SPS internal use

Project Plan Received	

SPS internal use

SPS:	

Emerging Security Challenges Division

Science for Peace and Security Programme

Multi-Year Project Application

NATO Emerging Security Challenges Division, SPS Programme, Bd. Léopold III, B-1110 Brussels, Belgium
Submit applications including scanned signatures in **Microsoft Word format** to sps.applications@hq.nato.int.
Only applications containing a single Word and a single Excel document will be accepted.

Project Title *80 characters maximum, including spaces. please select a title that is comprehensible to the non-specialist*

Smart Patch for Life Support Systems (SP4LIFE)

SPS Key Priority/Priorities *if more than one, please list in order of relevance/importance to the project please use the nomenclature and numbering from the guidelines*

1) Facilitate mutually beneficial cooperation on issues of common interest, including international efforts to meet emerging security challenges
a) Counter-Terrorism
iv) Risk management, best practices and technologies in response to terrorism.
i) Methods for the protection of critical infrastructure, supplies and personnel
ii) Human factors in the defence against terrorism
d) Defence against CBRN Agents
iii) Medical countermeasures against CBRN agents.

Funding Requested from NATO (EUR)	
Partner Countries	€115000
NATO Countries	€375000
Total	€490000

please fill in funding for NATO countries
this table will update when the budget is filled out below

Project Duration *maximum 36 months*

36 monts

NPD, PPD and co-directors A–C will fill automatically after print preview

Co-Directors

NPD, PPD, and Co-Directors A–C should fill automatically from the inform... following page; please add additional lines for additional Co-Directors as n...

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			Co-Director

Abstract

*please provide an abstract of your proposal in **100 words or fewer***

Wearable real-time systems collecting and smartly analysing information on respiration, heartbeat, SpO2, blood pressure and body temperature could help medical personnel adopting most suitable countermeasure in case of highly stressful situations in military and civil scenarios as a result of terrorist attacks, IEDs' or rescue operations. The system gives an alert if the health status of a person is changed to prevent overlook of critical health changes.

We propose design and development of a patch-like device prototypes and methodology enabling continuous evaluation of personnel or victims' vital parameters, using Artificial Intelligence to create software capable of real-time diagnostics and rapid countermeasures' selection.

How Did You Learn About SPS?		*please indicate where you learned about SPS and give details below*			
Word of Mouth	☒	*from whom?*	Online	☒	*which website?*
Journal Advertisement	☐	*which journal?*	SPS Information day	☐	*where and when?*
Conference	☐	*which conference?*	Other	☐	*details please*

Details

Project partners previously participated and run NATO SPS project SIARS and couple of NATO ATC and ARW courses.

We went through the NATO SPS web pages at https://www.nato.int/cps/en/natohq/topics_85373.htm and related subpages.

NATO and Partner Country Project Directors

a single NPD and single PPD are required

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at least one End-User is required

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Project Description

This section of the Project Plan must not exceed 20 pages.
(up to and including "Communications")

Short Description

single page overview of the project, its objectives, and expected outcomes ***comprehensible to the non-expert***

Wearable real-time physiological status monitors constructed as patch-like devices capable to collect and analyse information on vital parameters such as respiration (respiration rate - RR), heartbeat (heart rate – HR), SpO2, ECG, blood pressure (BP) or body temperature, can help first responders and remote personnel to rapidly implement countermeasures in time critical events in military and civil scenarios as a result of terrorist attacks, IEDs' explosions or during rescue operations. A real-time analysis of the health status of a person in action (e.g. rescuers, emergency crews) and its prompt communication to a team leader can have critical impact on the outcome of crisis events. Early diagnosis of the onset of respiratory disorders such as hyper- and hypoventilation, hyper-apnoea or agonal respiration, or cardiac events like arrhythmia and myocardial infarction can aid decision making and improve resource allocation in critical situations. With the creation of the patch-like sensor prototype, we are also addressing activities after a large-scale attack related to management of wounded victims in order to increase chance of their survival. The device will be placed by emergency crews on the victims' chests after first triage has been done. The patch will be placed on yellow and green labeled victims. According to START (Simple Triage and Rapid Treatment) triage approach emergency crews take care first of the victims who are labeled red (e.g. massive wounds, bleeding torso, tachycardia, etc.) and dispatch the victims to the appropriate medical facilities. The device will generate alert at the moment of changing the medical status from green-to-yellow (GtoY) or yellow-to-red (YtoR) and thus making the victim of higher priority.

A system for remote real-time monitoring and analysis of emergency personnel and wounded victim's health status thus addresses several key priorities of the SPS program, namely counter-terrorism and defence against chemical, biological, radiological and nuclear agents, but also environmental security, and security-related advanced technologies.

The objectives of the project are to:

- Develop wearable monitoring platforms with: a.) sensitive respiration, heartbeat and auditory sensors based on graphene, and b.) ECG, SpO2, BP and body temperature sensor modules,
- Create a biocompatible wearable body-sensing interface hosting electronics, alarm, low-power transmission for light-weight, portable applications
- Create a software that will generate alert in real time, at the moment of critical physiological parameter changes or changes of the triage medical status according to START algorithm,
- Use Artificial Intelligence to create unsupervised software capable of real-time diagnostics and rapid countermeasures' selection,
- Analyze existing (AS-IS) processes and consider their re-design (TO-BE processes) in organization of patient management on the site of accident with respect to wearable monitoring technology being developed,
- Create a network of young scientists training in soft and hard skills in the wearable electronics for biomedical applications.

Capacitive and strain sensors technologies prevail in the realm of monitoring respiration and heartbeat. The capacitance between a wearable electrode and the skin changes dynamically during breathing or with changing electrical signals that accompany heartbeats. Strain sensors measure the chest motion due to respiration and heartbeat. In the project we propose to enhance the existing technologies by i) creating new capacitive and strain sensors using graphene, that has showed superb sensitivity in early work performed in lab conditions and ii) integrating graphene-based miniaturized acoustic sensors (microphones) to record the audiograms of respiratory and cardiac cycles.
Integration of SpO2 sensor into chest-based patch device enables reduction in measurement delays of blood saturation by several seconds comparing to finger-based sensor. This is especially important in emergency situations and enables rescue teams to introduce treatment more rapidly. ECG and body temperature sensors provide additional information for complex assessment of victim's health status such as predicting blood pressure from ECG signal and data for development of prediction models related to health status changes.

The main contribution of the proposed solution is the novelty of the integrated sensors monitoring HR, RR and other parameters providing monitoring of health status of emergency crews or immediate alert generation if the

patient's health status in the triage process deteriorates, and the integration of artificial intelligence for a new generation of health monitoring solutions.

The main expected outcomes of the project are: i) innovative types of graphene-based sensors, ii) wearable platform optimized for remote wireless health parameter monitoring, iii) immediate response of the path-like-device in case of health changes of the emergency crew members or health deterioration of the victim/patient, iv) a database of vital parameters in normal and abnormal bodily functioning, v) updated processes in organization of patient management on the site of accident with respect to the wearable monitoring technology and vi) a new algorithms using AI for predictive modelling of respiratory and cardiac behaviour.

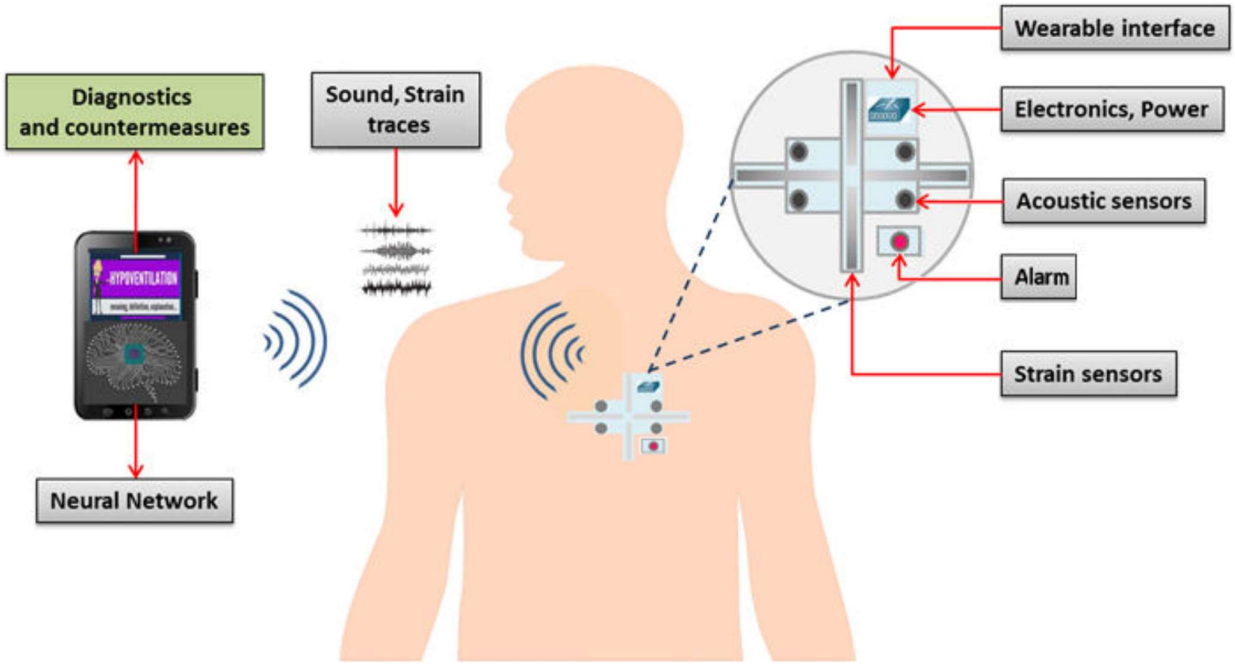
These outcomes will each be adaptable and usable in a variety of systems for improving the civilian management with crisis and security sectors, while the successful development of the merged proposed system will significantly impact the readiness of squads to tackle emergency situations that may affect crew and victim's health status in real time. We expect the final system to be of interest to both NATO and partner countries while addressing the key priorities mentioned above. The interdependence of the project components will ensure growing collaboration between NATO and non-NATO partner countries accompanied by a significant exchange of personnel. The capacity-building emphasis of the project is strong, due to the opportunity for training of young researchers on cutting-edge technology in an interdisciplinary framework.

The Problem and Proposed Solution

clearly identify the security problem to be addressed, its importance, the science or technology development proposed, and how it will address that problem

Personnel (e.g. emergency, rescuers) participating in high intensity stressful actions such as emergency operations and combat action experience rapid changes in physiological parameters that could give rise to undesired emergency medical conditions. The acute conditions, including fatigue, musculoskeletal injury, hyperventilation, arrhythmia, and other adverse health states, can be detected from early physiological warning signals. Monitoring vital health parameters such as respiration and cardiac performance of personnel under severe mental and physical stress, drawing conclusions from those parameters and applying them to modify personnel actions in real time is the next paradigm in control of small units. Wearable sensors, the Internet of Things, increased hardware performance and advanced machine learning technologies are all ripening in time to drive this paradigm shift. Nevertheless, a working fusion of these elements geared towards aiding a small unit commander or manager does not exist yet.

In this project, we propose to develop a compact, wearable smart patch for monitoring vital health parameters and enabling the immediate response of the local commander in case of health changes of the emergency crew members or health deterioration of some attack victims (Figure).



Integrated design of the patch poses several research questions:

Existing sensors of heart rate and respiration rate are either not sensitive enough, or not flexible, or not integrated in wearable platforms for this application. Furthermore, wearable acoustic sensors have not been applied to real-time health monitoring at all, even though very recent reports suggest that machine learning can train acoustic sensors to recognize conditions such as heart murmur with better than cardiologist-level accuracy. More sensitive strain and capacitive transducers, acoustic sensors with an increased bandwidth, custom wearable platforms with an alarm and high-performance artificial intelligence algorithms applied to the gathered vital parameters and reporting of the health of stressed personnel could save many lives and play a critical role in individual mission outcome. We are also proposing relevant methodology enabling data analysis for detection of change in health status [68, 69], and improvement of process management with respect to introduction of the new technology. Hereupon we need to consider a few aspects when proposing our solution: importance of design and development of the patch-like biosensor (including the security aspects of data transfer), data analyses of acquired physiological data [67, 70, 73] and their interdependencies reflecting change of health status, and changes of emergency management processes with respect to introduction of new technology. The importance of the proposed patch-like integrated biosensor is stressed by its capability to continuously measure vital parameters [58, 65, 69, 70], and process data.

The proposed highly sensitive, broadband graphene microphones are an excellent candidate for monitoring physiological parameters via acoustic signals. We will gear our development of graphene MEMS microphones towards integration into wearable, flexible solutions. For strain sensing we will follow two approaches, both based on inexpensive easily obtainable liquid phase exfoliated (LPE) graphene. LPE graphene can be made in the form of nano-flakes that are either dispersed in an elastic rubber matrix or attached to oil drops in an emulsion that is subsequently encapsulated in a silicone pipe.

Strain sensors based on graphene nanoparticles (GNP) draw their performance from a changing inter-particle electrical contact under strain. The GNP shape, size, as well as concentration of defects on edges, functionalization, and the surrounding polymer matrix all play a role in sensitivity. We propose to carefully optimize GNP morphology and edges by tuning sonication conditions (power, duration and temperature) and solvent composition. The composite matrix will also be a topic of study, all with the aim to produce strain gauges of utmost sensitivity. The making of strain gauges will be an iterative process, cycling between GNP production, dispersing in matrix, chemical treatment of the composite matrix and testing sensor performance. Oxidation of GNP with ozone treatment was shown to enhance electrical performance of GNP thin films, through binding of oxygen species to GNP edges. The same treatment will be performed on the composite GNP strain sensor. Sensor performance will be gauged with an in-house built tensing mechanism comprised of a linear stretch stage coupled with high-resolution optical inspection and electrical tests, including resistance and capacitance. The optical inspection will yield information on agglomeration and dispersion of nanoparticles in the matrix, while electrical measurements will gauge strain sensing performance. Nanoparticle morphology prior to matrix dispersion will be characterized with UV-VIS spectrophotometry, Raman spectroscopy, AFM and SEM, and optimized through iteration of the production-integration-treatment-testing cycle. Both strain gauges provide information through a simple measurement of electrical resistance and both can be directly attached to skin. The electronics that should be coupled to the sensing elements will be based on electric potential integrated circuits (EPIC). EPIC sensors will be integrated in a wearable platform, attached to the body, and heartbeat and respiration depth and rate will be measured in healthy and ill persons, both inactive and under strained conditions. The collected data will be implemented in a database and machine learning will be used to teach the system to recognize early warning signs of abnormal functioning.

For addressing activities after a large-scale attack related to management of wounded victims in order to increase the chance of their survival integration of SpO2 sensor into chest-based patch device enables reduction in measurement delays of blood saturation by several seconds comparing to finger-based sensor. This is especially important in emergency situations and enables rescue teams to introduce treatment more rapidly. Successful measurement requires proper illumination of the chest tissue, large gain, adjustment of circuit power supply voltage, proper angular rotation of photodiode and LEDs in respect to sensor surface, high filtering because of use of reflective sensors to detect PPG waveform that is few times weaker than in finger-based transmission sensor because signal is more prone to noise and distortions due to motion artefacts of skin. Examination of proper position on chest have potential to reduce noise due to motion artifacts (e.g. centre area of the manubrium bone). Further design consideration and evaluations will be done in the project implementation to ensure reliability of measurements.

ECG will consist of instrumental amplifier and probably rail to rail operational amplifier. The signal will be then converted by fast 10bit A/D converter which sufficient conversion rate. The temperature sensor will be chosen during the design. We are considering infrared temperature sensor or contact sensor. Further research is needed.

Cuffless continuous estimation of blood pressure is a promising approach in non-invasive and unobtrusive assessment of this vital parameter [76, 77, 78]. In 2014 the IEEE standard for wearable cuffless blood pressure measuring devices was introduced [82] and updated in 2019 [83]. Pulse transit time (PTT) is a potential indicator

for blood pressure (BP) estimation and has been intensively studied for past 15 years [75, 78, 86, 87]. This mechanism-driven BP estimation approach based on nonlinear model reached accuracy of 0.9 ± 5.6 mmHg for diastolic BP. Because of respiratory activity BP oscillates mostly at high frequency. Vasomotor tone is responsible for low frequency oscillations of BP. Despite a lot of the initial attracted interest, PTT can track BP variations only in high frequency range which is the reason for inadequate accuracy of approaches based solely on this parameter. Therefore in [84] was introduced the photophletysmogram intensity ratio (PIR), a new indicator which can trace low frequency variations. The proposed algorithm for BP estimation was based on both PTT and PIR. It outperformed previous algorithms by achieving accuracy of -0.37 ± 5.21 mmHg for systolic blood pressure and -0.18 ± 4.13 mmHg for diastolic blood pressure.

The methodology for detection of victim's health status from timely GtoY and YtoR and generation of relevant alert is the next research point in this project. It involves developing methods also in the Machine learning domain. We will organize the gathered data-bases of vital parameters and use publicly available ones (such as https://www.physionet.org) and establish the most appropriate methods that will produce models with best generalized performance (over 95% accuracy). The use of the built models will enable timely GtoY and YtoR alert of the prototype patch device. We will also use the shock index as included previous knowledge and will follow the triage decision process.

When handling the victims, simple triage and rapid treatment (START) is a triage method used by first responders to quickly classify victims of mass casualty incidents based on severity of inflicted injuries. Victims are evaluated into four categories: immediate need for treatment (red), delayed (yellow), walking wounded (green), deceased (black). Based on this evaluation the decisions are made about priorities for treatment and evacuation to hospital - red are managed first, then yellow, and the last green labeled patients. Limitation of triage system - START system does not provide resource allocation, classification procedure does not depend on the number of victims or resources available (medical emergency crew members). It does not provide any prioritization of patients within each of the four triage groups. In close cooperation with project end-users and medical partner we will analyze existing processes on site of accident. It will help project teams with technological background to better understand any weak points and expectations on new technology developed in this project. In our analyses of TO-BE processes we will consider possibilities of re-design of existing processes in organization of patient management on the site of accident with respect to new patch-like technology. This will include analyses of how introduction of new technology can help to support coordination of the medical teams in the field. Analyses will be done about possibilities to address above mentioned limitations of the triage system.

Time-sensitive and accurate information is a key point for proper communication design. Integrating the biosensors into the existing emergency communication strategies will require mechanisms for building trust among the emergency professionals in order to avoid misunderstanding and ignorance, and therefore achieve trustful communication. Involving medical experts into the project that will be directly included in the real-life simulation exercises and in the patch-like device prototype EP testing is a part of the strategy for ensuring EP's acceptance by the medical responders within their existing protocols.

It is important to indicate that validation of working prototype and methodology will be carried out within biomedical study approved by respective ethical committee. This will be done in accordance to the following national legislation: law no. 576/2004 Z.z. about healthcare and healthcare services [91], 6/1985 about processes related to verification of new medical knowledge and approaches [92], 40/2000 agreement about human rights and biomedicine [93], additional protocol about agreement on human rights and biomedicine 494/2007 [94] and the Law of Law of health protection in North Macedonia [95].

Current Status

describe the current status of related research; include the participants' research which demonstrates their capacity to contribute to the field

Terrorism and other types of attacks are serious threats to Europe. It ruins its security, democracy and freedom. The EU member states are determined to jointly fight terrorism and have adopted the EU counter-terrorism strategy. Significant effort is evident from the recent projects focused on prevention, protection, pursuing and response to different types of attacks. Prevention is on the top of the priority list and is focused on the identification of the factors that contribute to radicalization and the processes by which individuals are recruited to commit acts of terror. Protection is the second priority with the aim to protect the citizens and the infrastructure, including the protection of external borders, the improvement of transport security, the protection of strategic targets and the reduction of the vulnerability of critical infrastructure. Pursuing is the third priority with the goal to strengthen national capabilities, improve practical cooperation and information exchange between police and judicial authorities, tackle

terrorist financing, deprive terrorists of the means by which they mount attacks and communicate, and therefore to bring the terrorists to justice. The fourth priority is the response to terrorist attacks - to improve the capabilities to deal with and minimize the consequences of a terrorist attack. It is meant to develop strategies for improving the coordination and the response after the attack, improving the civil protection mechanisms, and sharing the best practices of assistance to victims of terrorism.

Real-time monitoring of vital parameters (RT-PSM) of personnel who are facing challenging and enduring physical tasks with high levels of stress as well of the victims is highly desired, especially when coupled with communication of health status to a small unit leader. Near-term targets include alertness/fitness for duty and musculoskeletal status and following the health status of the victims. Mid-term targets include neurocognitive status (mood and cognitive states) and in the longer-term, host defence responses (anticipation of impending illness). Some commercial solutions exist; however, they are not aimed at the particular segment that we target and are largely "black-box", with a wide range of accuracies and measured parameters [1]. Also, a key parameter for acceptance of RT-PSM solutions is wearer comfort, especially during long-duration wear in challenging field environments [2]. Thus, the main research directions for RT-PSM are in big data and novel minimally invasive sensors [1, 3]. Big data is becoming increasingly important because field tests on subjects under a large variety of conditions are a necessary part of the research [4-18]. The vast amounts of data obtained from field tests could be utilized in machine learning to train smarter sensor systems.

RT-PSM solutions in development have been focusing on wearable sensors integrated into garments [20, 21]. The sensors are made by interweaving conductive textile electrodes into a T-shirt, jacket, or other piece of top-worn garment. Measuring the capacitance across the electrodes yields an indication of the changes on the human body. Such changes are related to motion and shape change of muscles, skin, and other tissues. Although recent work demonstrated that worn sensors can accurately reproduce respiratory patterns [20, 21], there are still some drawbacks to each proposed solution. For example, it was shown that with sensors integrated into conductive fibre that is knitted into clothing, the way that the yarn is knit strongly influences sensor performance [22]. Other solutions employ sensing belts that are worn across the chest, providing a more reliable reading. Nevertheless, the sensitivity of such strain sensors was not great and was also influenced by artefact signals from other bodily motion [23, 24], emphasizing the need for highly sensitive "smart" respiration sensors. There are an increasing number of studies of using computers and smart algorithms for filtering noise in wearable biomedical sensors [25].

Graphene has recently emerged as a material with multiple interesting properties that have led to a number of enabling technologies and material improvements [26]. Although CVD-grown single-layer graphene is regarded as an excellent candidate for applications in high-frequency electronics and optoelectronics [27], liquid-phase exfoliated (LPE) graphene is considered to be more cost-effective, readily made, and applicable in a myriad of applications ranging from thin films to integration in composites [28-33]. LPE graphene consists of ultrathin nanoparticles of graphite, dispersed in a solution. The nanoparticles can subsequently be arranged in thin films or integrated in a polymer matrix, generally used to enhance the mechanical or electrical properties of the matrix. Such graphene has been integrated in a rubber elastic band using a facile method, and the enhanced band used to detect bodily motion [34]. As opposed to other, generally bulkier sensors, the graphene rubber band sensor is inexpensive, lightweight, mechanically compliant and reasonably sensitive to strain. The sensors were attached to the finger, wrist or throat to successfully detect breathing, pulse, and speech. Although possessing all the requirements imposed by RT-PSM applications, thus demonstrated graphene strain sensors are produced using volatile substances such as N-methyl-pyrrolidone (NMP), which poses a threat to the environment. Subsequent developments yielded graphene strain sensors that are produced in a much-more environmentally friendly way, using just water and soap as emulsion for dispersion of graphene [35]. These sensors have strain gauge factors as large as the ones made with NMP (~40) and consist of graphene-coated oil drops encapsulated in a silicone pipe. This most recent research, although demonstrating excellent compatibility with RT-PSM requirements, did not go beyond a proof-of-concept of the effectiveness of the graphene strain sensor.

Current status of participant's research

The group at Institute for Chemistry, Technology and Metallurgy, Centre for Microelectronic Technologies (ICTM) is in an excellent position to build on the graphene research and develop the use of these novel sensors for respiration detection. The PPD is on the forefront of the research on LPE, having shown the production of LPE graphene and assembly of nano-flakes into thin films [31-33]. Integration in oil or polymer matrices or with biomaterials, however, is slightly outside the area of expertise of the PPD, and will be perfectly complemented by partnership of Universitè libre de Bruxelles (ULB), where such experience exists [36-38]. The ULB partner is also experienced with graphene growth and its interaction with organic interfaces and materials [39-42]. It is interesting that there have been experiments with using acoustic sensors to monitor vital parameters of firefighters and soldiers [43], and those acoustic signals were used to train artificial intelligence to detect medical conditions like heart murmur. The

PPD has developed graphene microphones that are more sensitive than commercial ones and have a range extending to the ultrasonic part of the spectrum [44]. Graphene microphones will also be used as RT-PSM sensors in this project.

The sensor nodes reported in literature are all bulky, connected to a heavy CPU with long wires [20, 21]. Wearer comfort is of paramount importance for acceptance of a sensor platform, especially under sustained harsh conditions that first-responders and other units in operation may face [2]. Thus an important research direction for this project will be the development of a wearable platform that carries the sensors, the basic CPU and wireless module for transmitting parameters in real time. All the components will need to be lightweight, unobtrusive, and low-power, for long-term use with pacemaker batteries. The team from ULB and its partners are ideally suited to this challenge, due to their experience with packaging of electronics in Space experiments. For the time being, they will employ commercial EPIC capacitance sensors to monitor breath and heart rate and to develop the sensor platform in parallel to development of graphene-based sensors.

Machine learning has been applied to analyse physiological sensor signals in the context of diagnosing stress for vehicle drivers [45] and citizens [46], and for emotion recognition [47]. Machine learning analysis of respiration is on a rudimentary level, with just a few very recent studies that focused on stress prediction from breath rate signals [48, 49]. There is no publicly available data or reports on machine learning applied to stress recognition and prediction from respiration and heart rate. Especially data of these physiological parameters obtained from personnel under stressful situations is evidently lacking. Proposed solution will demand a novel algorithm in big data analysis applied to machine learning and will simultaneously generate databases populated with information from healthy, ill, resting and stressed individuals. ULB collaborators from the University from Cambridge have developed similar algorithms that were applied to biological systems [50-52].

The Institute of Measurement Science, Slovak Academy of Sciences, Bratislava is oriented to basic research in measurement science and mathematical methods for processing of measured data. It is concentrated to research and development of new methods and systems for measurement in biomedicine and material science. The Institute also offers advisory and expert services related to its research activities, performs postgraduate education, publishes the on-line journal Measurement Science Review and organizes national and international conferences. With respect to the proposed NATO project there is a long-term experience in the Department of Biomeasurements specifically oriented to new measurement technologies and model-based diagnostics of the cardiac electrical activity. They offer expertise in sensor HW design, development of SW solutions for data acquisition and analyses of physiological parameters and for process description and analyses [62]. Recently, their research was focused on measuring, communication and information systems for monitoring of the cardiovascular risk in hypertension patients and noninvasive localization of ectopic arrhythmias of heart ventricles using ECG mapping [63].

University “Ss Cyril and Methodius”, Faculty of computer science and engineering (FSCE) has recently been or currently is a part of 20 international and more than 40 national R&D projects. Relating to this NATO project, FCSE was involved among others as a part of the NATO SPS project SIARS (Smart I (eye) Advisory Rescue System, SfP 984753, 2015-2018) focused on modelling, developing and integration with selected existing Information Systems of a new state-of-the-art telemedical Information Systems that allow saving more injured patients and lessen the death-rate on the battlefields. The system consists of a mobile device that helps the life-savers on the battlefield, gather and organize the medical data of the injured patients, uses the satellite connection to transfer the data to the designated medical facility that will take medical care of the injured person. FCSE offers expert knowledge in Data Science and developing Intelligent systems. The software support for the patch-like sensor requires new methodology for GtoY and YtoR alerts. This new methodology will develop models from the Machine learning domain. Vital parameters gathered by SP4LIFE research and the existing databases will be used to establish the most appropriate methods that will produce models with best generalized performance (over 95% accuracy). Also the shock index as included previous knowledge will be used to follow the triage decision process. The process of developing the corresponding software utilizing the FCSE expert knowledge is reflected in the Working plan in this document. Good starting point is the new methodology developed by FCSE team for blood pressure estimation by using the ECG signal only [64, 95, 96, 97] that will be introduced in the prototype patch sensor to enable measurement of the blood pressure without separate BP device.

The Faculty of Medicine, which has been developing since 1919, is the first and founding faculty of the Comenius University in Bratislava. The Faculty of Medicine in Bratislava is the largest and oldest medical faculty in Slovakia. From the beginning, the Faculty of Medicine was focused on two tightly interconnected activities, education and research. In 1921 there was established a scientific medical journal Bratislava Medical Journal (Bratisl Lek Listy), which has been published so far as the oldest medical journal in Slovakia. In the last decade, the research at the Faculty of Medicine is focused on four main research areas: neuroscience, cardiovascular diseases, oncological diseases, metabolic, endocrine, and inflammatory diseases. In respect to this proposal the medical experts from

emergency medicine clinics of the medical faculty will be involved in the project to guarantee correct evaluation and interpretation of the recorded physiological signals and the following triage process.

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Impact

in ten lines or fewer, provide a clear description of the impact of the project, quantitative if at all possible; what will be different as a result of a successful project?

The project addresses several key priorities of the SPS programme tackling with the medical countermeasures to terroristic attacks with numerous injured victims and defence against chemical, biological, radiological and nuclear agents threats inducing respiratory and cardiovascular disorders in high-stress combat situations.

Early detection and rapid contrast of physical threats such as the one concerning respiratory and cardiovascular system is inevitably the first line of defence to reduce casualties and increase the safety of operating personnel and civilians. The wearable sensing platform developed in this project will increase the detection and contrast capability of the above-mentioned disorders to at least 90% of reliability in terms of correct disorder classification while reducing the detection time to the order of minutes. Also, a platform having similar characteristics and working principles can help creating a new tool to counteract and remediate in loco and rapidly the effects of the exposure to various critical situations, including CBRNs’ one.

This patch-like device prototype also enables assessment of sudden degradation of victim’s health condition after different types of attacks. Continuous measurement and analyses of victim’s vital parameters and real-time calculation of derived vital parameters will revolutionize detection of critical changes in victim’s health status after initial triage. Emergency crews will be able to better understand dynamics of on-site situation, prioritize activities and timely direct resources to help ones in need. Quantitative data will be available during system testing and evaluation. The platform will be adjustable to specific needs of NATO units in combat conditions.

Being disposable, this enhanced patch-like device, together with the whole system can be made available to civil population, greatly enhancing the local social confidence towards NATO missions in the – sometimes – hostile operating scenarios.

If successful, the project will introduce a new concept in the trend of wearable devices. Also, it will strongly enhance the civil and military capability of counteract rapidly to potentially critical threats.

Work Plan

detail the major steps or sub-projects, their sequencing and interdependence, and the research group(s) involved; provide a detailed description of activities and methodologies for each step; what are you proposing to actually do? for each step, identify risks or anticipated difficulties, technical or otherwise, and actions to be taken to mitigate them;
identify critical milestones for each step and for the project as a whole

WP1: Flexible Capacitive and Strain Sensors with Biocompatible, Wearable Interface
Organization(s): **ICTM, ULB**
Lead member: **Marko Spasenović**
Other members: **Carlo Saverio Iorio**
End Users: **Flexenable LTD, MJR pharmjet GMBH**

Task(s) and Methodology

T1.1 Design and Materials Choice: in this task, the optimal configuration in terms of signal-to-noise ratio and little limitation to freedom of movement will be studied and designed. Also, a fine tuned choice of the materials to be used for the sensing element will be done; in the material choice several parameters will be considered such as lightweight, excellent electric properties, resistance to environmental changes, easiness of handling and manufacturing.

T1.2 Sensing element manufacturing, assembling and functional testing: the sensing elements will be produced by different techniques, including 3D material printing. Different functional tests will also be performed to assure for the time responsiveness, the small impedance, and the correct sensitivity range. Final tests on the sensing element will include a real test scenario (measurement of heart beat and respiratory cycle). Capacity and strain sensors performances will be compared to the existing solutions, while acoustic sensors outputs will be compared against database of clinical data (e.g. https://physionet.org/physiobank/database/)

T1.3 Biocompatible materials choice: in this task, different kind of biocompatible materials and the mixtures will be tested in order to assure for the correct combination of wearability, little invasiveness, and robustness requested for sensing housing. The partners have already tested cellulose and alginate based materials although to comply with the above-mentioned requirements additional functional groups should be added.

T1.4 Mechanical properties assessment: The biomaterials will be prepared in single layers and/or in a composite structure configuration. In both configurations, a detailed assessment of the tensile stress and strain will be studied and real scenario tests performed. A preliminary integration of the sensing elements will also be considered in this task to check for both changing in the sensing response and biomaterials properties.

Deliverable(s)

D1.1 Report on the development and testing of the sensing elements

D1.2 Report on the biocompatible interface protocol, including mechanical characterization

D1.3 White paper on biocompatible materials and their applications in the wearable electronics domain

D1.4 Prototype of the sensing elements with body interface

Milestones(s)

M1 creation of a working prototype of graphene-based sensors with biocompatible interface complying with the mechanical requirement of stretchability, light invasiveness and robustness.

Risks: The use of new and not completely explored materials such as graphene could create unexpected failures in terms of performances and sensitivity. Moreover, in the assembly phase, the sensing element characteristics may change when inserted and/or printed on a material matrix of different materials. Countermeasures: the partners agreed to test in parallel to the new sensing elements some existing, similar commercial sensors. In case of no compliance of direct printing on the stretchable interface, the sensing

elements will be housed in rigid spot created in the matrix. This solution is not optimal because will increase the invasiveness of the sensors, but it increases the stability of the sensing response.

WP2: Smart Patch HW Definition, Integration, Testing and Evaluation
Organization(s): **ULB, IMS, ICTM, FM**
Lead member: **Carlo Saverio Iorio,**
Other members: **Milan Tyšler, Marko Spasenović, Oto Masár**
End Users: **Fire and Rescue Corps of Slovak Republic**

Task(s) and Methodology

T2.1 Definition of the sensor modules for physiological data acquisition and analysis: In this task commercially available sensors (modules for ECG, SpO2, body temperature, BP measurements) as well as own developed (graphene-based) sensors will be considered and selected for subsequent integration and testing.

T2.2 Data processing, transmission protocols and network management: In this task, an assessment of the computational power, transmission protocols and data management for the multi-parametric analysis at the sensors level is performed. Performant secure protocols and data management will pave the way for an efficient smart patch functioning.

T2.3 Assessment of power requirements for sensing, processing and transmission: one of the major problems in the development of IoT systems is the available power for sensing activation and data transmission. In this task, a survey of the existing technologies will be done and solution compliant with the needs will be selected. The development of power delivering electronics is also part of this task.

T2.4 Integrated platform assembly and testing: the final step of the HW platform creation consists in the overall assembly of all the subsystems and its testing and performances' evaluation: the testing will be done at laboratory scale and in simulated real world scenarios with different respiratory or cardio disturbances. Real world tests in medical facility and on-field testing and evaluation checked for compliance with the simulated scenarios are also envisaged.

Deliverable(s)

D2.1 Report on tested sensor modules and their performance.

D2.2 Report on possible solutions for computational electronics, transmission protocols and power delivery.

D2.3 Prototype of the full HW sensing platform for demonstration.

D2.4 Report on fully integrated HW and SW platform tested in laboratory and field situations (outside laboratory environment)

Milestones(s)

M2 Tested and operational wearable HW platform for physiological data acquisition and analysis

Risks: the main risk is the electronics that should be very compact, lightweight and with low power consumption while enabling fast data processing and transmission. Another risk is access to real world field situations (e.g. military training areas for management of hazardous situations) and mismatch between the laboratory and the on-field testing results. Countermeasures: the partners will try to test the existing body rechargeable batteries. In case of no compliance with the power needs, the power will be assured by off-shelves product (pacemaker's batteries) housed in an non-obstructing section of the wearable platform. To address technical challenges recurrent on-field testing with Fire and Rescue Corps of Slovak Republic is foreseen.

WP3: Methods and Software for Acquisition, Processing and Evaluation of Physiological Signals
Organization(s): **IMS, FCSE, ICTM, ULB, FM**
Lead member: **Milan Tyšler**
Other members: **Ana Madevska Bogdanova, Marko Spasenović, Carlo Saverio Iorio, Oto Masár**

End Users: **Fire and Rescue Corps of Slovak Republic**

Task(s) and Methodology

T3.1 Specification, development and implementation of software modules for physiological data measurement, processing and analysis: Modules for robust local processing of ECG, SpO2 and breathing signals.. SpO2 measured on the patch enables reduction of measurement delays of blood saturation by several seconds comparing to finger-based sensor. ECG and body temperature sensors provide additional information for complex assessment of crew member‘s or victim's health status, such as predicting blood pressure from the ECG signal.

T3.2 Method, and software development and testing for cuffless blood pressure measurements: the new methodology developed by FCSE team for blood pressure estimation by using the ECG signal only will be introduced in the prototype patch sensor to enable measurement of the blood pressure without separate BP measuring device.

T3.3 Methods and software for processing of acoustic signals to extract information on heart beating and breathing. Methods are based on high-performance artificial intelligence algorithms applied to the signals from graphene-based acoustic sensors with increased bandwidth.

T3.4 Fast and secured transfer of physiological data: methods and software for data compression and coding will be proposed and implemented in the patch HW.

Deliverable(s)

D3.1 Software modules for measurement and local processing of ECG, SpO2 and breathing signals.

D3.2 Software module for cuffless blood pressure measurement based on measured ECG signal.

D3.3 Software for extracting information on heart rate and breathing from acoustic signals.

D3.4 Software modules for physiological data compression and coding.

Milestone(s)

M3 Software modules for acquisition, local processing and possible transfer of physiological data.

Risks: The main risks may be the possibility of attacks on the smart patch communication and limited computational power on the patch and resulting necessity of using fast simplified algorithms and minimizing the data transfer between the patch and any control and monitoring unit. Countermeasures: development of optimal algorithms for real-time application, transfer of compressed and coded data.

WP4: Predictive Tools and Alerting System
Organization(s): **FCSE, ULB, IMS, FM**
Lead member: **Ana Madevska Bogdanova,**
Other members: **Carlo Saverio Iorio, Fedor Lehocki, Oto Masár**
End Users: **Fire and Rescue Corps of Slovak Republic**

Task(s) and Methodology

T4.1 Exploiting existing and building own databases of collected vital parameters from ECG, SpO2, body temperature (heart rate, respiratory rate, temperature, blood oxygenation, blood pressure).

T4.2 Big Data in support of the sensing platform: discovering hidden patterns in huge volume of data as the ones provided by sensors is of outmost importance for connecting the respiratory, cardiac and other physiological parameters to the parameters’ space readings.

T4.3 Training of the analysis software to understand correctly how to evaluate specific event: Machine learning concepts can create real breakthrough from the scientific point of view, by recognizing features that are difficult to unveil, thus speeding up significantly the diagnosis and medical countermeasures.

T4.4 Development of mathematical models for health status changes: Analysis of data science state-of-the-art methodologies, creating models for Green to Yellow and Yellow to Red (GtoY and YtoR) status changes and their implementation, testing and evaluation.

T4.5 Analysis of AS-IS processes and definition of TO-BE processes of medical response to massive incidents with respect to the proposed technology/service innovation. Analysis of existing management information systems in emergency services, identification of system interoperability requirements and definition of system architecture.

Deliverable(s)

D4.1 Database of vital signs from ECG, SpO2, body temperature.

D4.2 Transfer function for linking the status of the person and the parameters' space monitored based on unsupervised training and deep learning concepts.

D4.3 Software platform to be used as analytical tool for pattern recognition in sensing data.

D4.4 Software implementation of the mathematical models for detection of changes in victims health status.

D4.5 Report on analysis of existing management information systems in emergency services, description of AS-IS processes of medical response to massive incidents and definition of TO-BE processes with respect to the proposed smart monitoring technology.

Milestones(s)

M4 Software platform to analyse in real time physiological data including the cardiac and respiratory rhythm, and create mathematical models based on Big Data, AI and Deep Learning to connect them with known disorders, for assessment of person's health status change from YtoG and GtoY, and corresponding alarm generation.

Risks: the main risk is the lack of a sufficient number of training data sets to train the software for the different disorders and development of inappropriate use-case scenarios during mathematical model development. Countermeasures: To tackle these issues the partners will establish contact with clinical data repository, obtain also the necessary data from patient simulators owned by FM in Bratislava and medical partners will be integrated in the design and revision of the use-cases.

WP5: Dissemination, Communication and Exploitation
Organization(s): **IMS, ICTM, ULB, FCSE, FM**
Lead member: **Milan Tyšler**
Other members: **Marko Spasenović, Carlo Saverio Iorio, Ana Madevska Bogdanova, Oto Masár**

Task(s) and Methodology

T5.1 Development of the Communication plan: Internal communication flow planning; External communication flow planning: recruitment advertising; project website;

T5.2 Dissemination - Publication of the results in high impact journal; Participation in international conferences with oral presentation and peer-reviewed papers with proceedings publications; Agreement with publishing houses (the partnership includes scientists acting as editor of many scientific journals) to publish special issues on the specific topics of research; Publication of the experimental data in shared databases such as the Nature sponsored open-access scientific database (http://www.nature.com/sdata/data-policies); Participation to technology transfer conferences;

T5.3 Exploitation of the results: Detailed exploitation plan based on guidelines of the project plan; pre-implementation stage management of IPRs; implementation stage management of IPRs;

Deliverable(s)

D5.1 Annual report on Communication activities including Recruitment of young researchers

D5.2 Annual report on Dissemination and Communication activities

D5.3 Annual report on Exploitation activities

Milestones(s)

M5 Organization of the events foreseen for the dissemination and communication campaigns in due time

Risks: At this stage and by considering the expertise of the partners in the organization of impactful events, no major risks are foreseeable.

WP6: Management
Organization(s): **IMS, ULB, ICTM, FCSE, FM**
Lead member: **Milan Tyšler**
Other members: **Carlo Saverio Iorio, Marko Spasenović, Ana Madevska Bogdanova, Oto Masár**

Task(s) and Methodology

T6.1 Financial and administrative management: Overall legal and contractual management; Overall financial management: Arrange collection of financial returns and cost statements; ensure that resources are deployed as planned; Manage project issues, disputes or disagreements between partners.

T6.2 Technical Management of the whole project: Coordinate the project and manage the work flow; Keep the project on schedule; Handle liaison with NATO; Facilitate communication between all members of the consortium; Project risks management. Identification, assessment, prioritization and mitigation of risks. Reporting and regular project meetings organization.

T6.3 Quality Management - Approve the quality of the project outputs, including deliverables and dissemination, and supporting the consortium in key decisions taken within the project, while maintaining their independence.

Deliverable(s)

D6.1 Progress activity reports, including dissemination, communication and exploitation plans and timeline updates

D6.2 Annual progress reports incl. financial reports

D6.3 Final report, including final dissemination, communication and exploitation activities and overall financial report, outlook/plan for the afterlife of the project

Milestones(s)

M6 Annual report in due time and correctly filled

Risks: At this stage and by considering the previous participation of project partners in NATO SPS projects, no major risks are foreseeable for the correct financial and technical management of SP4LIFE.

DELIVERABLES:

ID	Deliverable title	Due Dates	Description
D1.1	Report on the development and testing of the sensing elements	M18	Description of the design, material choice and configuration of the acoustic sensing elements and their testing on acoustic spectra of humans (databases) or digitally synthetized sounds.
D1.2	Report on the biocompatible interface protocol, including mechanical characterization	M12	Description of the manufacturing protocol for the biocompatible interface and its characteristics in terms of mechanical elasticity and robustness
D1.3	White paper on biocompatible materials and their applications in the wearable electronics domain	M18	Reference paper for spreading the SP4LIFE results to stakeholders, oriented to the medical sector
D1.4	Prototype of the sensing elements with body interface	M20	Prototype to be presented at NATO events and DEMO conferences

D2.1	Report on tested sensor modules and their performance.	M12	Description on tested commercial modules and comparison of their suitability for the use with the smart patch
D2.2	Report on possible solutions for computational electronics, transmission protocols and power delivery	M24	Description of the proposed HW solution for the goals of SP4LIFE, its computational parameters, power requirements and transmission protocols
D2.3	Prototype of the full HW sensing platform for demonstration	M30	Presentation of the HW prototype to NATO authorities and in fairies
D2.4	Report on fully integrated HW and SW platform tested in laboratory and field situations (outside laboratory environment)	M36	On-field testing and validation of the complete smart patch prototype
D3.1	Software modules for measurement and local processing of ECG, SpO2 and breathing signals	M18	Set of programs for local processing of selected physiological signals focused on noise and artefacts removal and identification of selected diagnostic parameters
D3.2	Software module for cuffless blood pressure measurement based on measured ECG signal	M24	Software implementation of the original method developed at FCSE
D3.3	Software for extracting information on heart rate and breathing from acoustic signals	M30	Software for AI-based processing of acoustic signals from graphene-based sensors
D3.4	Software modules for physiological data compression and coding.	M36	Software modules facilitating fast and secure data transfer from/to the smart patch
D4.1	Database of vital signs from ECG, SpO2, body temperature	M18	Construction of own database, including more than 3000 ECG signals
D4.2	Transfer function for linking the status of the person and the parameters' space monitored based on unsupervised training and deep learning concepts	M32	Report on the rationale and evidences to model the coupling between the patient status and the monitored signals
D4.3	Software platform to be used as analytical tool for pattern recognition in sensing data.	M24	Presentation of the software platform capable of be trained on existing datasets and predict actual status of the cardiac or respiratory disorders
D4.4	Software implementation of the mathematical models for detection of changes in victims health status	M24	Development mathematical models for GtoY and YtoR alerts
D4.5	Report on existing management information systems in emergency services, description of AS-IS processes of medical response to massive incidents and definition of TO-BE processes with respect to the proposed smart monitoring technology	M30	Description and analysis of existing emergency information systems, description of currently used processes of medical response to massive incidents and definition of proposed processes with respect to the smart monitoring technology
D5.1	Annual report on Communication activities including Recruitment of young researchers	M12 M24 M36	Description of the communication activities and related KPIs
D5.2	Annual report on Dissemination and Communication activities	M12 M24 M36	Description of the dissemination activities and related KPIs
D5.3	Annual report on Exploitation activities	M12 M24 M36	Description of the exploitation activities and related KPIs

D6.1	Progress activity reports, including DCE plans and timeline updates	M12 M24 M36	Report on the implementation of project, re-evaluation of the risks, and planning forward
D6.2	Annual progress reports incl. financial reports	M12 M24 M36	Description of the SP4LIFE progresses and checkpoint for financial activities
D6.3	Final report, including final DCE activities and overall financial report, outlook/plan for the afterlife of the project	M36	Description of the overall achievements of the project, its implementation, as well as the future sustainability

Implementation and End-User Role

if the project is successful, describe how the results will be implemented; what would the next step(s) be? what is the role of the end-user in guiding the project toward implementation?

This project will pave the way for several domains of implementation. On the scientific level, the increased knowledge on the relation between the physical status and the recorded stress at circulatory and respiratory level will pave the way to a better management of the military personnel in combat areas as well as to new application in the domain of personalized medicine. The development of stretchable matrix integrated with sensing elements will allow fostering academic collaborations between partners and contributing to the creation of a durable network of exchange for young scientist in the exponential growing domain of wearable electronics.

Also, the multi-disciplinary aspect of the project will help to generate new ideas and find new field of application for the results acquired in the frame of the project.

As a complement of the academic collaborations, results will allow publishing a number of papers in high impact factor journal and to participate to high profile conferences in biomedicine, sensors, artificial intelligence, and material sciences/technology. This latter point is of particular interest not only for the intrinsic potentiality in terms of benefit for the entire and widespread scientific community but also and especially as a training for young scientist to present their ideas in international forums and foster innovation.

Moreover, the increased knowledge and innovative solutions elaborated during the project as well as the creation of a core network of partner countries will help creating enlarged consortium for exploiting the results in the frame of national, bilateral and European funded projects (like Horizon 2020, and beyond).

An important implementation pathway concerns the technological output of the project. Sensing system on stretchable platform represents a disrupting technology if coupled with data mining. It is the concept of industry 4.0 that is gaining importance also in the security and defence domain. Market sharing of wearable technologies is improving at a rapid pace in the last ten years and an even more acceleration is expected in the near future. If successful, the project will allow for filing patents on both sensing and software platforms and healing platform. This will open up the way for further development in cooperation with institutional bodies, such as Hospitals, health centres, international organizations and NGOs in the health sector, and with industrial stakeholders.

The actual End-users of the project are representative of these potentialities. Also, the patent filing could help young scientist participating in the project and/or co-opted during the implementation phase to set-up new start-ups with the help of business angels and venture capitalists.

In case the project is successful, its results will be implemented also by the Fire and Rescue Corps (Ministry of Interior of the Slovak Republic). They can easily fit the patch-like prototype in their existing urgent medicine equipment, since the system will follow the existing protocols (procedures and equipment) when designing the patch.

Specification of possible next steps:

The developed prototype patch device can be incorporated into existing NATO protocols and platforms (military, for following the hemostability of wounded soldiers from the moment of their injury and civilian, for saving victims of nature disasters), and also it will be extensible, i.e. additional services can be added after the prototype development.

The end users involved in the project play and important role in guiding the project toward implementation and exploiation of its results:

The **Flexenable, LTD (UK)** has developed the world first flexible platform for transistor technology, OLED and OLCD displays and various biometric sensors. Their expertise will help to solve possible technical issues during development of the graphene sensors. Their involvement will also help to introduce the project outcomes to leading experts in health care sector and facilitate development of new collaborations for their exploitation.

The **MJR Pharmjet GmbH (GE)** is a provider of analytical and development services namely for pharmaceuticals with a special focus on low soluble substances. They offered assistance namely during development of sensors based on liquid phase exfoliated (LPE) graphene and welcome the possibility to follow the research.

The Fire and Rescue Corps (Slovakia) will be an active end-user during the project activities related to:
1. Definition of use-cases related to management of victims after terrorist attacks;
2. Process and system definition from emergency service requirements with respect to effective management of terrorist attack consequences;
3. Cooperation in system testing and evaluation.

In case of project success, it is the potential user of its results.

Risks

describe the principal risks, technical, political, and/or commercial, to project success and implementation

The evaluation of risks is an important step in assessing the feasibility, success and impact of the project. A correct assessment should take into account not only the impact that unforeseen situations could have on the implementation of the project, but also the probability that those situations will occur.

Given the expertise of the researchers involved and their experience in managing projects at European and international level, the risks associated to the development of the project should be considered not exceeding the normal threshold of typical innovative research projects. Table below summarize the risks that could be spotted at this stage and the appropriate countermeasures foreseen by the partnership.

Risks	Probability	Impact	Nature of the risks	Countermeasures
Problems related to the development of the components of each subsystem	Medium	Medium/High	Technical	Foresee in the design of the components alternative solutions and take advantage of external experts
Difficulties in integrating the different subsystems	Medium	Medium	Technical	Take advantage of the external experts and end users for finding alternative paths
Difficulties in integrating the partners' research	Medium/High	Medium	Technical	Establish a realistic roadmap and integrating subsystems

results to reach a DEMO Phase				as long as they become available
Representativeness of laboratory experiment respect to field applications	Medium/High	Medium	Technical	Continuous contact with potential End Users Requirements
Delay in the schedule for components and integration	Medium/High	Medium/Low	Technical	Regular meeting (tele-conferences) and continuous "reality check" with advisors. Realistic schedule at the beginning of the project.
Difficulties in Visa procedures	Low	Medium	Political	Coordinate with the partners and foresee enough time in young researchers displacements
Difficulties in recruitment of young researchers	Medium	Medium	Training	Early warning of available vacancies and widespread communication
Delay in keeping pace with the agreed schedules	Medium	Medium	Training	Having regular meetings on the organization/implementation of the training exchange
Conformity of the proposed technical solutions with existing GDPR, health regulation and safety awareness	Medium/High	Medium	Implementation	Take advantage of the Advisors to help match innovative solutions and existing regulations
Conflict between non-civil and commercial applications respect to confidentiality and patenting	Medium	Medium	Implementation	Coordination between NATO officers and End Users on confidentiality and patenting

Communication

detail the communication activities to be undertaken as part of this project; identify opportunities for public exposure of the project; identify likely subjects of photography or video to be submitted to the SPS Office

The communication and public engagement strategy is organized according to three main factors: i) Level of communication (internal network communication flow, external communication); ii) Actors of communication activities (young researchers); iii) Target audience (academic, stakeholders, investors, general audience (including primary and secondary schools)).

Internal network communication flow: the internal network communication flow will be centralized and managed by the Coordinator. The full spectra of communication media will be used to make the proper actions efficient, and timely.

External communication: communication towards the actors not involved in the project will be inspired by the principle of maximum impact and tailored to target audience.

Target Audience	Message to be conveyed	Communication tools	Frequency

Internal Communication (Main role: PI, teams' members including ESRs, partners organizations)			
Consortium	PI, teams' members including ESRs, partners organizations	Videoconferences; dedicated member area in the official project website; creation of shared folders for documents (e.g. Dropbox, Xdrive)	Continuous
External Communication (Main role: Partners organizations, PI, teams' members including young scientists)			
Academic, Scientific	Information about project's results, the network, and network's initiatives	leaflets, files, posters at conferences, project website, mailing lists, and word of mouth at scientific meetings;	Continuous
Stakeholders	• **Companies**: the results of SP4LIFE have a great business potential; the ESRs will be the next leaders in the field • **Public Authorities**: the results of SP4LIFE will help implementing more efficient healthcare policies by reducing the costs thanks to new clinical protocols, new diagnostics and therapies. • **NATO-oriented:** the results of SP4LIFE can contribute to the safety of the personnel in situation of distress and high-stress as well as increase the support of local civilians toward NATO	• **Companies**: B2B meetings with consortium members, especially industrial ones. Demo progress at consortium premises. • **Public Authorities**: the results of SP4LIFE will help implementing more efficient healthcare policies by reducing the costs thanks to new clinical protocols, new diagnostics and therapies. • **NATO-oriented:** Conferences under the support of NATO, Videos of students working in labs in the frame of the projects, videos and photo shooting of the team members during DEMO sessions; Interviews; dedicated website. NATO logo in oral presentation at conferences, acknowledge NATO in published papers.	• **Companies**: two B2B meetings/year, five Demo progress/year • **Public Authorities**: Annual meeting with European, National, regional Authorities • **Associations**: Continuous
Society at Large	Science is good for Society and SP4LIFE can significantly improve point-of-care for better personalized and humane healthcare	Participation to national fairies, open science days; visit to secondary schools and of secondary schools in consortium premises	The partners spotted 5 science fairies for 2020 (such as the annual Open Science Days - http://osd.mpdl.mpg.de/) . Each partner will also receive at least three secondary schools per year at its premises.

Schedule

provide a detailed schedule, including a Gantt or other suitable chart, showing the estimated duration of each step or sub-project and their interdependence, the critical milestones, and, if applicable, the deliverables

SP4LIFE	Year 1		Year 2		Year 3	
	1st Semester	2nd Semester	1st Semester	2nd Semester	1st Semester	2nd Semester
WP1: Flexible Capacitive and Strain Sensors with Biocompatible, Wearable Interface						
T1.1 Design and Materials choice	■	■	■			
T1.2 Sensing element manufacturing, assembling and functional testing			■	■	■	■
T1.3 Biocompatible materials choice	■	■	■	■		
T1.4 Mechanical properties assessment				■	■	■

WP2: Smart Patch HW Definition, Integration, Testing and Evaluation	
T2.1 Definition of the sensor modules for physiological data acquisition and analysis	
T2.2 Data processing, transmission protocols and network management	
T2.3 Assessment of power requirements for sensing, processing and transmission	
T2.4 Integrated platform assembly and testing	
WP3: Methods and Software for Acquisition, Processing and Evaluation of Physiological Signals	
T3.1 Specification, development and implementation of software modules for physiological data measurement, processing and analysis	
T3.2 Method, and software development and testing for cuffless blood pressure measurements	
T3.3 Methods and software for processing of acoustic signals	
T3.4 Fast and secured transfer of physiological data	
WP4: Predictive Tools and Alerting System	
T4.1 Exploiting existing and building own databases of collected vital parameters	
T4.2 Big Data in support of the sensing platform	
T4.3 Training of the analysis software to understand correctly how to evaluate specific event	
T4.4 Development of mathematical models for health status changes	
T4.5 Analysis of AS-IS processes and definition of TO-BE processes of medical response to massive incidents	
WP5: Dissemination, Communication and Exploitation	
T6.1 Development of the Communication plan	
T6.2 Dissemination	
T6.3 Exploitation of the results	
WP6: Management	
T6.1 Financial and administrative management	
T6.2 Technical Management of the whole project	
T6.3 Quality Management	
Deliverables	
Milestones	

Reporting

list project events which will form the basis for progress reports; the number will vary by project; leave unused rows blank

Event	Description	Expected Date (after kickoff)	
Kickoff	**Project kickoff meeting**	**0**	
Milestone One	**First progress and Financial Report**	**6 months**	
Milestone Two	**Progress and Financial Report - First Scientific and Technical report**	**12 months**	*No more than 12 months between reports*
Milestone Three	**Progress and Financial Report - Second Scientific and Technical report**	**24 months**	
Milestone Four	**Progress and Financial Report - Third Scientific and Technical report**	**30 months**	*if needed*
Final Report	**Final technical and financial report**	**36 monts**	

List of Abbreviations

all abbreviations found in the project plan

IMS - Institute of Measurement Science, Slovak Academy of Sciences
ICTM - Institute for Chemistry, Technology and Metallurgy, Centre for Microelectronic Technologies
ULB - Universitè libre de Bruxelles
FCSE - Faculty of Computer Sciences and Engineering, University of Cyril and Methodius
FM - Faculty of Medicine in Bratislava, Comenius University

AI - artificial intelligence
BP - blood pressure

CBRN - Chemical, Biological, Radiological and Nuclear
ECG - electrocardiogram
GNP - graphene nanoparticles
GtoY - green to yellow health status change
HR - heart rate
LPE - liquid phase exfoliated (graphene)
PIR - photophletysmogram intensity ratio
PPG - photoplethysmogram
PTT - pulse transmit time
RR - respiration rate
YtoR - yellow to red health status change

Project Participants and Roles

describe the principal tasks of each co-director and other key participant(s), including young scientists and end-user(s); identify the fraction of time each will devote to this project;
add additional rows as needed by copying and pasting the last row

Name	Affiliation	Position/Title	% Time	Task(s)
Milan Tyšler	**Institute of Measurement Science, Slovak Academy of Sciences (IMS)**	**Department Head**	**30%**	WP2: Definition of the sensor modules for physiological data acquisition and analysis. WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis WP5: Development of the Communication plan. Dissemination of knowledge. Exploitation of the results. WP6: Management.
Marko Spasenović	**Institute for Chemistry, Technology and Metallurgy, Centre for Microelectronic Technologies (ICTM)**	**Associate Research Professor**	**20%**	WP1: Graphene sensors design, manufacturing and materials choice. Biocompatible materials choice and mechanical properties assessment. WP5: Development of the Communication plan. Dissemination of knowledge. Exploitation of the results. WP6: Management.
Carlo Saverio Iorio	**Universitè libre de Bruxelles (ULB)**	**Senior Researcher**	**20%**	WP1: Graphene-based sensing element manufacturing, assembling and functional testing WP2: Assessment of power requirements for sensing, processing and transmission. Integrated platform assembly and testing WP3: Methods and software for processing of acoustic signals to extract information on heart beating and breathing. WP5: Development of the Communication plan. Dissemination of knowledge. Exploitation of the results. WP6: Management.

Ana Madevska Bogdanova	**Faculty of Computer Sciences and Engineering, Sts Cyril and Methodius (FCSE)**	**Full Professor**	**30%**	WP3: Method, and software development and testing for cuffless blood pressure measurements. WP4: Exploiting existing and building own databases of collected vital parameters. Big Data in support of the sensing platform. Training of the analysis software to understand correctly how to evaluate specific event: Machine learning concepts. Development of mathematical models for health status changes. Creating models for GtoY and YtoR status changes and their implementation, testing and evaluation. Analysis of AS-IS processes and definition of TO-BE processes of medical response to massive incidents WP5: Development of the Communication plan. Dissemination of knowledge. Exploitation of the results. WP6: Management.
Oto Masár	**Faculty of Medicine in Bratislava, Comenius University in Bratislava (FM)**	**Full Professor**	**30%**	WP3: Specification of software modules for physiological data measurement, processing and analysis. WP4: Analysis of AS-IS processes and definition of TO-BE processes of medical response to massive incidents with respect to the proposed technology/service innovation. WP5: Development of the Communication plan. Dissemination of knowledge. Exploitation of the results. WP6: Management.

Fedor Lehocki	**IMS**	**Senior Researcher**	**30%**	WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis. Fast and secured transfer of physiological data. WP4: Analysis of AS-IS processes and definition of TO-BE processes of medical response to massive incidents with respect to the proposed technology/service innovation. Creating models for GtoY and YtoR status changes and their implementation, testing and evaluation. WP5: Dissemination of knowledge.
Juraj Slačka	**IMS**	**Researcher**	**20%**	WP2: Smart Patch HW Definition. Definition of the sensor modules for physiological data acquisition and analysis. Integrated platform assembly and testing WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis. Fast and secured transfer of physiological data: methods and software for data compression and coding.
Jana Švehlíková	**IMS**	**Senior Researcher**	**20%**	WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis. WP5: Dissemination of knowledge.
Ján Zelinka	**IMS**	**Senior Researcher**	**20%**	WP2: Data processing, transmission protocols and network management. WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis. Fast and secured transfer of physiological data: methods and software for data compression and coding.

Miroslav Haška	**IMS**	**PhD Student (young scientist)**	**100%**	WP2: Smart Patch HW Definition. Data processing, transmission protocols and network management. Integrated platform assembly and testing WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis. Fast and secured transfer of physiological data: methods and software for data compression and coding. WP5: Dissemination of knowledge.
Beáta Ondrušová	**IMS**	**PhD Student (young scientist)**	**100%**	WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis. WP5: Dissemination of knowledge.
Milija Sarajlić	**ICTM**	**Postdoc (young scientist)**	**25%**	WP1: Flexible Capacitive and Strain Sensors. Sensing element manufacturing, assembling and functional testing.
Stevan Andrić	**ICTM**	**PhD Student (young scientist)**	**30%**	WP1: Flexible Capacitive and Strain Sensors. Design and Materials Choice. Sensing element manufacturing, assembling and functional testing.
Immacolata Grieco	**ULB**	**PhD Student (young scientist)**	**100%**	WP1: Biocompatible, Wearable Interface materials choice. Mechanical properties assessment.
Vanja Miskovic		**PhD Student (young scientist)**	**30%**	WP1: Biocompatible, Wearable Interface materials choice. Mechanical properties assessment.
Katerina Zdravkova	**FCSE**	**Senior Researcher**	**20%**	WP4: Development of mathematical models for health status changes. Analysis of AS-IS processes and definition of TO-BE processes of medical response to massive incidents. Creating models for GtoY and YtoR status changes and their implementation, testing and evaluation. WP5: Dissemination of knowledge
Vladimir Trajkovik	**FCSE**	**Senior Researcher**	**20%**	WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis. Method, and software development and testing for cuffless blood pressure measurements

				WP4: Big Data in support of the sensing platform. Training of the analysis software. Analysis of AS-IS processes and definition of TO-BE processes of medical response to massive incidents. WP5: Dissemination of knowledge
Nevena Ackovska	**FCSE**	**Senior Researcher**	**20%**	WP4: Big Data in support of the sensing platform. Creating models for GtoY and YtoR status changes and their implementation, testing and evaluation. WP5: Dissemination of knowledge
Nikola Jankulovski	**FCSE**	**Senior Researcher**	**20%**	WP4: Analysis of AS-IS processes and definition of TO-BE processes of medical response to massive incidents. WP5: Dissemination of knowledge
Magdalena Kostoska Gjorcevska	**FCSE**	**Postdoc (young scientist)**	**100%**	WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis. Method, and software development and testing for cuffless blood pressure measurements. WP4: Exploiting existing and building own databases of collected vital parameters. Big Data in support of the sensing platform: discovering hidden patterns in huge volume of data. Development of mathematical models for health status changes. Analysis of AS-IS processes and definition of TO-BE processes of medical response to massive incidents. Creating models for GtoY and YtoR status changes and their implementation, testing and evaluation. WP5: Dissemination of knowledge
Monika Simjanoska	**FCSE**	**Postdoc (young scientist)**	**100%**	WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis. Method, and software development and testing for cuffless blood pressure measurements. System integration and testing. WP4: Training of the analysis software to understand correctly how to evaluate specific event: Machine learning concepts. Development of mathematical models for health

				status changes. Creating models for GtoY and YtoR status changes and their implementation, testing and evaluation. WP5: Dissemination of knowledge
Bojana Koteska	**FCSE**	**Postdoc (young scientist)**	**100%**	WP3: Specification, development and implementation of software modules for physiological data measurement, processing and analysis. Method, and software development and testing for cuffless blood pressure measurements. System integration and testing. WP4: Development of mathematical models for health status changes. Creating models for GtoY and YtoR status changes and their implementation, testing and evaluation. WP5: Dissemination of knowledge
			%	

Criteria for Success

precise criteria by which the success of the project in fulfilling the objectives detailed above will be judged; criteria should be as quantitative as possible
add additional rows as required by copying and pasting the last rwo

Criterion	Relative Weight
Creation of a working prototype of graphene-based sensors with biocompatible interface complying with the mechanical requirement of stretchability, light invasiveness and robustness.	**20 %**
Fully tested and operational HW platform for physiological data acquisition and analysis	**20 %**
Software modules for acquisition, local processing and possible transfer of physiological data	**20 %**
Software platform to analyse in real time physiological data including the cardiac and respiratory rhythm, and create mathematical models based on Big Data, AI and Deep Learning to connect them with known disorders, for assessment of person's health status change from YtoG and GtoY, and corresponding alarm generation	**30 %**
Organization of the events foreseen for the dissemination and communication campaigns in due time	**10 %**
Total	**100 %**

Related Projects

please list related projects in which participants (or other key personnel from their institution) are involved including, for each project, the personnel involved, the project title, dates, funding organisation and reference number and the total granted, along with a very brief description of the project and how it differs from/complements the present application.

Partner (and persons)	Funding Institution	Amount	Topic	Dates and administrative references
IMS (Milan Tyšler, Jana Švehlíková Ján Zelinka)	Slovak Research and Development Agency	250 000 €	Noninvasive localization of ectopic ventricular arrhythmias ECG mapping	2015 - 2018 APVV-14-0875
IMS (Jana Švehlíková, Milan Tyšler,	Scientific Grant Agency of the Ministry of Education, science, research and sport	55 430 €	Modeling of the cardiac electrical field for inter-pretation of structural	2019 – 2021 VEGA 2/0125/19

Ján Zelinka, Miroslav Haška, Beáta Ondrušová)	of the Slovak Republic and the Slovak Academy of Sciences		heart changes leading to ventricular arrhythmias	
IMS Juraj Slačka	Slovak Organization for Space Activities	100 000 €	first Slovak satellite	2016 - 2020 SkCube project
ICTM (Marko Spasenović)	Innovation Fund of the Republic of Serbia	335 000 €	Lightweight graphene microphones for use on drones	2017-2019. Academic-industrial partnership
ULB (Carlo Saverio Iorio, Vanja Miskovic, Immacolata Grieco)	European Space Agency, Belgian Space Agency	70 000 €	Study of a biocompatible interface for sensing housing in hyper-loading and un-loading conditions	Oct. 2018 - present The contract is a general funding framework called PRODEX support.
ULB (Carlo Saverio Iorio, Vanja Miskovic, Immacolata Grieco)	EU Graphene Flagship	340 000 €	Study of graphene materials in support of sensing application in biomedical and aeronautical sector	2020 – 2022 Industrial Contract - the project has been awarded and it is in signature phase
FCSE (Ana Madevska Bogdanova, Bojana Koteska, Monika Simjanoska, Magdalena Kostoska Gjorchevska)	NATO Science for Peace and Security - SIARS - Smart I (eye) Advisory Rescue System	390 000 €	Telemedicine Information system with biosensor integration	2015 - 2018 984753
FCSE (Ana Madevska Bogdanova, Vladimir Trajkovik, Fedor Lehocki)	COST - European Cooperation in Science and Technology	240 000 €	ENJECT - European Network for the Joint Evaluation of Connected Health Technologies	2014 – 2018 TD 1405

Related/Competing Projects

please list related or competing efforts by other groups and briefly describe how they differ from the present application

The challenge tackled by this project is of utmost importance in the emergency medical sector especially for rescue teams and victims of various attacks. It is possible, then, to find an important literature on the subject as well as commercial solutions and research and development projects. The partnership conducted a detailed survey of the existing market solutions and of the recent research projects, (we took as a reference the CORDIS database of the EU for the European and international projects while we did a google search for non-European research). In the following, the solutions that are closest to our proposal as well as the steps beyond the state-of-art proposed by SP4LIFE.

Projects	Goals	Status	SP4LIFE specificities
AMON **https://cordis.europa.eu/project/id/IST-2000-25239**	Wrist sensor to monitor and to evaluate heart rhythm, ECG, BP, SpO2, perspiration and body temperature with local expert	2001-2002, closed	SP4LIFE is patch, not wrist oriented and aimed at monitoring vital functions in emergency situations

	system and telemonitoring capabilities		
FRESP **https://cordis.europa.eu/project/rcn/87957/factsheet/en**	Countermeasure to avoid respiratory disorders	2008-2012, closed	SP4LIFE is more oriented to the detection. Countermeasures are calculated based on the real-time results of the Big Data and machine learning software
SAFECITI **https://cordis.europa.eu/project/id/607626/reporting**	Simulation platform for police to predict the behaviour of crowds under specific threats or stresses	2014-2016, closed	SP4LIFE is aimed at monitoring personal vital functions in emergency situations, not crowd behaviour
NATO RAWINTS **http://mrc.ulb.be/project-item/rawints/**	Project dealing with the creation of smart platform to heal and monitor tissue healing	2016-2018, closed	SP4LIFE is aimed at monitoring several vital functions in emergency situations
WISH **https://cordis.europa.eu/project/id/744157**	Wearable Integrated System for Early Detection of Preterm Labour by contraction sensing	2016-2017, closed	SP4LIFE is aimed at monitoring other vital functions in emergency situations
PREPARE **https://cordis.europa.eu/project/rcn/201668/factsheet/en**	To develop the world first purpose designed respiratory monitoring sensor delivering consistent and reliable results	2016-2018, now it is in commercial phase	Respect to Prepare, SP4LIFE will focus also on recording ECG, PPG, BP and sound that provides more information than the simple body movement sensors. Also, SP4LIFE adds AI networks to detect the disorders
WECARMON **https://cordis.europa.eu/project/id/745755**	Create a wearable monitoring system for respiratory and cardiovascular diseases	2017-2020, open	The project is an individual Marie-Curie Action. In contrast to SP4LIFE it is focused on the sensing elements exclusively
LifeCall **https://cordis.europa.eu/project/id/809158**	Mobile, wearable device in shirt, which captures ECG and stores it remotely to share with related parties. Detects cardiac arest	2018, closed	SP4LIFE is aimed at monitoring much more vital functions in emergency situations and AI based evaluation
A3BL **https://cordis.europa.eu/project/rcn/217251/factsheet/en**	Rehabilitation of pulmonary conditions in chronic disorders	2018, closed	SP4LIFE is a complete platform that goes far beyond the sensing and digital transmission by integrating a physical devices, a transmission protocol, and an Artificial Intelligence code.

Budget

please ensure that the summary numbers here are consistent with the detailed budgets in the attached excel file
make sure to update the totals before printing or exporting (F9 or right-click to update)

SPS-Funded Budget by Co-Director

Co-Director	Institution	Country	*6 months* Milestone One	*12 months* Milestone Two	*24 months* Milestone Three	30 months Milestone Four	*36* monts Final	Total
Milan Tyšler	Institute of Measurement Science, Slovak Academy of Sciences (IMS)	Slovakia	8200	33200	49800	17500	10300	€119000
Marko Spasenović	Institute for Chemistry, Technology and Metallurgy, Centre for Microelectronic Technologies (ICTM)	Serbia	13200	72400	19700	8000	1700	€115000
Carlo Saverio Iorio	Universitè libre de Bruxelles (ULB)	Belgium	44000	38500	10000	6000	1500	€100000
Ana Madevska Bogdanova	Faculty of Computer Sciences and Engineering, Sts Cyril and Methodius (FCSE)	North Macedonia	9900	20900	44300	16000	10900	€102000
Oto Masár	Faculty of Medicine in Bratislava, Comenius University in Bratislava (FM)	Slovakia	400	17500	22700	10300	3100	€54000

Budget Summary by Item

Budget Category	*6 months* Milestone One	*12 months* Milestone Two	*24 months* Milestone Three	*30 months* Milestone Four	*36* monts Final	Total
(a) Equipment *(including computers & software)*	49000	122400	47500	8000	0	€226900
(b) Training *(including related travel)*	1500	12500	23000	7000	500	€44500
(c) Communication & Publications *(incl. books & IPR)*	1700	4200	8800	4200	1700	€20600
(d) Experts & Advisors	0	0	0	0	0	€0
(e) Travel	1300	9700	16300	10900	7200	€45400
(f) Consumables and Spares	7000	12500	14000	10000	1900	€45400
(g) Other	2000	3000	6000	3500	3000	€17500
(h) Stipends *(for young researchers)*	13200	18200	30900	14200	13200	€89700
SPS Total	€75700	€182500	€146500	€57800	€27500	€490000

Nationally-Funded Budget

(j) Salaries	108250	108250	216500	108250	108250	€649500
(k) Equipment	35000	30000	0	0	0	€65000
(l) Other	0	0	0	0	0	€0
Nationally-Funded Total	€143250	€138250	€216500	€108250	€108250	€714500

According to the size of the project and the financial capability of the Co-Director and his/her institution, co-funding of some expenses particularly equipment, training, and conferences may be required. Stipends are only available to young researchers in eligible countries; please see the guideline

Equipment

list major equipment to be purchased, its role in the project, and approximate price; please indicate any co-funding proposed by the recipient's institution or country; consistent with budget items a, b, and k

The total estimated budget for equipment for all project partners is € 204 000 and will cover following items:

Partner	Name	Description, justification	Price €
IMS	SW modules for physiological and contextual data acquisition	Modules will provide developer platform for development and testing of software for data acquisition and processing for integrated patch.	27 000
IMS	Body Sensor Networks (BSN)	Body sensor networks will provide commercial off-shelf sensory equipment for laboratory and clinical testing of physiological data acquisition. It will serve also for purposes of testing validity of measurements carried by patch prototype and compare them with certified devices for individual signals (ECG, heart rate, PPG, temperature, blood pressure, breathing rate).	11 000
ICTM	Laser engraver	It was found that laser induced graphene is an excellent strain sensor which can be made on biocompatible substrates for just this application. We are thus requesting to purchase a CO2 laser engraver to produce such sensors, in addition to the solutions originally proposed.	10 000
ICTM	Interference microscope with additions and software	Upgrading of optical microscope for visual inspection of sensor elements. Especially relevant for strain sensor development, in evaluating agglomeration of graphene nanoparticles in stretchable polymer matrix.	28 000
ICTM	Semiconductor parameter analyser	For sensor performance testing, including precise resistance and capacitance measurements for strain and acoustic sensors	28 900
ULB	Viscosity meter	Will be used for defining the bioprinting range of hydrogels used in the manufacturing of the wearable sensing interface.	20 000
ULB	3D bioprinter	The bioprinter will be used for the testing and printing of a prototype patch to host the full sensing device.	19 000
ULB	Network analyzer	Will be used for testing signals' outputs of the sensors and the power supply stability.	30 000
FCSE	SW platform for implementation of the health status prediction system	The platform will be used for development of mathematical models for health status changes and creation of software for alerts after GtoY and YtoR status changes, their testing and evaluation	18 000
FCSE	3D printer	3D Printer for developing different models of the smart patch	2 000
FCSE	Mobile infrastructure for software development	Mobile devices for testing the communication during software development	4 000
FM	Software for trials at emergency units	Software infrastructure for monitoring the processes and communication at emergency units in hospital for	25 000

		purposes of understanding the flow of the healthcare procedures	
FM	Mobile infrastructure for emergency unit	Update of mobile devices for medical personnel during testing of the smart patch communication.	4 000

Training

training planned, to include contact between NATO and partner scientists; please note that SPS does not support fellowships so training should be of limited duration; consistent with budget item c

One of the main goals of the SPS programme is to enhance networking between partners and create common research platforms. In this context, training of students and young investigators represents an important step in achieving a fruitful exchange of best practices, know-how and knowledge. It will also help in establishing long-lasting relationships for future collaborations and further shared activities. By taking into account the need for partners' countries to be fully involved, the partnership agreed to implement short duration training periods of two weeks (with corresponding budget of € 44 500) according to the following preliminary general training schedule:

	Year 1	Year 2	Year 3
IMS	1 young from ICTM 1 young from FCSE	summer school: 2 young from IMS 2 young from ICTM 1 young from ULB 2 young from FCSE	1 young from FCSE
ICTM	1 young from IMS 1 young from ULB	1 young from ULB	2 young from ULB
ULB	1 young from ICTM 1 young from IMS	young from ICTM 1 student from IMS	
FCSE	1 young from IMS 1 young from ULB	1 young from IMS 1 young from ICTM	1 young from IMS
FM	1 young from FCSE	1 young from FCSE	1 young from FCSE

Travel

travel planned for internal project coordination and external scientific meetings; consistent with budget item e

Budget for travelling (€ 45 400) will essentially cover two main activities:

Project meetings: To foster the partnership, it will be very important to attend project meeting with a representative delegation. Participation of partners' countries representative should be considered crucial in that respect. Project meeting will be held at different partners each time, first and last meeting is supposed to be held at IMS.

Conferences & Workshops: Participation to conferences and workshops are an essential part of training of young researchers, one of the pillars of the SPS programme. Students involved in the project will be strongly encouraged to submit papers and attend international conferences as well as actively participate in dedicated workshops.

Advisors & Experts

participation of advisors/experts; the expert must be hired for a short duration from a NATO country to solve a specific project-related problem in the partner country; consistent with budget item d

In the frame of the project, experts might be hired for short periods (typically one week) if necessary to complement and integrate partnership's competences on some specific issues. They can also help young researchers involved in the project in tackling peculiar bottlenecks possibly arising in their training and research.

Advisors might help the partnership in keeping the pace of the development of the project and spot new pathways and applications eventually arising from the research's results.

Eventual budget for advisors and experts will be provided by National funding.

Other Major Expenses

please list other major expenses not covered above and their role in the project

No.

National Contribution

detail the contribution of participating nations & institutions including salaries, overhead, and existing equipment; should be consistent with budget items j, k, and l

Partners will complement the budget provided in the frame of this NATO-sponsored project with their national resources (estimated € 714 500) that will mainly cover:

Part of the salaries (devoted to the project) of Senior Researchers and full Young researcher salaries will be covered by national funding. Salaries of 7 PhD students and young researchers will be complemented with stipends from the NATO project (€ 89 700).

General equipment (data logger, cameras, computers, measurement systems, tensiometers for stretchable polymers, sputterers for scaffold generation, etc.) will be part of the national contribution to the project. NATO funding will be used only for buying special and dedicated equipment related to the project as shown above.

Advisors and Experts will also be covered by National Funding.

Financial Rules

NATO funds are managed in accordance with the financial regulations of the NPD's institution; please attach a copy or a link to these financial regulations

Financial information could be found on the website of the central administration of the IMS https://www.um.sav.sk. For specific questions, it is possible to address the head of department.

NATO funds will be managed according to the following financial regulations of Slovak Republic (NPD):

NATO Act No. 523/2004 Coll. on Budget Rules of the Public Service, Zákon o rozpočtových pravidlách 523/2004 Z.z. https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2004/523/

Act No. 357/2015 Coll. on Financial Control and Audits, Zákon o finančnej kontrole 357/2015 Z.z., https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2015/357/

Act No. 431/2002 Coll. on Accounting, Zákon o účovníctve, 431/2002 Z.z., https://www.zakonypreludi.sk/zz/2002-431 ,

Act No. 222/2004 Coll. on Value Added Tax, Zákon o DPH, 222/2004 Z.z., https://www.zakonypreludi.sk/zz/2004-222 ,

Act No. 595/2003 Coll. Income Tax Act, Zákon o Dani z príjmov, 595/2003 Z.z., https://www.zakonypreludi.sk/zz/2003-595 Act No. 283/2002 Coll. on Travel Expenses Reimbursements, Zákon o cestovných náhradách, 283/2002 Z.z.
www.zakonypreludi.sk/zz/2002-283
Act No. 553/2003 Coll. on Renumeration of Some Employees Performing Work in Public Interest, Zákon o odmeňovaní niektorých zamestnancov pri výkone práce vo verejnom záujme 553/2003 Z.z.
www.zakonypreludi.sk/zz/2003-553

Act No. 131/2002 Coll. on Universities, Zákon o Vysokých školách, 131/2002 Z.z., https://www.zakonypreludi.sk/zz/2002-131

Detailed Budgets

Please fill out a detailed budget for each Co-Director in the Excel file provided.

SPS : Smart Patch for Life Support Systems		Detailed Budget	NPD
NPD name	Institution	Country	Project Duration

Milan Tyšler	Institute of Measurement Science, SLovak ACademy of Sciences (IMS)	Slovak Republic	36

Anticipated Date (after kickoff)	6	12	24	30	36
	Milestone 1	Milestone 2	Milestone 3	Milestone 4	Final
Equipment	*including computers and software*				
SW for physiological and contextual data acquisition		12 000	12 000	3 000	
Body Sensor Networks (BSN)		5 500	5 500		
Subtotal Equipment	**€0**	**€17 500**	**€17 500**	**€3 000**	**€0**
Training	*including related travel*				
Summer schools, training missions		2 500	5 000	1 500	
Subtotal Training	**€0**	**€2 500**	**€5 000**	**€1 500**	**€0**
Communication & Publication					
Books & Journals	300	1 000	2 000	500	
Publication & IPR Protection			1 000	200	
Communications & Publicity	300	300	500	200	200
Subtotal Communication & Publication	**€600**	**€1 300**	**€3 500**	**€900**	**€200**
Travel					
Conferences (e.g. organized by IEEE, IFMBE - 1 attendee, 2 conference per year)	800	1 800	3 600	2 000	600
Project meetings (2 attendees, 1-2 meetings per year)		1 800	3 600	1 800	1 800
Subtotal Travel	**€800**	**€3 600**	**€7 200**	**€3 800**	**€2 400**
Consumables					
Electronic components for adjustment of BSN and prototype development	500	1 000	2 000	1 000	400
Subtotal Consumables	**€500**	**€1 000**	**€2 000**	**€1 000**	**€400**
Other					
Project management	1 500	2 500	5 000	2 500	2 500
Subtotal Other	**€1 500**	**€2 500**	**€5 000**	**€2 500**	**€2 500**
Stipends					
Young Scientist PhD. 1	2 400	2 400	4 800	2 400	2 400
Young Scientist PhD. 2	2 400	2 400	4 800	2 400	2 400
Subtotal Stipends	**€4 800**	**€4 800**	**€9 600**	**€4 800**	**€4 800**
SPS Total	**€8 200**	**€33 200**	**€49 800**	**€17 500**	**€10 300**

	SPS Grand Total	**€ 119 000**

SPS : Smart Patch for Life Support Systems	**Detailed Budget**				**PPD**
PPD name	**Institution**		**Country**		**Project Duration**
Marko Spasenović	Institute for Chemistry, Technology and Metallurgy, Centre for Microelectronic Technologies (ICTM)		Serbia		36
Anticipated Date (after kickoff)	*6*	*12*	*24*	*30*	*36*
	Milestone 1	**Milestone 2**	**Milestone 3**	**Milestone 4**	**Final**
Equipment	*including computers and software*				
Interference microscope additions, software		28 000			
Semiconductor parameter analyzer		28 900			
Laser engraver	10 000				
Subtotal Equipment	**€10 000**	**€56 900**	**€0**	**€0**	**€0**
Training	*including related travel*				
2 young researchers - 2weeks/year		5 000	10 000		
Subtotal Training	**€0**	**€5 000**	**€10 000**	**€0**	**€0**
Communication & Publication					
Books & Journals		500	500	500	
Publication & IPR Protection			1 000		
Communications & Publicity	200	200	200	200	200
Subtotal Communication & Publication	**€200**	**€700**	**€1 700**	**€700**	**€200**
Travel					
Project meetings		1 500	1 500	1 300	
Conferences		800		1 500	1 000
Subtotal Travel	**€0**	**€2 300**	**€1 500**	**€2 800**	**€1 000**
Consumables					
Small equipment computers and connectors	2 500	4 500	4 000	4 000	
Graphene production chemicals	500	1 000	500	500	500
Subtotal Consumables	**€3 000**	**€5 500**	**€4 500**	**€4 500**	**€500**
Other					

Subtotal Other	**€0**	**€0**	**€0**	**€0**	**€0**
Stipends					
2 Young Scientists PhD		2 000	2 000		
Subtotal Stipends	**€0**	**€2 000**	**€2 000**	**€0**	**€0**
SPS Total	**€13 200**	**€72 400**	**€19 700**	**€8 000**	**€1 700**
			SPS Grand Total		**€ 115 000**

SPS : Smart Patch for Life Support Systems	**Detailed Budget**				**CoA**
CoA name	**Institution**		**Country**		**Project Duration**
Carlo Saverio Iorio	Universitè libre de Bruxelles (ULB)		Belgium		36
Anticipated Date (after kickoff)	*6*	*12*	*24*	*30*	*36*
	Milestone 1	**Milestone 2**	**Milestone 3**	**Milestone 4**	**Final**
Equipment	*including computers and software*				
Viscosity meter	20 000				
3D bioprinter	19 000				
Network analizer		30 000			
Subtotal Equipment	**€39 000**	**€30 000**	**€0**	**€0**	**€0**
Training	*including related travel*				
1 PhD 2weeks/year	1 000	500	1 000	1 000	500
Subtotal Training	**€1 000**	**€500**	**€1 000**	**€1 000**	**€500**
Communication & Publication					
Books & Journals					
Publication & IPR Protection					
Communications & Publicity					
Subtotal Communication & Publication	**€0**	**€0**	**€0**	**€0**	**€0**
Travel					
Project meetings	500	500	2 000	500	1 000
Subtotal Travel	**€500**	**€500**	**€2 000**	**€500**	**€1 000**
Consumables					
Hydrogels components	1 000	2 000	2 000	2 000	
Aerogels components	2 500	2 500	2 500	1 500	
Subtotal Consumables	**€3 500**	**€4 500**	**€4 500**	**€3 500**	**€0**
Other					

Subtotal Other	**€0**	**€0**	**€0**	**€0**	**€0**
Stipends					
Young scientist one/year		3 000	2 500	1 000	
Subtotal Stipends	**€0**	**€3 000**	**€2 500**	**€1 000**	**€0**
SPS Total	**€44 000**	**€38 500**	**€10 000**	**€6 000**	**€1 500**
			SPS Grand Total		**€ 100 000**

SPS : Smart Patch for Life Support Systems	**Detailed Budget**				**CoB**
SPS : Smart Patch for Life Support Systems	**Institution**		**Country**		**Project Duration**
Ana Madevska Bogdanova	Faculty of Computer Science and Engineering, University Sts Cyril and Methodius (FCSE)		North Macedonia (the Invitee)		36
Anticipated Date (after kickoff)	*6*	*12*	*24*	*30*	*36*
	Milestone 1	**Milestone 2**	**Milestone 3**	**Milestone 4**	**Final**
Equipment	*including computers and software*				
Software for GtoY and YtoR alert			18 000		
3D printer		2 000			
Mobile communication devices		4 000			
Subtotal Equipment	**€0**	**€6 000**	**€18 000**	**€0**	**€0**
Training	*including related travel*				
Summer schools, courses, training missions	500	2 500	3 000	2 500	
Subtotal Training	**€500**	**€2 500**	**€3 000**	**€2 500**	**€0**
Communication & Publication					
Books & Journals	500				
Publication & IPR Protection		1 200	2 000	1 600	
Communications & Publicity		300	500	500	1 000
Subtotal Communication & Publication	**€500**	**€1 500**	**€2 500**	**€2 100**	**€1 000**
Travel					

Conferences (e.g. organized by IEEE - 1 attendee, 2 conferences per year)	0		1 000	1 000	
Project meetings (3 attendees, 2 meetings per year)		1 500	1 000	1 000	1 000
Subtotal Travel	**€0**	**€1 500**	**€2 000**	**€2 000**	**€1 000**
Consumables					
SSD, grpahical processing units		500	1 000		
Subtotal Consumables	**€0**	**€500**	**€1 000**	**€0**	**€0**
Other					
Third party services	500	500	1 000	1 000	500
Subtotal Other	**€500**	**€500**	**€1 000**	**€1 000**	**€500**
Stipends					
Young Scientist PhD. 1	3 000	3 000	6 000	3 000	3 000
Young Scientist PhD. 2	3 000	3 000	6 000	3 000	3 000
Young Scientist MSc. 3	2 400	2 400	4 800	2 400	2 400
Subtotal Stipends	**€8 400**	**€8 400**	**€16 800**	**€8 400**	**€8 400**
SPS Total	**€9 900**	**€20 900**	**€44 300**	**€16 000**	**€10 900**
			SPS Grand Total		**€ 102 000**

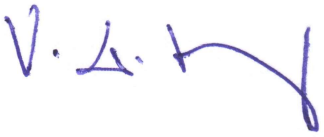
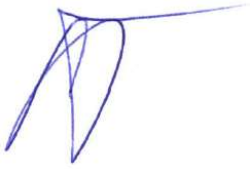
SPS : Smart Patch for Life Support Systems		**Detailed Budget**			**CoC**
CoC name	**Institution**		**Country**		**Project Duration**
Oto Masár	Faculty of Medicine in Bratislava, Comenius University (FM)		Slovak Republic		36
Anticipated Date (after kickoff)	*6*	*12*	*24*	*30*	*36*
	Milestone 1	**Milestone 2**	**Milestone 3**	**Milestone 4**	**Final**
Equipment	*including computers and software*				
SW for trials at emergency units		10 000	10 000	5 000	
Mobile infrastructure for emergency units		2 000	2 000		
Subtotal Equipment	**€0**	**€12 000**	**€12 000**	**€5 000**	**€0**
Training	*including related travel*				
Summer schools, training missions		2 000	4 000	2 000	
Subtotal Training	**€0**	**€2 000**	**€4 000**	**€2 000**	**€0**
Communication & Publication					
Books & Journals	200	400	500	300	100
Publication & IPR Protection					

Communications & Publicity	200	300	600	200	200
Subtotal Communication & Publication	**€400**	**€700**	**€1 100**	**€500**	**€300**
Travel					
Conferences (e.g. organized by IEEE, IFMBE - 1 attendee,2 conferences per year)		1 000	2 000	1 000	1 000
Project meetings (1 attendee, 2 meetings per year)		800	1 600	800	800
Subtotal Travel	**€0**	**€1 800**	**€3 600**	**€1 800**	**€1 800**
Consumables					
Material for emergency units		1 000	2 000	1 000	1 000
Subtotal Consumables	**€0**	**€1 000**	**€2 000**	**€1 000**	**€1 000**
Other					
Subtotal Other	**€0**	**€0**	**€0**	**€0**	**€0**
Stipends					
Subtotal Stipends	**€0**	**€0**	**€0**	**€0**	**€0**
SPS Total	**€400**	**€17 500**	**€22 700**	**€10 300**	**€3 100**
			SPS Grand Total		**€ 54 000**

Agreement for Joint Research

signatures of all Co-Directors

We agree that we wish to carry out the joint research reflected in this proposal. Furthermore, we acknowledge the grant terms set out in the SPS Multi-Year Projects Handbook and confirm that, if awarded, we will be in a position to execute the grant.

Name	Signature	Institution	Signature for Institution
Milan Tyšler		Institute of Measurement Science, Slovak Academy of Sciences (IMS)	
Marko Spasenović		Institute for Chemistry, Technology and Metallurgy, Centre for Microelectronic Technologies (ICTM)	
Carlo Saverio Iorio		Universitè libre de Bruxelles (ULB)	
Ana Madevska Bogdanova		Faculty of Computer Sciences and Engineering, Sts Cyril and Methodius (FCSE)	
Oto Masár		Faculty of Medicine in Bratislava, Comenius University in Bratislava (FM)	

Attachments

Please include the following attachments:

Attachment 1. CVs for all Co-Directors using the templates below

Attachment 2. Acceptance by NPD Institute of Management of SPS Funds using the template below

Attachment 3. An intellectual property rights agreement among the Co-Directors and their institutions or a waiver signed by all Co-Directors and the heads or IPR delegates of their institutions stating that no such agreement is necessary for this project. A sample IPR agreement can be found in the Project Plan Guidelines.

Attachment 4. A brief overview of the participating institutions, their capabilities, resources, and facilities. Please include the address of the institutional web page as well as the web address(es) of any school or institute linked to the project

Attachment 5. Written commitment from the end-user(s) to active involvement in the project including a description of their interest in the outcomes

Attachment 6. The project summary

Attachment 7. Detailed project budgets for each co-director; a separate Excel file is provided.

Please submit the Project Plan electronically in this original Microsoft Word format with all attachments included in the single document. The MYP Detailed Budget Excel workbook should be a separate attachment.

Curriculum Vitae

Please include a CV no longer than two pages in this format for the NPD.

NATO Country Project Director

Family Name	First Name	Title	Job Title
Tyšler	Milan	Assoc.prof. Dr.	Department Head

Institution	Full mailing address	Country
Institute of Measurement Science, Slovak Academy of Sciences (IMS)	Dubravska cesta 9, 841 04 Bratislava	Slovakia

Telephone	Fax	Email	Nationality	Date of Birth
+421 2 5910 4550	+421 905 203 525	tysler@savba.sk	Slovak	2.9.1951

Education

degrees, universities, and dates

Ing. (MSc.) Faculty of Electrical Engineering, Slovak Technical University, Bratislava, 1969 - 1974

CSc. (PhD.) Institute of Measurement Science, Slovak Academy of Sciences, Bratislava, 1978 - 1982

doc. (Assoc.prof.) Faculty of Mechanical Engineering, Technical University Košice, Dept. of Instrumentation and Biomedical Engineering, 2006

Employment

employers, positions, and dates

full time:

1981 - (cont.) Institute of Measurement Science, Slovak Academy of SCiences, Bratislava
since 1985 - head, Department of Biomeasurements
2006 – 2018 director of the Institute

part time:

1988 - 1989 Faculty of Medicine, Comenius University, Bratislava, senior research worker
1989 - 1993 Faculty of Electrical Engineering, Slovak Technical University, Bratislava, visiting professor
1989 - 1996 Faculty of Mechanical Engineering, Slovak Technical University, Bratislava, visiting professor
1997 – 2002 Faculty of Mechanical Engineering, Technical University Košice, seminars on Biomedical Engineering
2006 - (cont.) Czech Technical University in Prague, Kladno, Czech Republic, Faculty of BMI, associate professor

Research

brief description of past and current research and the field(s) of specialization

Biomedical measurements and instrumentation

1. Development of intelligent measuring systems for biosignal recording, processing and evaluation, oriented namely to ECG, EEG, EGG and reflexometry.

2. Research of new methods for biosignal processing, imaging and model-based diagnostic or therapeutic evaluation and their application for selected pathologies.

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

Modeling and identification of biological processes, oriented to cardiovascular system:

1. Modelling of normal and pathological excitation of the heart using cellular-automata or finite element based methods, computer simulations of body surface cardiac electrical field.

2. Research of non-invasive inverse diagnostic methods for cardiology (ECG imaging methods) based on multichannel surface ECG measurements and individual CT/MRI-based torso models and their use for identification of arrhythmogenic substrates or local ischemic changes in the ventricular myocardium.

3. Research and development of PC-based systems and methods for measurement, processing and diagnostic interpretation of multichannel ECG.

Publications

up to three recent publications relevant to this project plan

1. SVEHLIKOVA, Jana - ZELINKA, Jan - BACHAROVA, Ljuba - TYSLER, Milan. Modeling and visualization of the activation wavefront propagation to improve understanding the QRS complex changes indicating left ventricular hypertrophy. In Journal of Electrocardiology, 2016, vol. 49, no. 5, p. 755-762. ISSN 0022-0736.
2. PUNSHCHYKOVA, O. - ŠVEHLÍKOVÁ, Jana - TYŠLER, Milan - GRÜNES, R. - SEDOVA, K. - OSMANČÍK, P. - ŽĎÁRSKÁ, J. - HEŘMAN, D. - KNEPPO, P. Influence of torso model complexity on the noninvasive localization of ectopic ventricular activity. In Measurement Science Review, 2016, vol. 16, no. 2, p. 96-102. ISSN 1335-8871.
3. TYŠLER, Milan – PUNSHCHYKOVA, Olena – ŠVEHLÍKOVÁ, Jana – OSMANČÍK, Pavel – ŽĎÁRSKÁ, Jana – KNEPPO, Peter. Noninvasive identification of local disorders of electrogenesis in ventricular arrhythmias. Cardiology Lett. Vol.26, No.1 p.39-46 2017. print: ISSN 1338-3655, on line: ISSN 1338-3760.

Honours

awards, fellowships, professional societies, etc.

1994-1997	IFMBE Working Group for European Activities, member
1995 -	IEEE Engineering in Medicine and Biology Society, member
1998 -	IEEE Instrumentation and Measurement Society, member
1996 -	International Society of Electrocardiology since 2000: International Council member, 2014-2019 Scientific secretary of the Society
1996 -	Slovak Society of Biomedical Engineering, 2008-2020 President of the Society
1997 -	International Measurement Confederation IMEKO, 2011-2015 President of Slovak IMEKO committee
2007-2018	Scientific board member, Faculty of Electrical Engineering and Information Technology, Slovak Technical University in Bratislava
2008	Scientific board member, Faculty of Biomedical Engineering, Czech Technical University in Prague, Kladno, Czech Republic
2011	Honour SAS plaquette of Aurel Stodola for the merits in technical science

Curriculum Vitae

Please include a CV no longer than two pages in this format for the PPD.

Partner Country Project Director

Family Name	First Name	Title	Job Title
Spasenović	Marko	Dr.	Associate Research Professor

Institution	Full mailing address	Country
Institute for Chemistry, Technology and Metallurgy, Centre for Microelectronic Technologies (ICTM)	Njegoseva 12 11000 Beograd	Serbia

Telephone	Mobile	Email	Nationality	Date of Birth
+381643318338	+381643318338	spasenovic@nanosys.ihtm.bg.ac.rs		

Education

degrees, universities, and dates

PhD in Applied Physics, University of Twente, the Netherlands, 2011

MSc in Physics, University of Toronto, Canada, 2006

BEng in Engineering Physics, Carleton University, Canada, 2005

Employment

employers, positions, and dates

Aug 2018-present: Associate Professor, Institute for Chemistry, Technology and Metallurgy, Belgrade

Oct 2014-July 2018: Assistant Professor, Institute of Physics, Belgrade

Oct 2011-Sept 2014: Postdoctoral Researcher, ICFO (Institute of Photonic Sciences), Barcelona, Spain

Research

brief description of past and current research and the field(s) of specialization

Graphene production, characterization, and application to devices; Liquid phase exfoliation of graphene; nanoparticles and their use in thin films for transparent conductor and sensor applications; Graphene microphones and capacitive pressure sensors; Past research includes Nano photonics and plasmons in graphene.

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

Surface chemistry of graphene nanoparticle thin films and their application to chemical and strain sensors; Customization of GNP production and film deposition environments to fit a desired application; Nano characterization of multilayer graphene and its application in microphones and membranes; Associate Member of the Graphene Flagship European Commission FET project, Work Package Sensors.

Publications

up to three recent publications relevant to this project plan

1. Tomasevic-Ilic, T., Jovanovic, D., Popov, I., Fandan, R., Pedros, J., Spasenovic, M., and Gajic, R., Reducing sheet resistance of self-assembled transparent graphene films by defect patching and doping with UV/ozone treatment, Appl. Surf. Sci. 458, 446-453 (2018)
2. Matkovic, A., Milosevic, I., Milicevic, M., Tomasevic-Ilic, T., Pesic, J., Music, M., Spasenovic, M., Jovanovic, D., Vasic, B., Deeks, C., Panajotovic, R., Belic, M.R., and Gajic, R., Enhanced sheet conductivity of Langmuir–Blodgett assembled graphene thin films by chemical doping, 2D Materials 3, 015002 (2016)
3. Todorovic, D., Matkovic, A., Milicevic, M., Jovanovic, D., Gajic, R., Salom, I., and Spasenovic, M., Multilayer graphene condenser microphone, 2D Materials 2, 045013 (2015)

Honours

awards, fellowships, professional societies, etc.

- ICFOnest (Marie Curie COFUND) postdoctoral fellowship: 2012-2014
- Marie Curie PhD fellowship: 2007-2010
- Dean's list of distinguished students (Carleton University): 2002, 2004, and 2005
- Nortel Networks undergraduate scholarship: 2001, 2002, and 2004

- Marie Curie Alumni Association member: 2014-present
- Optical Society of America (OSA) Member Advisory Network: 2013, 2014
- OSA Member: 2009-2017
- Founding president of OSA student chapter in Amsterdam: Sept 2010-May 2011
- Graphene Stakeholders Association Advisory Board Member: 2013-present

Curriculum Vitae

Please include a CV no longer than two pages in this format for each project Co-Director; copy and paste this entire form as necessary

Co-Director

please ensure that in writing names the same spelling is used throughout

Family Name	First Name	Title	Job Title
Iorio	Carlo Saverio	Dr.	Senior Researcher

Institution	Full mailing address	Country
Universitè libre de Bruxelles (ULB)	Avenue P.Heger	Belgium

Telephone	Mobile	Email	Nationality	Date of Birth
+3226503173	+32498317175	ciorio@ULB .ac.be	Italian	24.11.1969

Education

degrees, universities, and dates

- Diploma of the United Nation Academy on "International Negotiation: Practical skills and techniques" – Score: 97/100 - 2012
- Diploma of the World Intellectual Property Organization on "Advanced Course on Intellectual Property" - 2009
- PhD in Applied Sciences – Université Libre de Bruxelles, Brussels – Belgium – 2006
- MSc in Aeronautical Engineering – Università degli Studi di Napoli, Napoli – Italy – 1998

Employment

employers, positions, and dates

Oct. 2000 - Present, Université Libre de Bruxelles, Brussels- Belgium

Nov. 1998 – Sept. 2000, Università degli Studi di Napoli, Napoli – Italy

Research

brief description of past and current research and the field(s) of specialization

Main topics: layer-by-layer deposition of functionalized substrates, for biomedical applications; multi-layered biocompatible interface characterized by variable mechanical properties; carbon-based electrodes for dermal water content detection

Other Topic: Heat and Mass transfer in simple and complex fluids. Evaporation and condensation phenomena in microgravity conditions, packaging of heat and mass transfer devices

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

At present my research group is involved in activities on different domain of fluidic:

- Flexible detection platforms based on carbon-based/conductive polymers coupling
- Advanced printing: research on alginate based conductive ink for smart microelectrode printing
- Biocompatible interfaces for wearable applications
- Heat and mass transfer: Complex fluids droplet manipulation and characterization

Publications

up to three recent publications relevant to this project plan

1. H. Machrafi, C. Minetti, V. Miskovic, P.C. Dauby, F. Dubois, C.S. Iorio, Self-assembly of carbon nanotube-based composites by means of evaporation-assisted depositions: Importance of drop-by-drop self-assembly on material properties, Materials Chemistry and Physics, Volume 218, 2018, Pages 1-9
2. V. Miskovic, S. Traettino, C. Minetti, H. Machrafi, A. Amirfazli,F. Dubois,and C.S.Iorio,Fabrication and Characterization of Polystyrene Colloidal Photonic Crystals on Soft Sodium Alginate Film, Journal of Nanoelectronics and Optoelectronics, 2018, 13, 4, pages 472-478
3. H. Machrafi, G. Lebon, C.S. Iorio, Effect of volume-fraction dependent agglomeration of nanoparticles on the thermal conductivity of nanocomposites: Applications to epoxy resins, filled by SiO2, AlN and MgO nanoparticles, Composites Science and Technology, Volume 130, 2016, Pages 78-87

Honours

awards, fellowships, professional societies, etc.

- Coordinator of the European Space Agency Topical team on 'Tissue healing in Space" – 2016 – present
- Coordinator of the European Space Agency Microgravity Application Promotion on Wound Monitoring and biomaterials 2019 - present
- Coordinator of the European Space Agency Microgravity Application Promotion on Evaporative phenomena in simple and complex fluids 2017 - present
- Coordinator of the European Space Agency Sounding Rocket Experiment " Arles " on layer-by-layer manufacturing in Space - 2016- present
- Coordinator of the NATO SPS project "RaWInts" - G4961 - on Rapid Wound Healing and Monitoring - 2016-2018
- Delegate of Belgium at IUPAP (International Union of Pure and Applied Physics) - Physics for Development Committee – 2014 -present
- Task leader (WP14.3.5 - enhanced evaporators for thermal management) of the EU Flagship programme on Graphene - 2014- present

Curriculum Vitae

Please include a CV no longer than two pages in this format for each project Co-Director; copy and paste this entire form as necessary

Co-Director

please ensure that in writing names the same spelling is used throughout

Family Name	First Name	Title	Job Title
Madevska Bogdanova	Ana	Dr.	Full Professor

Institution	Full mailing address	Country
Faculty of Computer Sciences and Engineering, Sts Cyril and Methodius (FCSE)	Rugjer Boskovic 16, Skopje	North Macedonia

Telephone	Mobile	Email	Nationality	Date of Birth
+389 23070377	+389 70400310	ana.madevska.bogdanova@FCSE.ukim.mk	Macedonian	1.11.1967

Education

degrees, universities, and dates

1991 – BSc. University "Sts Cyril and Methodius", Faculty of Science and Mathematics, Institute of Informatics

1996 – MSc, University "Sts Cyril and Methodius", Faculty of Science and Mathematics, Institute of Informatics

2003 - PhD, University "Sts Cyril and Methodius", Faculty of Science and Mathematics, Institute of Informatics

Employment

employers, positions, and dates

1992 – 1996	Junior Assistant, University "Sts Cyril and Methodius", Faculty of Science and Mathematics, Institute of Informatics
1996 – 2003	Assistant, University "Sts Cyril and Methodius", Faculty of Science and Mathematics, Institute of Informatics
2004 – 2009	Assistant professor, University "Sts Cyril and Methodius", Faculty of Science and Mathematics, Institute of Informatics
2009 - 2011	Associate professor, University "Sts Cyril and Methodius", Faculty of Science and Mathematics, Institute of Informatics
2011- 2014	Associate professor, University "Sts Cyril and Methodius", Faculty of Computer Science and Engineering
2014 - current	Full professor, University "Sts Cyril and Methodius", Faculty of Computer Science and Engineering

Research

brief description of past and current research and the field(s) of specialization

Broader research interest of Ana Madevska Bogdanova is in the field of computer sciences: building Intelligent systems, Artificial Intelligence, optimization, Simulation, Algorithms, ICT in education. Specific domain of research: Knowledge engineering, Pattern Recognition, Neural Networks, Support Vector Machines, developing parallel algorithms, Methodology in teaching Intelligent Systems and Informatics.

The main research interest is toward developing modern Machine learning methods that have to consider the fact that the real data are full of uncertainty, noise, and high dimensionality. Also, today we are dealing with exponential growth in stored data (genomic data, geographical information, social networks, e-health records). In building applications that solve real world problems, the ability to learn as they obtain new data becomes essential. The data sets can be integrated from a cloud of different data sources and the system has to extract the information from each individual source. The evolution of the Intelligent Systems has always followed the technology leading edge of knowledge.

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

- Blood pressure estimation (in cooperation with Faculty of Electrical Engineering – University of Ljubljana)
- Bayesian recognition of blood pressure

- Deep Learning, Convolutional Neural Networks
- Knowledge engineering in telemedicine

Publications

up to three recent publications relevant to this project plan

1. Simjanoska M., Kochev S., Tanevski J., Bogdanova A.M., Papa G., & Eftimov T. (2020), Multi-level information fusion for learning a blood pressure predictive model using sensor data. In Information Fusion, ISSN 1566-2535, https://doi.org/10.1016/j.inffus.2019.12.008. JCR Impact Factor: 10.716
2. Simjanoska, M., Gjoreski, M., Gams, M., & Madevska Bogdanova, A. (2018). Non-Invasive Blood Pressure Estimation from ECG Using Machine Learning Techniques. Sensors, 18(4), 1160.
3. Lina Xu, Monika Simjanoska, Bojana Koteska, Vladimir Trajkovikj, Ana Madevska Bogdanova, Kristina Drusany Starič, Fedor Lehocki, "What Clinics are Expecting From Data Scientists? A Review on Data Oriented Studies Through Qualitative and Quantitative Approaches", IEEE Access, 2019, Vol.7, pp 641-654

Honours

awards, fellowships, professional societies, etc.

2003 - current European Neural Network Society member

Curriculum Vitae

Please include a CV no longer than two pages in this format for each project Co-Director; copy and paste this entire form as necessary

Co-Director

please ensure that in writing names the same spelling is used throughout

Family Name	First Name	Title	Job Title
Masár	Oto	MD PhD.	Full Professor

Institution	Full mailing address	Country
Faculty of Medicine in Bratislava, Comenius University in Bratislava (FM)	Špitálska 24, 813 72 Bratislava	Slovakia

Telephone	Mobile	Email	Nationality	Date of Birth
+421 2 593 57 466	+421 903 325 458	oto.masar@jfmed.uniba.sk	Slovak	8.1.1956

Education

degrees, universities, and dates

Faculty of Medicine, Charles University, Prague, 1981

Employment

employers, positions, and dates

Chief of Dept. Urgency and General Medicine, Faculty of Medicine, Comenius University in Bratislava, since 2007

Research

brief description of past and current research and the field(s) of specialization

In 1990s research activities primary on management of emerging drug abuse epidemic in Slovakia - research project DRSPT II, Committee for drug abuse, Government Office of the Slovak Republic, in cooperation with Council of Europe

Research on nutrition habits in chronic patients, Faculty of Agrobiology and Food Resources, Slovak University of Agriculture in Nitra

Education on automatic external defibrillators (AED), Department of Emergency medicine, Institute for Postgraduate Medical Education, Ministry of Health of Czech Republic

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

Telemonitoring of patients with chronic conditions, National Centre of Telemedicine Services, 2017-2018

Development of educational materials for medical students and paramedics, Faculty of Medicine and Dentistry, Palacký University Olomouc, Czech Republic and University of South Bohemia in České Budejovice, Czech Republic (ongoing since 2016)

Publications

up to three recent publications relevant to this project plan

1. Compendium of medical care in toxicology (in Slovak language, "Kompendium medicínskej starostlivosti o toxikomanov"), O. Masár, V. Valkučáková, I. Mauritzová, Plzeň : Maurea, 2013
2. Compendium of Disaster Medicine, O. Masár, A. Nejedlý, K. Arendášová, Bratislava : Kartprint, 2016
3. Compendium of Health Consequences of Weapons of Mass Destruction, O. Masár, K. Žákovičová
4. Bratislava : Záchranná akadémia Activa C&S, 2013

Honours

awards, fellowships, professional societies, etc.

Editorial board of Journal of Emergency Care, Council for Research and Development of the Czech Republic.

STIPENDIARY CVs

Emerging Security Challenges Division

Science for Peace and Security Programme

Curriculum Vitae

Family Name	First Name	Title	Job Title
Haška	Miroslav	Ing.	PhD student

Institution	Address	Country
Institute of Measurement Science, SAS	Dúbravská cesta 9, 84104, Bratislava 4,	Slovakia

Telephone	Fax	Email	Nationality	Date of Birth
+421-2591045 53		umerhask@savba.sk	Serbian	30.05.1991

Education

degrees, universities, and dates

Ing. (MSc.), Faculty of Electrical Engineering and Information Technology STU in Bratislava, 2015 - 2018 Electronics and Photonics

Bc., Faculty of Electrical Engineering and Information Technology STU in Bratislava, 2010 - 2015, Electronics

Employment

employers, positions, and dates

ER&P elektro sro, Electrician**,** 09/2016 - 12/2016
Institute of Measurement Science, SAS, Electrical Engineer, 09/2017 - yet

Research

brief description of past and current research and the field(s) of specialization

Participation in creation of technical and software equipment of experimental systems for measurement and evaluation of biosignals and processing of necessary technical and user documentation.

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

Development of hardware and software equipment of experimental system for measurement and evaluation of ECG.

Role/Activity

Please describe the project-specific role and activity(ies) you will undertake

Smart Patch HW Definition. Definition of the sensor modules for physiological data acquisition and analysis. Data processing, transmission protocols and network management. Integrated platform assembly and testing. Specification, development and implementation of software modules for physiological data measurement, processing and analysis. Software fast and secured transfer of physiological data.

Period of Involvement (estimated)

The period/dates for which you will be involved and receive a stipend

2020 – 2023

Publications

up to three recent publications relevant to this project plan

1. HAŠKA, Miroslav – TYŠLER, Milan. Multichannel wireless bioelectric potential measurement: State of the art and applicability for BSP mapping. In MEASUREMENT 2019 : Proceedings of the 12th International Conference on Measurement. Editors: J. Maňka, J. Švehlíková, V. Witkovský, I. Frollo. – Bratislava, Slovakia: Institute of Measurement Science, Slovak Academy of Sciences, 2019, p. 211-214. ISBN 978-80-972629-2-1.
2. ŠVEHLÍKOVÁ, Jana – ZELINKA, Ján – HAŠKA, Miroslav – TYŠLER Milan. Simulation of measured body surface potential map during early right ventricular pacing. In MEASUREMENT 2019 : Proceedings of the 12th International Conference on Measurement. Editors: J. Maňka, J. Švehlíková, V. Witkovský, I. Frollo. – Bratislava, Slovakia: Institute of Measurement Science, Slovak Academy of Sciences, 2019, p. 34-37. ISBN 978-80-972629-2-1.
3. TYŠLER, Milan – ŠVEHLÍKOVÁ, Jana – ZELINKA, Ján – HAŠKA, M. – HATALA, R. Noninvasive localization of the origin of ectopic ventricular activation. In Trends in Biomedical Engineering 2019 : 13.

Conference of Slovak and Czech Biomedical Engineering Workplaces. – Žilina, Slovak Republic: University of Žilina, 2019. ISBN 978-80-554-1587-1.

Honours

awards, fellowships, professional societies, etc.

Emerging Security Challenges Division

Science for Peace and Security Programme

Curriculum Vitae

Family Name	First Name	Title	Job Title
Ondrušová	**Beáta**	**Ing.**	First Stage Researcher

Institution	Address	Country
Institute of Measurement Sciense Slovak Academy of Sciences	**Dúbravská cesta 9 841 04 Bratislava 4**	**Slovakia**

Telephone	Fax	Email	Nationality	Date of Birth
+421 259 104 552	**-**	**umerondb@savba.sk**	**Slovak**	**18.04.1991**

Education

degrees, universities, and dates

Master's Degree in Biomedical Engineering, Czech Technical University in Prague, 2016

Bachelor's Degree in Biomedical Technique, Czech Technical University in Prague, 2014

Employment

employers, positions, and dates

Institute of Measurement Science, Slovak Academy of Sciences, First Stage Researcher, 2019 – present

Czech Hydrometeorological Institute, Sectoral Expert for Greenhouse Gas Emissions from Industrial Processes, 2016 - 2019

Research

brief description of past and current research and the field(s) of specialization

Processing of biosignals, forward and inverse modeling in electrocardiography

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

Measurement and modeling of the cardiac electrical field for noninvasive identification and interpretation of structural changes of the ventricular myocardium leading to ventricular arrhythmias, Program: VEGA

Role/Activity

Please describe the project-specific role and activity(ies) you will undertake

Participation as a PhD student. Specification, development and implementation of software modules for physiological data measurement, processing and analysis.

Period of Involvement (estimated)

The period/dates for which you will be involved and receive a stipend

2020 - 2023

Publications

up to three recent publications relevant to this project plan

1. Beáta Ondrušová, Eva Krtková: The Phoenix calculation model for emission estimates of F-gases used in refrigeration and air conditioning. Meteorologické zprávy, Praha: ČHMÚ, 2018(1). ISSN 0026-1173.
2. Beáta Ondrušová, Eva Krtková. Emissions of flourinated greenhouse gases in the Czech Republic for 1990-2015 period. Meteorologické zprávy, Praha: ČHMÚ, 2017(3).ISSN 0026-1173.

Honours

awards, fellowships, professional societies, etc.

Dean's Award for the diploma thesis, Czech Technical University in Prague, 2016

Emerging Security Challenges Division

Science for Peace and Security Programme

Curriculum Vitae

Family Name	First Name	Title	Job Title
Sarajlić	Milija	Dr	Associate Research Professor

Institution	Address	Country
ICTM	Njegoševa 12, 11000 Beograd	Serbia

Telephone	Fax	Email	Nationality	Date of Birth
+381 11 2638 188		milijas@nanosys.ihtm.bg.ac.rs	Serbian	March 5, 1994

Education

degrees, universities, and dates

PhD Physics, University of Belgrade, May 2013

MSc Physics, University of Belgrade, July 2007

BSc Physics, University of Belgrade, February 2002

Employment

employers, positions, and dates

Institute for Chemistry, Technology and Metallurgy – ICTM, Associate Professor, Dec 2017-present

Deutsches Elektronen-Synchrotron (DESY), Project leader, Dec 2013-Nov 2017

Research

brief description of past and current research and the field(s) of specialization

Silicon planar technology-based temperature and gas sensors.

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

Development of novel photo, thermo, and gas sensors based on silicon, graphene, and other materials.

Role/Activity

Please describe the project-specific role and activity(ies) you will undertake

Fabrication and testing of sensors for human health parameter monitoring

Period of Involvement (estimated)

The period/dates for which you will be involved and receive a stipend

Month 6 – month 18

Publications

up to three recent publications relevant to this project plan

1. Sarajlić, M., Đurić, Z., Jović, V., Petrović, S., Đorđević, D. Detection limit for an adsorption-based mercury sensor (2013) Microelectronic Engineering 103 pp. 118 122. DOI: 10.1016/j.mee.2012.10.009, ISSN: 0167-9317, IF: 1,557 (2011) (Engineering, Electrical & Electronic): 7/245 (2011)
2. Sarajlić, M., Đurić, Z. G., Jović, V. B., Petrović, S. P., & Đorđević, D. S., An adsorption-based mercury sensor with continuous readout (2013) Microsystem Technologies, 19(5), pp. 749-755. DOI: 10.1007/s00542-012-1679-6 ISSN: 0946-7076, IF: 0,952 (2013) (Engineering, Electrical & Electronic): 151/248 (2013)
3. M. Sarajlić et al. Thin-film four-resistor temperature sensor for measurements in air (2019) Meas. Sci. Technol. DOI: 10.1088/1361-6501/ab326c

Honours

awards, fellowships, professional societies, etc.

Best poster award at International conference MIEL 2006. Best paper award for MO section at International conference IcETRAN 2014. Best paper award for MO section at International conference IcETRAN 2019

Emerging Security Challenges Division

Science for Peace and Security Programme

Curriculum Vitae

Family Name	First Name	Title	Job Title
Andrić	Stevan	Mr	PhD student

Institution	Address	Country
ICTM	Njegoševa 12, 11000 Beograd	Serbia

Telephone	Fax	Email	Nationality	Date of Birth
+381 11 2638 188		stevan@nanosys.ihtm.bg.ac.rs	Serbian	March 5, 1994

Education

degrees, universities, and dates

MSc Physical Chemistry, University of Belgrade, Jun 2018

BSc Physical Chemistry, University of Belgrade, September 2017

Employment

employers, positions, and dates

Institute for Chemistry, Technology and Metallurgy – ICTM, PhD student, Oct 2018-present

Rajamangala University of Technology Phra Nakhon, Bangkok, Thailand, exchange student, July 2018 – Sept 2018

Research

brief description of past and current research and the field(s) of specialization

Gas, strain, capacitive, and respiration sensors made of graphene.

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

Production and testing of fast sensors based on graphene, for respiration monitoring.

Role/Activity

Please describe the project-specific role and activity(ies) you will undertake

Fabrication and testing of sensors for human health parameter monitoring

Period of Involvement (estimated)

The period/dates for which you will be involved and receive a stipend

Month 6 – month 18

Publications

up to three recent publications relevant to this project plan

1.
2.
3.

Honours

awards, fellowships, professional societies, etc.

Emerging Security Challenges Division

Science for Peace and Security Programme

Curriculum Vitae

Family Name	First Name	Title	Job Title
Koteska	Bojana	Dr	Assistant professor

Institution	Address	Country
University Ss. Cyril and Methodius, Faculty of Computer Science and Engineering, Skopje	Rugjer Boshkovikj, 16, 1000, Skopje	N.Macedonia

Telephone	Fax	Email	Nationality	Date of Birth
+38975388556		bojana.koteska@finki.ukim.mk	Macedonian	21.10.1988

Education

degrees, universities, and dates

PhD in Computer Science 2012–2018 Faculty of Computer Science and Engineering, University of "Ss. Cyril and Methodius", Skopje, Macedonia

Master of Science, 2011-2012 Faculty of Computer Science and Engineering, University of "Ss. Cyril and Methodius", Skopje, Macedonia

Bachelor of Science, 2007-2011, Faculty of Computer Science and Engineering, University of "Ss. Cyril and Methodius", Skopje, Macedonia

Employment

employers, positions, and dates

- Faculty of Computer Science and Engineering, University of "Ss. Cyril and Methodius", Skopje, Macedonia, Assistant Professor, 2018-present
- Faculty of Computer Science and Engineering, University of "Ss. Cyril and Methodius", Skopje, Macedonia, Assistant Doctorand, 2017-2018
- Faculty of Computer Science and Engineering, University of "Ss. Cyril and Methodius", Skopje, Macedonia, Lab Assistant, 2011-2017
- Faculty of Natural Science and Informatics, University of "Ss. Cyril and Methodius", Skopje, Macedonia, Lab Assistant, 2009-2011

Research

brief description of past and current research and the field(s) of specialization

- Modeling and simulations
- Scientific computing
- Databases
- Software engineering
- Signal processing

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

(i) Participation in project: "NI4OS Europe" funded by Horizon 2020 – Faculty of Computer Science and Engineering

(ii) Participation in project: Real-time spectroscopy to optimize yield by soil nutrient monitoring, Faculty of Electrical Engineering, University in Ljubljana, Slovenia.

(iii) Participation in project: GLUCO: Non-invasive solution for measurement and monitoring of the glucose level of patients. Innovation DOOEL, Skopje, North Macedonia

(iv) Participation in project: PRE-FETCH - Pro-active Memory Management with Page Faults Prediction in Cloud, Bilateral project with Austria, Faculty of Computer Science and Engineering, Skopje, N. Macedonia

(v) Participation of project: ECG2BP, Faculty of Computer Science and Engineering, Skopje, North Macedonia

(vi) Coordination of project: SQISOFT-QUE, Faculty of Computer Science and Engineering, Skopje, North Macedonia

Role/Activity

Please describe the project-specific role and activity(ies) you will undertake

- Dissemination of the knowledge through workshops on scientific conferences
- Review of existing similar system and identification of system interoperability requirements, review state of the art

- Development of operator side infrastructure (database application server, interface, alarming)

Period of Involvement (estimated)

The period/dates for which you will be involved and receive a stipend

36 Months

Publications

up to three recent publications relevant to this project plan

4. Marjan Gusev, Lidija Poposka, Gjoko Spasevski, Magdalena Kostoska, Bojana Koteska, Monika Simjanoska, Nevena Ackovska, Aleksandar Stojmenski, Jurij Tasic, Janez Trontelj. “Non-invasive Glucose Measurement using Machine Learning and Neural Network Methods, and Correlation to Heart Rate Variability”. In: Journal of Sensors, 2019, accepted. JCR Impact Factor 3.03.
5. Natasa Koceska, Radko Komadina, Monika Simjanoska, Bojana Koteska, Andrej Strahovnik, Anton Jost, Rok Macek, Ana Madevska-Bogdanova, Vladimir Trajkovik, Jurij Franc Tasic, and Janez Trontelj. “Mobile wireless monitoring system for prehospital emergency care”. In: European Journal of Trauma and Emergency Surgery (2019). ISSN:1863-9941. DOI: 10.1007/s00068-019-01130-4. URL:https://doi.org/10.1007/s00068-019-01130-4, JCR Impact Factor 1.781.
6. Monika Simjanoska, Bojana Koteska, Ana Madevska Bogdanova, Nevena Ackovska,Vladimir Trajkovik, and Magdalena Kostoska. “Automated triage parameters estimation from ECG”. In: Technology and Health Care 26.2 (2018), 387–390, JCR Impact Factor 0.724

Honours

awards, fellowships, professional societies, etc.

- “Engineering ring” award for best student at Faculty of Computer Science and engineering received from Engineering Institution, N. Macedonia.
- “Golden coin” award received from University Ss. Cyril and Methodius, Skopje, N. Macedonia
- Stipend received from Ministry of Education and Science, N. Macedonia.
- Reward from Ministry of Education for impact factor paper.

Emerging Security Challenges Division

Science for Peace and Security Programme

Curriculum Vitae

Family Name	First Name	Title	Job Title
Kostoska Gjorcevska	Magdalena	Dr	Associate professor

Institution	Address	Country
University Ss. Cyril and Methodius, Faculty of Computer Science and Engineering, Skopje	Rugjer Boshkovikj, 16, 1000, Skopje	N.Macedonia

Telephone	Fax	Email	Nationality	Date of Birth
+38970531640		magdalena.kostoska@finki.ukim.mk	Macedonian	06.10.1982

Education

degrees, universities, and dates

PhD in Computer Science 2014 Faculty of Computer Science and Engineering, University of "Ss. Cyril and Methodius", Skopje, N. Macedonia

MSc in computer science – software engineering, 07.04.2010, Faculty of Natural Sciences and Mathematics, Institute of Informatics, Univ. Sts Cyril and Methodius, R.N. Macedonia

Engineer in computer science, 30.10.2006, Faculty of Natural Sciences and Mathematics, Institute of Informatics, Univ. Sts Cyril and Methodius, R. N.Macedonia

Employment

employers, positions, and dates

- Faculty of Computer Science and Engineering, University of "Ss. Cyril and Methodius", Skopje, Macedonia, Associate Professor, 2019-present
- Faculty of Computer Science and Engineering, University of "Ss. Cyril and Methodius", Skopje, Macedonia, Assistant Professor, 2014-2019
- Faculty of Computer Science and Engineering, University of "Ss. Cyril and Methodius", Skopje, Macedonia, Research and Teaching Assistant, 2010-2014
- Faculty of Natural Sciences and Mathematics, Institute of Informatics, University of "Ss. Cyril and Methodius", Skopje, Macedonia, Junior Research and Teaching Assistant, 2007-2010
- Faculty of Natural Sciences and Mathematics, Institute of Informatics, University of "Ss. Cyril and Methodius", Skopje, Macedonia, Lab Assistant, 2005-2007

Research

brief description of past and current research and the field(s) of specialization

- Cloud and edge computing
- Software engineering
- Distributed computing

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

(vii) Participation in project: GLUCO: Non-invasive solution for measurement and monitoring of the glucose level of patients. Innovation DOOEL, Skopje, North Macedonia

(viii) Participation in project: PRE-FETCH - Pro-active Memory Management with Page Faults Prediction in Cloud, Bilateral project with Austria, Faculty of Computer Science and Engineering, Skopje, N. Macedonia

Role/Activity

Please describe the project-specific role and activity(ies) you will undertake

- Dissemination of the knowledge through workshops on scientific conferences
- Review of existing similar system and identification of system interoperability requirements, review state of the art
- Development of operator side infrastructure (database application server, interface, alarming)

Period of Involvement (estimated)

The period/dates for which you will be involved and receive a stipend

36 Months

Publications

up to three recent publications relevant to this project plan

1. Marjan Gusev, Lidija Poposka, Gjoko Spasevski, Magdalena Kostoska, Bojana Koteska, Monika Simjanoska, Nevena Ackovska, Aleksandar Stojmenski, Jurij Tasic, Janez Trontelj. “Non-invasive Glucose Measurement using Machine Learning and Neural Network Methods, and Correlation to Heart Rate Variability”. In: Journal of Sensors, 2019, accepted. JCR Impact Factor 3.03.

2. Gusev M.; Koteska B.; Kostoska M.; Jakimovski B.; Dustdar S.; Scekic O.; Rausch T.; Nastic S.; Ristov S.; Fahringer T.; A Deviceless Edge Computing Approach for Streaming IoT Applications, IEEE Internet Computing,23,1,37-45,2019,IEEE Impact Factor 1.521

3.Monika Simjanoska, Bojana Koteska, Ana Madevska Bogdanova, Nevena Ackovska,Vladimir Trajkovik, and Magdalena Kostoska. “Automated triage parameters estimation from ECG”. In: Technology and Health Care 26.2 (2018), 387–390, JCR Impact Factor 0.72

Honours

awards, fellowships, professional societies, etc.

- IEEE and IEEE Computer Society Member
- Macedonian Computer Society

Emerging Security Challenges Division

Science for Peace and Security Programme

Curriculum Vitae

Family Name	First Name	Title	Job Title
Simjanoska	Monika	Dr	Assistant professor

Institution	Address	Country
Faculty of Computer Science and Engineering, Ss. Cyril and Methodius University - Skopje	Rugjer Boshkovikj 16, Skopje	N.Macedonia

Telephone	Fax	Email	Nationality	Date of Birth
+38976472195		monika.simjanoska@finki.ukim.mk	Macedonian	18.10.1988

Education

degrees, universities, and dates

PhD in Computer science 2014–2019 Faculty of Computer Science and Engineering, Ss. Cyril and Methodius University, Skopje, Macedonia

Master of Science, 2012-2013, Faculty of Computer Science and Engineering, Ss. Cyril and Methodius University, Skopje, Macedonia

Bachelor of Science, 2007-2012, Faculty of Natural Sciences and Mathematics, Ss. Cyril and Methodius University, Skopje, Macedonia – Skopje, Macedonia

Employment

employers, positions, and dates

- Faculty of Computer Science and Engineering, Ss. Cyril and Methodius University, Skopje, Macedonia, Assistant professor, 2019 - present
- Faculty of Computer Science and Engineering, Ss. Cyril and Methodius University, Skopje, Macedonia, Teaching assistant, 2017 - 2019
- Faculty of Informatics, “Goce Delchev” University, Shtip, Macedonia, Teaching assistant, 2017 - 2017

Research

brief description of past and current research and the field(s) of specialization

- Machine Learning
- Artificial Intelligence
- Bioinformatics
- Biomedical signal processing
- Biosensors
- Robotics
- Microprocessor systems

Current Research Activities

titles of ongoing activities; please give the names and institutions of any international collaborators

(ix) Participation in project: Real-time spectroscopy to optimize yield by soil nutrient monitoring, Faculty of Electrical Engineering, University in Ljubljana, Slovenia.

(x) Participation in project: GLUCO: Non-invasive solution for measurement and monitoring of the glucose level of patients. Innovation DOOEL, Skopje, North Macedonia

(xi) Coordinator of project: ECG2BP, Faculty of Computer Science and Engineering, Skopje, North Macedonia

(xii) Participant in project: SCISOFT-QIE, Faculty of Computer Science and Engineering, Skopje, North Macedonia

Role/Activity

Please describe the project-specific role and activity(ies) you will undertake

- System mock-up design and detailed definition of the overall system;
- Evaluation of user’s experiences with the model using predefined questionnaires
- Workshops and meetings to coordinate and unify methodological approaches; invitation of experts in the relevant topics of the project to these meetings is planned

Period of Involvement (estimated)

The period/dates for which you will be involved and receive a stipend

36 Months

Publications

up to three recent publications relevant to this project plan

7. Monika Simjanoska, Stefan Kochev, Jovan Tanevski, Ana Madevska Bogdanova, Gregor Papa, Tome Eftimov, Multi-level information fusion for learning a blood pressure predictive model using sensor data, Information Fusion, (2019), ISSN 1566-2535, https://doi.org/10.1016/j.inffus.2019.12.008. **JCR Impact Factor: 10.716**
8. Natasa Koceska, Radko Komadina, Monika Simjanoska, Bojana Koteska, Andrej Strahovnik, Anton Jost, Rok Macek, Ana Madevska-Bogdanova, Vladimir Trajkovik, Jurij Franc Tasic, and Janez Trontelj. "Mobile wireless monitoring system for prehospital emergency care". In: European Journal of Trauma and Emergency Surgery (2019). ISSN:1863-9941. DOI: 10.1007/s00068-019-01130-4. URL: https://doi.org/10.1007/s00068-019-01130-4, **JCR Impact Factor: 1.7181**
9. Monika Simjanoska, Martin Gjoreski, Matjaž Gams, and Ana Madevska Bogdanova. Non-invasive blood pressure estimation from ECG using machine learning techniques. Sensors, 18(4):1160, (2018), **JCR Impact Factor: 3.031**

Honours

awards, fellowships, professional societies, etc.

- 2019 Faculty of Electrical Engineering, University of Ljubljana, Slovenia (Research at Laboratory for Microelectronics)
- 2016 - 2018 Internship at "Institute Jozef Stefan", Ljubljana, Slovenia (Biomedical Signal Processing)
- 2016 University College of Dublin, Ireland (Short Term Mission Stay within COST Action TD1405 European Network for the Joint Evaluation of Connected Health Technologies (ENJECT)
- 2015 Maison Jean Kuntzmann, Université Grenoble Alpes, Grenoble, France (Grant for COST IC1205 Summer School on Fair Division)
- 2014 FESTO Young Researchers and Scientists Support Scholarship, Vienna, Austria
- 2014 Best Paper Award, 25th DAAAM International Symposium, Vienna, Austria

Acceptance by NPD Institute of Management of SPS Funds

please include here the completed Acceptance by NPD Institute of Management of SPS Funds

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NATO internal use

SPS:

Emerging Security Challenges Division

Science for Peace and Security Programme

Multi-Year Project (MYP) Application

Acceptance by NPD Institute of Management of SPS Funds

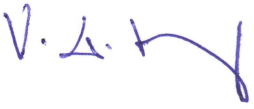
NATO Emerging Security Challenges Division, SPS Programme, Bd. Léopold III, B-1110 Brussels, Belgium
This form must be completed and submitted as **Attachment 2** of the MYP Application, without which the application is null and void.

Agreement for Receipt and Management of SPS Project Funds

*signatures of the lead NATO country Project Director, Head of Institution, **and/or** Financial Authority*

We agree with the proposed SPS Multi-year Project and acknowledge the grant terms set out in the SPS MYP Management Handbook.

We confirm that, if awarded, we will be in a position to accept and manage NATO SPS Funds within the NATO approved budget.

Name	Role (e.g. NPD, Head of Institution, Financial Authority, etc).	Institution Name and Address	Signature
Assoc. Prof. RNDr. Viktor Witkovský, PhD.	**Director of the Institute**	**Institute of Measurement Science, Slovak Academy of Sciences, Dúbravská cesta 9, 841 04 Bratislava, Slovakia**	

Intellectual Property Rights Agreement (or waiver)

please include the IPR agreement (or a waver) here

Will be signed later.

Institutional Overviews

Please insert overviews of the participating institutions

Institute of Measurement Science, Slovak Academy of Sciences, Bratislava (IMS)

IMS (http://www.um.sav.sk) is oriented to basic research in measurement science and mathematical methods for processing of measured data. It is concentrated to research and development of new methods and systems for measurement in biomedicine and material science. The Institute also offers advisory and expert services related to its research activities, performs postgraduate education, publishes the on-line journal Measurement Science Review and organizes national and international conferences.

The research activities of the Institute are organized within 5 scientific departments: Department of Theoretical Methods, Department of Optoelectronic Measuring Methods, Department of Magnetometry, Department of Imaging Methods and Department of Biomeasurements. In last few years it participated in several EU FP and COST projects, projects supported from EU structural funds, and numerous international and national projects. Currently it is involved in 3 COST projects oriented to use of electromagnetic fields (EMF) in biomedical applications, CT and NMR imaging, and 5 bilateral projects with Japan, Belgium, Austria and Czech Republic devoted to optical measuring methods for nanoelectronics, HT superconductors, MRI, and interaction of EMF with biological tissues. The Institute also coordinates 11 national projects aimed at measurements in biomedicine and material science and is a part of the "University research park Biomedicine, Bratislava" built from the EU structural funds.

With respect to the proposed NATO project there is a long term experience in the Department of Biomeasurements specifically oriented to new measurement technologies and model-based diagnostics of the cardiac electrical activity. Recently this research was supported by two grants from the national grant agency APVV ("Measuring, communication and information systems for monitoring of the cardiovascular risk in hypertension patients", "Noninvasive localization of ectopic arrhythmias of heart ventricles using ECG mapping and its use for causal therapy") and two grants from the VEGA grant agency ("Methods and systems for multichannel measurement and evaluation of bioelectric signals of the heart and brain", "Methods and systems for measurement, displaying and evaluation of the cardiac electrical field at hypertension and hypertrophy".

Universite Libre of Brussels (ULB)

ULB (https://www.ulb.be/en/ulb-homepage), with its central location in Europe, is a multicultural University that offers 40 undergraduate programs and 235 graduate programs. With more than 1600 PhD in progress, ULB is an active member in the Research area that is involved in 130 projects supported by the 7th European Framework Programmes. Among the different laboratories, the Department of Physical-Chemistry of the Faculty of Engineering has many collaboration projects in the field of physics of multi-scale, multi-phase and multi-component fluid systems with a particular emphasis on the processes of heat and mass transfer through fluid interfaces. Collaborations with the European Space Agency represent one of the core activities of the laboratory microgravity applications.

New collaborations have been instituted on sensing platforms based on stretchable biopolymers for biomedical applications. Besides the standard chemical bench facilities, including a chemical hood, the laboratory is equipped with manufacturing tools for rapid prototyping: 3D printer, CO2 engraver Laser, bench cutter. It also offers the software resources for designing and modelling both flow and mechanical parts. The Department, headed by Professor F. Dubois, has the required staff (2 professors, 4 researcher managers, about 20 researchers, 1 administrative and 1 technician) to carry out large projects.

University "Ss Cyril and Methodius", Faculty of computer science and engineering (FCSE)

FCSE (http://www.ukim.edu.mk/en_struktura_contact.php?inst=48) has been and currently is part of several international and a lot of national R&D projects. In the recent past, FCSE was actively

involved in 20 international projects, and +40 national projects. We present only two of the current projects where FCSE is involved.

FSCE was a part of the NATO project - Science for Peace and Security – SIARS (Smart I (eye) Advisory Rescue System) SfP 984753, 2015-2018. SIARS is about modelling, developing and integration with selected existing Information Systems of a new state-of-the-art telemedical Information Systems that will allow saving more injured patients and lessen the death-rate on the battlefields. The system will be consisted of mobile device that will help the life-savers on the battlefield, gather and organize the medical data of the injured patients, use the satellite connection to transfer the data to the designated medical facility that will take medical care of the injured person.

FCSE (local coordinator Marjan Gusev, PhD) is one of the 18 partners for FP7 project – Future Policy Modeling, FUPOL, 2011-2015, Austria, Croatia, China, Cyprus, France, Republic of North Macedonia, Germany, Kenya, Latvia, Romania, Spain, UK. Objective of the project is to build an integrated governance model for cities based on social media policy simulation and related IT tools. FUPOL will automatically collect, analyze and interpret opinions expressed on a large scale from the Internet, it provides innovative tools to shape the wealth of information coming from the Internet.

FCSE is awarded with another FP7 project 2014-2017: MAESTRA - Learning from Massive, Incompletely annotated, and Structured Data, FP7 FET Open Xtrack, grant no. ICT-2013-612944 (local coordinator Ivica Dimitrovski, PhD). The need for machine learning (ML) and data mining (DM) is ever growing due to the increased pervasiveness of data analysis tasks in almost every area of life, including business, science and technology. The project will develop predictive modelling methods capable of simultaneously addressing several (ultimately all) of the above complexity aspects. Some of these applications, such as relating the composition of microbiota to human health and the design of social media aggregators, have the potential of transformational impact on important aspects of society, such as personalized medicine and social media.

The Institute for Chemistry, Technology and Metallurgy in Belgrade (ICTM)

ICTM (https://147.91.79.142/en/members/institutes/chemestry-technology-metallurgy.php) is the oldest scientific institution in the country, established in 1859 as the State Chemical Laboratory. Having undergone several transformations, ICTM now consists of seven departments performing a broad span of research in chemistry and material science. The institute employs more than 200 people, of whom 150 are research staff. In 2018 ICTM became one of only five National Institutes, which is a title of highest ranking awarded by a special decree of the government.

The Centre for Microelectronic Technologies (CMT) is a multidisciplinary department with research geared towards fundamental discovery and applications in the fields of sensors, microelectromechanical systems (MEMS), nanoscience and nanotechnology, photonics and plasmonics, as well as semiconductor science and technology. Having developed sensing components from theory to packaging, CMT deployed its sensors to customers in several industries, including gas and oil transportation and electrical power generation. Most recently, since the arrival of the PPD, graphene has become a material of interest with applications in all research directions of the CMT. In particular, graphene microphones and applications of liquid-phase-exfoliated graphene to chemical sensors have gained momentum and ICTM has joined the Graphene Flagship FET project as Associate Member. CMT employs about 25 research staff, supported by mechanical, software, and electronics technicians, with access to SEM, AFM, FTIR and UV-VIS spectroscopy, direct laser writing and accompanying lithography toolset, thermal silicon oxidation, a Langmuir-Blodgett trough, chemical wet benches and fume hoods, and various environmental chambers and testing equipment for chemical, temperature and pressure sensors.

Faculty of Medicine in Bratislava, Comenius University in Bratislava (FM)

The Faculty of Medicine (https://www.fmed.uniba.sk/en/), which has been developing since 1919, is the first and founding faculty of the Comenius University in Bratislava. The Faculty of Medicine in Bratislava is the largest and oldest medical faculty in Slovakia. From the beginning, the Faculty of Medicine was focused on two tightly interconnected activities, education and research. In 1921 there was established a scientific medical journal Bratislava Medical Journal (Bratisl Lek Listy), which has been published so far as the oldest medical journal in Slovakia. In the last decade, the research at the Faculty of Medicine is focused on

four main research areas: neuroscience, cardiovascular diseases, oncological diseases, metabolic, endocrine, and inflammatory diseases.

Neuroscience research has a long tradition at the Faculty of Medicine. Whereas in the past research was focused mainly on investigation of axonal transport and morphological features of nerve tissue, recently is represented by investigation of optimal therapy of cerebral gliomas, etiopathogenesis of neurodegenerative diseases, multiple sclerosis, depression and other disease.

In the field of cardiovascular disease, research at Faculty of Medicine in Bratislava is focused mainly on investigation of etiopathogenesis of hypertension, heart failure and vessels diseases. Original data were obtained from experiments investigating mechanisms of heart failure and remodeling in cardiovascular system.

Oncological research if currently focused on investigation of etiopathogenesis of mammary, urological, and other malignancies. Outstanding findings were obtained in the research focused on the role of circulation tumor cells.

Traditionally, in metabolic, endocrine, and inflammatory diseases research at Faculty of Medicine in Bratislava is focused on investigation of etiopathogeneis of diabetes mellitus, osteoporosis, thyroid diseases, rheumatoid arthritis, sepsis, and other immune diseases.

In respect to this proposal the medical experts from emergency medicine clinics of the medical faculty will be involved into the project.

Recently the research was supported by several VEGA grants, grants from national grant agency APVV an from Ministry of Health of the Slovak Republic.

End User Commitments

Please include commitments or letters of interest from the End-Users

FlexEnable
Truly flexible electronics

To: Dr. Carlo Saverio Iorio
Universite Libre de Bruxelles
Microgravity Research Center
Dept. Chimie-Physique E.P. CP 165/62
Avenue P. Heger Bat. UD3 1050

Date 20/02/2020

RE: Smart Patch for Life Support Systems (SP4LIFE)

To whom it may concern,

This letter is written in support of the international project "Smart Patch for Life Support Systems (SP4LIFE)" within the framework of NATO's Science for Peace and Security program.

Flexenable has developed the world's first truly flexible transistor technology platform; the key to cost effective electronics over large and small surfaces. The company's proven technology platform enables customers to create compelling flexible electronic products and to manufacture them in volume. Combining stable, high performance organic t hin film transistors (OTFT) with passive elements, Flexenable's platform is the perfect toolkit of electronic components for enabling new mobile and wearable products as well as sensor arrays and structural elect ronics that bring an extra dimension to the loT (Internet of Things). The company has demonstrated a number of world firsts, including fully flexible electrophoretic displays, flexible active matrix OLED displays and conformed organic liquid crystal displays (OLCD). Flexenable has also demonstrated a range of optical, biometric and gas sensors.
The success of this application allow FlexEnable to develop its expertise and address the technical issues around the fabrication of the devices but also introduce FlexEnable to the consortium of leading experts in health sector in order to develop collaborative opportunities.

Therefore we fully support this enterprise, and we will follow its progress closely.

Sincerely

Guillaume Fichet,
Program Manager

MJR PharmJet GmbH | Industriestraße 1B | 86902 Überherrn

MJR PharmJet GmbH

Contact person
Dr. Nazende Günday Türeli
Phone.: +49 6836 9691-176
Fax: +49 6836 9691-199
E-Mail: n.guenday@mjr-pharmjet.com

Date 20/02/2020

Lol: Smart Patch for Life Support Systems (SP4LIFE)

To whom it may concern,

This letter is written in support of the international project "Smart Patch for Life Support Systems (SP4LIFE)" within the framework of NATO's Science for Peace and Security program.

MJR Pharmjet GmbH is not only highly interested in the topics addressed by this highly qualified team but also believe that this project will enable strong networking possibility with the partners involved from Belgium, Slovakia, North Macedonia and Serbia.

MJR Pharmjet GmbH will follow the developments of the project and provide our assistance, whenever required. We believe that output of this project will also contribute to MJR's vision and will enable us following the recent developments in the area.

Sincerely

Dr. Nazende Günday Türeli
R&D Team Leader

Ministry of the Interior of the Slovak Republic
Fire and Rescue Corps
Drieňová 22
826 86 Bratislava
Slovak Republic

Bratislava, October 24th, 2019

Dear Mr. Tyšler,

The FRC expresses full support and interest in involment in the proposet NATO Science for Peace and Security programme project: ***„SP4LIFE - Smart Patch for Life Support Systems".***

The FRC is willing to participate as an active end user of the project outcomes. Involvement will be in the following areas:

- *definition of use-case related to management victims after terrorist attacks;*
- *process and system definition from emergency service requirements with respect to effective management of terrorist attack consequences;*
- *cooperation in system testing and evaluation.*

Realisation of the project´s objective - „improving the activities after terrorist attack related to management of wounded victims", will increase the chance of their survival. The expertise and the experience of the FRC officers will help the development of the proposed project activities.

Sincerely,

plk. Ing. Pavol Nereča
president
of the Fire and Rescue Corps

Mr.
Ing. Milan Tyšler, PhD.
Institute of Measurement Science
Slovak Academy of Science
Dúbravská cesta 9
Bratislava

SPS:

Science for Peace and Security Programme
Multi-Year Research Project

Smart Patch for Life Support Systems (SP4LIFE)

please limit this summary to four pages

SPS Key Priorities	Project Duration
1) Facilitate mutually beneficial cooperation on issues of common interest, including international efforts to meet emerging security challenges a) Counter-Terrorism iv) Risk management, best practices and technologies in response to terrorism. i) Methods for the protection of critical infrastructure, supplies and personnel ii) Human factors in the defence against terrorism d) Defence against CBRN Agents iii) Medical countermeasures against CBRN agents.	**36 monts**

Title and Name	Institution	Country	NPD/PPD/ Co-Director/Other
Assoc.prof. Dr. Milan Tyšler	**Institute of Measurement Science, Slovak Academy of Sciences (IMS)**	**Slovakia**	**NPD**
Dr. Marko Spasenović	**Institute for Chemistry, Technology and Metallurgy, Centre for Microelectronic Technologies (ICTM)**	**Serbia**	**PPD**
Dr. Carlo Saverio Iorio	**Universitè libre de Bruxelles (ULB)**	**Belgium**	**Co-Director**
Dr. Ana Madevska Bogdanova	**Faculty of Computer Sciences and Engineering, Sts Cyril and Methodius (FCSE)**	**North Macedonia**	**Co-Director**
MD PhD. Oto Masár	**Faculty of Medicine in Bratislava, Comenius University in Bratislava (FM)**	**Slovakia**	**Co-Director**

NATO Funding Requested (ceiling)	
Equipment	€272760
Training/Stipends	€133200
Implementation	€84300
NATO Total Ceiling	**€490000**
Non-NATO Funding	€714500

Project Goals

*describe briefly the goals of this Project and **how it addresses one or more of the SPS Key Priorities***

The objectives of the project are to:

- Develop wearable monitoring platforms with: a.) sensitive respiration, heartbeat and auditory sensors based on graphene, and b.) ECG, SpO2, BP and body temperature sensor modules,
- Create a biocompatible wearable body-sensing interface hosting electronics, alarm, low-power transmission for light-weight, portable applications
- Create a software that will generate alert in real time, at the moment of critical physiological parameter changes or changes of the triage medical status according to START algorithm,

- Use Artificial Intelligence to create unsupervised software capable of real-time diagnostics and rapid countermeasures' selection,
- Analyze existing (AS-IS) processes and consider their re-design (TO-BE processes) in organization of patient management on the site of accident with respect to wearable monitoring technology being developed,
- Create a network of young scientists training in soft and hard skills in the wearable electronics for biomedical applications.

Deliverables

detail the project deliverables, scientific and technical as well as in terms of partnership

The main project outcomes are:

- Creation of a working prototype of graphene-based sensors with biocompatible interface complying with the mechanical requirement of stretchability, light invasiveness and robustness.
- Tested and operational wearable HW platform for physiological data acquisition and analysis
- Software modules for acquisition, local processing and possible transfer of physiological data
- Software platform to analyse in real time physiological data including the cardiac and respiratory rhythm, and create mathematical models based on Big Data, AI and Deep Learning to connect them with known disorders, for assessment of person's health status change from YtoG and GtoY, and corresponding alarm generation. Organization of the events foreseen for the dissemination and communication campaigns in due time

Partial deliverables include:

ID	Deliverable title	Due Dates	Description
D1.1	Report on the development and testing of the sensing elements	M18	Description of the design, material choice and configuration of the acoustic sensing elements and their testing on acoustic spectra of humans (databases) or digitally synthetized sounds.
D1.2	Report on the biocompatible interface protocol, including mechanical characterization	M12	Description of the manufacturing protocol for the biocompatible interface and its characteristics in terms of mechanical elasticity and robustness
D1.3	White paper on biocompatible materials and their applications in the wearable electronics domain	M18	Reference paper for spreading the SP4LIFE results to stakeholders, oriented to the medical sector
D1.4	Prototype of the sensing elements with body interface	M20	Prototype to be presented at NATO events and DEMO conferences
D2.1	Report on tested sensor modules and their performance.	M12	Description on tested commercial modules and comparison of their suitability for the use with the smart patch
D2.2	Report on possible solutions for computational electronics, transmission protocols and power delivery	M24	Description of the proposed HW solution for the goals of SP4LIFE, its computational parameters, power requirements and transmission protocols
D2.3	Prototype of the full HW sensing platform for demonstration	M30	Presentation of the HW prototype to NATO authorities and in fairies
D2.4	Report on fully integrated HW and SW platform tested in laboratory and field situations (outside laboratory environment)	M36	On-field testing and validation of the complete smart patch prototype
D3.1	Software modules for measurement and local processing of ECG, SpO2 and breathing signals	M18	Set of programs for local processing of selected physiological signals focused on noise and artefacts removal and identification of selected diagnostic parameters
D3.2	Software module for cuffless blood pressure measurement based on measured ECG signal	M24	Software implementation of the original method developed at FCSE
D3.3	Software for extracting information on heart rate and breathing from acoustic signals	M30	Software for AI-based processing of acoustic signals from graphene-based sensors
D3.4	Software modules for physiological data compression and coding.	M36	Software modules facilitating fast and secure data transfer from/to the smart patch
D4.1	Database of vital signs from ECG, SpO2, body temperature	M18	Construction of own database, including more than 3000 ECG signals
D4.2	Transfer function for linking the status of the person and the parameters' space monitored based on unsupervised training and deep learning concepts	M32	Report on the rationale and evidences to model the coupling between the patient status and the monitored signals

D4.3	Software platform to be used as analytical tool for pattern recognition in sensing data.	M24	Presentation of the software platform capable of be trained on existing datasets and predict actual status of the cardiac or respiratory disorders
D4.4	Software implementation of the mathematical models for detection of changes in victims health status	M24	Development mathematical models for GtoY and YtoR alerts
D4.5	Report on existing management information systems in emergency services, description of AS-IS processes of medical response to massive incidents and definition of TO-BE processes with respect to the proposed smart monitoring technology	M30	Description and analysis of existing emergency information systems, description of currently used processes of medical response to massive incidents and definition of proposed processes with respect to the smart monitoring technology
D5.1	Annual report on Communication activities including Recruitment of young researchers	M12 M24 M36	Description of the communication activities and related KPIs
D5.2	Annual report on Dissemination and Communication activities	M12 M24 M36	Description of the dissemination activities and related KPIs
D5.3	Annual report on Exploitation activities	M12 M24 M36	Description of the exploitation activities and related KPIs
D6.1	Progress activity reports, including DCE plans and timeline updates	M12 M24 M36	Report on the implementation of project, re-evaluation of the risks, and planning forward
D6.2	Annual progress reports incl. financial reports	M12 M24 M36	Description of the SP4LIFE progresses and checkpoint for financial activities
D6.3	Final report, including final DCE activities and overall financial report, outlook/plan for the afterlife of the project	M36	Description of the overall achievements of the project, its implementation, as well as the future sustainability

Security Relevance/Impact

describe the relevance of this Project to security and to the SPS Key Priorities cited above

The project addresses the above shown key priorities of the SPS programme tackling with the medical countermeasures and diagnostics in situations inducing life threatening respiratory and cardiovascular disorders such as terrorist attacks, high-stress combat situations or CBRNs release.

Project Impact

describe the likely impact of Project on the field and beyond

Early detection and rapid contrast of physical threats such as the one concerning respiratory and cardiovascular system is inevitably the first line of defence to reduce casualties and increase the safety of operating personnel and civilians. The wearable sensing platform developed in this project will increase the detection and contrast capability of the above-mentioned disorders to at least 90% of reliability in terms of correct disorder classification while reducing the detection time to the order of minutes. Also, a platform having similar characteristics and working principles can help creating a new tool to counteract and remediate in loco and rapidly the effects of the exposure to various critical situations, including terrorist attack or CBRNs releaseone.

End Users

who will ultimately benefit from the research discussed at this Project and its applications

The beneficiaries of this project are various Institutions of NATO members and NATO partner countries. It would have benefits for civilian sector, e.g. medical centres, as well as non-governmental organizations involved in cooperation for development in rural areas. Commercial companies in the biotech sector and wearable electronics show great interest in the achievements of the project. The protocols and assessments generated in the frame of the project can eventually help policy makers in formulating protocols and recommendations in the field of countermeasure and safety against the effects of stress conditions, terrorist attacks and CBRNs exposure.

The end users involved in the project play and important role in guiding the project toward implementation and exploiation of its results:

The **Flexenable, LTD (UK)** has developed the world first flexible platform for transistor technology, OLED and OLCD displays and various biometric sensors. Their expertise will help to solve possible technical issues during

development of the graphene sensors. Their involvement will also help to introduce the project outcomes to leading experts in health care sector and facilitate development of new collaborations for their exploitation.

The **MJR Pharmjet GmbH (GE)** is a provider of analytical and development services namely for pharmaceuticals with a special focus on low soluble substances. They offered assistance namely during development of sensors based on liquid phase exfoliated (LPE) graphene and welcome the possibility to follow the research.

The Fire and Rescue Corps (Slovakia) will be an active end-user during the project activities related to i) Definition of use-cases related to management of victims after terrorist attacks, ii) Process and system definition from emergency service requirements with respect to effective management of terrorist attack consequences, iii) Cooperation in system testing and evaluation. In case of project success, it is the potential user of its results.

Risks

please summarize risks to project execution, both technical and political, and measures foreseen to mitigate them

The evaluation of risks is an important step in assessing the feasibility, success and impact of the project. A correct assessment should take into account not only the impact that unforeseen situations could have on the implementation of the project, but also the probability that those situations will occur.

Given the expertise of the researchers involved and their experience in managing projects at European and international level, the risks associated to the development of the project should be considered not exceeding the normal threshold of typical innovative research projects. Table below summarize the risks that could be spotted at this stage and the appropriate countermeasures foreseen by the partnership.

Risks	Probability	Impact	Nature of the risks	Countermeasures
Problems related to the development of the components of each subsystem	Medium	Medium/High	Technical	Foresee in the design of the components alternative solutions and take advantage of external experts
Difficulties in integrating the different subsystems	Medium	Medium	Technical	Take advantage of the external experts and end users for finding alternative paths
Difficulties in integrating the partners' research results to reach a DEMO Phase	Medium/High	Medium	Technical	Establish a realistic roadmap and integrating subsystems as long as they become available
Representativeness of laboratory experiment respect to field applications	Medium/High	Medium	Technical	Continuous contact with potential End Users Requirements
Delay in the schedule for components and integration	Medium/High	Medium/Low	Technical	Regular meeting (tele-conferences) and continuous "reality check" with advisors. Realistic schedule at the beginning of the project.
Difficulties in Visa procedures	Low	Medium	Political	Coordinate with the partners and foresee enough time in young researchers displacements
Difficulties in recruitment of young researchers	Medium	Medium	Training	Early warning of available vacancies and widespread communication
Delay in keeping pace with the agreed schedules	Medium	Medium	Training	Having regular meetings on the organization/implementation of the training exchange
Conformity of the proposed technical solutions with existing GDPR, health regulation and safety awareness	Medium/High	Medium	Implementation	Take advantage of the Advisors to help match innovative solutions and existing regulations
Conflict between non-civil and commercial applications respect to confidentiality and patenting	Medium	Medium	Implementation	Coordination between NATO officers and End Users on confidentiality and patenting

Related Projects/Duplication

please summarize related or competing projects from the applicants and others and how this project differs and will make a unique contribution

The challenge tackled by this project is of utmost importance in the emergency medical sector especially for rescue teams and victims of various attacks. It is possible, then, to find an important literature on the subject as well as commercial solutions and research and development projects. The partnership conducted a detailed survey of the existing market solutions and of the recent research projects, (we took as a reference the CORDIS database of the EU for the European and international projects while we did a google search for non-European research). In the following, the solutions that are closest to our proposal as well as the steps beyond the state-of-art proposed by SP4LIFE.

Projects	Goals	Status	SP4LIFE specificities
AMON **https://cordis.europa.eu/project/id/IST-2000-25239**	Wrist sensor to monitor and to evaluate heart rhythm, ECG, BP, SpO2, perspiration and body temperature with local expert system and telemonitoring capabilities	2001-2002, closed	SP4LIFE is patch, not wrist oriented and aimed at monitoring vital functions in emergency situations
FRESP **https://cordis.europa.eu/project/rcn/87957/factsheet/en**	Countermeasure to avoid respiratory disorders	2008-2012, closed	SP4LIFE is more oriented to the detection. Countermeasures are calculated based on the real-time results of the Big Data and machine learning software
SAFECITI **https://cordis.europa.eu/project/id/607626/reporting**	Simulation platform for police to predict the behaviour of crowds under specific threats or stresses	2014-2016, closed	SP4LIFE is aimed at monitoring personal vital functions in emergency situations, not crowd behaviour
NATO RAWINTS **http://mrc.ulb.be/project-item/rawints/**	Project dealing with the creation of smart platform to heal and monitor tissue healing	2016-2018, closed	SP4LIFE is aimed at monitoring several vital functions in emergency situations
WISH **https://cordis.europa.eu/project/id/744157**	Wearable Integrated System for Early Detection of Preterm Labour by contraction sensing	2016-2017, closed	SP4LIFE is aimed at monitoring other vital functions in emergency situations
PREPARE **https://cordis.europa.eu/project/rcn/201668/factsheet/en**	To develop the world first purpose designed respiratory monitoring sensor delivering consistent and reliable results	2016-2018, now it is in commercial phase	Respect to Prepare, SP4LIFE will focus also on recording ECG, PPG, BP and sound that provides more information than the simple body movement sensors. Also, SP4LIFE adds AI networks to detect the disorders
WECARMON **https://cordis.europa.eu/project/id/745755**	Create a wearable monitoring system for respiratory and cardiovascular diseases	2017-2020, open	The project is an individual Marie-Curie Action. In contrast to SP4LIFE it is focused on the sensing elements exclusively
LifeCall **https://cordis.europa.eu/project/id/809158**	Mobile, wearable device in shirt, which captures ECG and stores it remotely to share with related parties. Detects cardiac arest	2018, closed	SP4LIFE is aimed at monitoring much more vital functions in emergency situations and AI based evaluation
A3BL **https://cordis.europa.eu/project/rcn/217251/factsheet/en**	Rehabilitation of pulmonary conditions in chronic disorders	2018, closed	SP4LIFE is a complete platform that goes far beyond the sensing and digital transmission by integrating a physical devices, a transmission protocol, and an Artificial Intelligence code.