain of applicability of the monitoring systems is very large, being possible to implement them for a variety of applications into the real-life, but also for different activities accomplished into laboratories. In the same time, the main components of the monitoring systems, could be used independently, adapted for different purposes. The wireless sensor network and the software applications developed for this system, could be adjusted for functioning accordingly into other similar systems. BY example, at the wireless sensor network there could be replaced the sensors modules for monitoring other parameters (by example: the monitoring of the behavior and the health conditions of the animals during the migration from one area to another). The software applications developed for the subsystem of storage, processing and distribution could be modified accordingly or just reconfigured for functioning with other systems which use wireless sensors for determining the energy consumption into an office building.

For each network device, developed at this project, will be done the preliminary steps for promoting them and use them at other similar projects, with none or minimum number of

modifications done on them. Profiting on the advantages, considered to be implemented during the design stage of the devices (low cost, low energy consumption, general character and modular format), it will be considered the valorisation of the devices at commercial level, case when it will be necessary to develop and some documentation for presenting, use and develop of the application specific to the network devices. In the same time it will be considered the future development of the network devices, for new improved versions, once with the technology evolution and the appearance of new solutions, more advantageous to be implemented, or which allow implementing new functionalities.

Some examples of using the wireless sensor networks:

- the monitoring of the air quality (for the indoor and outdoor environment), the water quality, the normal functioning of the equipment and installations, the hydration of the soil for agriculture, the packages and luggage at the airports, the buildings structures, etc.
- the detection of the forest fires;
- the prevention of the natural disasters (by example: detection of the landslides);
- the spatial modeling;
- the recovery after disaster occurrence;
- the analyse of animals behaviour;
- the monitoring and control of the functional systems from a car.

At each development of a new product, for which it is desired to exist also the possibility of commercialization, it is necessary to follow some specific steps to obtain quality products, competitive on the market which is expanding fast (Fig. 4).

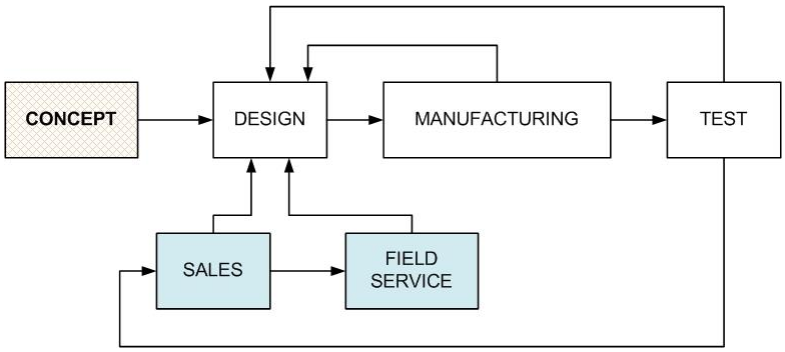

Fig. 4. The stages of the process for developing-commercialization of the new WSN product

The software models for the simulation of the network devices, fixed and mobile, could be easily updated, accordingly, when the hardware and software configuration of the network devices is modified. The simulation models could be offered to the researchers and developers, at the network devices acquisition, for executing supplementary tests and analysis.

4. ESTIMATED IMPROVEMENTS IN THE QUALITY OF LIFE, WITH RESPECT TO CURRENT PERFORMANCE OF PRODUCTS, TECHNOLOGIES AND/OR SERVICES

4.1 The contribution at the improvement of the life quality

Through the treated problem, the project contribute at the increasing of the life quality, by offering continuous support to the tourists, during their trips, and immediate support when unpleasant situations appear, like accidents. The improvement of the life quality could be confirmed by analysing of the results from the questionnaires distributed to the tourists, which contain questions related to this subject, and also by realizing statistical analysis regarding the state of the accidents before and after the implementation of the monitoring system.

Nowadays, according to our knowledge, there are no implemented systems to offer continuous support to the tourists or which to detect automatically the accidents. Usually, without such a system, the tourists receive a minimum training before their trips on the mountains, and then they have to take care on their own. In case of accident the mobile phones have to be used for announcing the emergency teams, but the emergency call could not always be done, because of radio signal problems which could appear, or because the person is unconscious, being unable to ask for help. In the same time, the precise localization of the area where the accident occurred is not always possible, this fact delaying the intervention procedure and increasing the risk for the situation to get worse.

4.2 The advantages of the project's innovative results:

- Innovative service for tourists assistance and accidents detection – according to our knowledge there is no other implemented service which to offer similar functionalities;
- Innovative network device which uses the DASH7 protocol, protocol used at very small scale into real-life implementations, because there are very few electronic components which to implement it. The protocol DASH7 offers obvious advantages, being a superior candidate from some points of view, at the development of the wireless sensor networks.
- Experimental network device which integrates methods for energy harvesting, includes multiple possibilities for testing and analyse of these methods, the efficiency of which depends on the application type and existent conditions. Since nowadays, some of the commercial devices include connectors for attaching a small solar panel and recover in this way energy from the solar radiation. Our wish is to implement and other techniques for energy harvesting (by example: the energy provided by temperature gradients, vibrations, electrostatic charges), more suitable for some types of applications.

- The network devices (coordinator, fixed or mobile), developed in this project, present significant advantages comparing with other devices existent on the market. As main advantages there could be specified: the use of the high level of technology for developing the electronic circuits, so there are available the newest solutions obtained after the research and development activities, there could be obtained a low cost of implementation, modular format and general character.
- The software applications dedicated for the subsystem of storage, processing and distribution presents evident advantages related to the interoperability with the other components of the system, comparing with other similar applications, since they have been specially designed for the implementation of the innovative service for tourists support.

5. PROJECT INTEGRATION IN THE DEVELOPMENT STRATEGY OF PARTNER COMPANIES

The partner COMPANY P1 has started its activities by developing new software products or modification of some existent products, for improving their performances or the adding of new functionalities. Mainly, the developed applications have been dedicated to resources management. During the enterprise development it has been started the development of more complex systems of applications, dedicated especially for monitoring and analyse of the parameters from the industrial environment. A few years ago, the enterprise has added a new activity area, pointing to the domain of research and development, trying in this way to expand the activity area to new types of applications, considering the new and best solutions existent. It has been existent and a previous collaboration at the development of the wireless sensor networks, and also for this reason it has appeared the wish to evolve to this domain, of maximum interest into the monitoring systems. The enterprise supports the development of the monitoring systems, and indirect of the wireless sensor networks, by developing the software application necessary for these systems implementation. It will be an interest from this side and for the promoting of the new constructed network devices and in the same time of its own software applications for the implementation of new monitoring systems.

The project responds to the necessities of the partner enterprise P1 by offering the possibility of expanding its area of activities, to new types of monitoring systems which include wireless sensor networks.

Partner P2 is the UNIVERSITY.

Related to the COMPANY P3, its main activities are related to the management, coordination, financing and development of the research and development projects, existing a special interest and for the development of the proposed project.

6. INTELLECTUAL PROPERTY PROTECTION

It is considered that the software applications designed and developed, especially the Client and Driver applications, will be protected by registering the author rights by the developing enterprise P1.

The novelty elements obtained after the development of the network devices, will be identified and analysed, for sending requests for new invention certificates and protecting this way the intellectual property. The main certificates will be registered by the project coordinator, which will accomplish the most important activities for network devices developing.

Before submitting a request for an innovation certificate it will be asked for the agreement of all partners implied into the project.