National Research Programme

„Cyber-physical systems, ontologies and biophotonics for safe&smart city and society" (SOPHIS)

Progress report for period
1.05.2015-31.03.2016

ELEKTRONIKAS UN DATORZINĀTNU INSTITŪTS
INSTITUTE OF ELECTRONICS AND COMPUTER SCIENCE

LATVIJAS UNIVERSITĀTE
ANNO 1919

RĪGAS TEHNISKĀ UNIVERSITĀTE

Latvijas Universitātes
Matemātikas un informātikas institūts

Scientific report for the 2nd period

PART 1 – INFORMATION ON PROGRAM

1.1. Title of the programme: „**Cyber-physical systems, ontologies and biophotonics for safe&smart city and society"**
1.2. Programme acronym: **VPP SOPHIS**
1.3. Programme web page address: **http://sophis.edi.lv/** http://www.edi.lv/en/projekti/vpp-projekti/vpp-sophis/
1.4. Programme principal investigator: **Dr.sc.comp. Modris Greitāns,** +371 67558155, modris_greitans@edi.lv
1.5. Contact person: **Dr.sc.comp. Modris Greitāns** , +371 67558155, modris_greitans@edi.lv.
1.6. Report for a period: **1 May 2015 – 31 March 2016**

1.7. The aim of the programme and objectives:

The goal of SOPHIS is development of the next generation ICT systems focused on solution of tasks crucial for Latvian society related to health, transport, security, bridging of digital gap, effective use of knowledge, as well as contributing to the economy transformation to products and services with high added value. SOPHIS is organized in four projects:
1. „Development of technologies for cyber physical systems with applications in medicine and smart transport";
2. „Ontology-based knowledge engineering technologies suitable for web environment";
3. "BIOPHOTONICS: imaging, diagnostics and monitoring";
4. "Development of technologies for secure and reliable smart-city".
*SOPHIS is implemented by internationally recognized research teams with expertise in NRP and international projects from **IECS, UL FC, UL IAPS, UL IMCS, RTU FCSIT, RTU TI** and **RTU WPL**. The multidisciplinary team is well balanced and contains highly qualified researchers, young scientists, doctoral students and undergraduate students. The cooperation partners from economic sector represent end-users, producers and technology transfer companies. Strategic steering board includes the world-class scientists from the relevant areas as well as leading industry representatives.*
Activities of the programme contain research, technology validation and transfer, investment in education, publicity and technological forecasting. Most significant achievements obtained in the first two periods are:

- *Improved functionality and effectiveness of wireless sensor and data network test-bed;*
- *Mobile body movement monitoring system and its approbation in rehabilitation tasks;*
- *Method for fast answers by different criteria (without programmers assistance) from stored data, i.e. in databases of hospitals;*
- *Method for retrieving the semantics of the natural language for large text blocks;*
- *Training and use of "deep" neural networks for high performance computers;*
- *Advanced technology for data transmission in optical network using Wavelength-division multiplexing approach;*
- *Developed model of water supply system for investigation of detection of pollution.*

These achievements illustrate the potential of research results for bringing them in new products and service, which could be used in different fields of economy, including health, telecommunications, transport, logistics, water supply, security etc.

1.8. Executive summary of the programme

The main activities, fulfilled tasks and achieved results of the projects are summarized in the following tables:

Project 1:

Tasks	Main results
1.Development of cyber-physical systems of smart sensor and their network innovative hardware and software platform: 1.1.First period 1.1.1.Development of experimental prototype of modular platform for embedded systems prototyping, profiling and debugging and evaluation; 1.1.2.Development of testbed for wireless sensor networks. 1.2 Second period 1.2.1 Development, testing, gathering and analysis of experimental data from prototype joint system of modular platform for embedded systems prototyping, profiling and debugging and evaluation; 1.2.2. Integration and work analysis of modular platform prototype system within wireless sensor network testbed	Planned: Experimental prototype; Achieved: Experimental prototype of EDI Testbed adapter was developed (Appendix 1, section 1.2.4.5) Planned: Developed system concept; Achieved: Testbed architecture concept was developed (Appendix 1, section 1.2.4.1.) Additionally: Submitted and published one publication ("EDI WSN TestBed: Multifunctional, 3D Wireless Sensor Network Testbed") Planned: System prototype, Set of software Achieved: Developed a prototype of modula platform for embedded systems prototyping, profiling, debugging and evaluation, as well as the set of supporting software (Appendix 1, section 1.2.4) Planned: System concept validated Achieved: System concpet validated by integrating the prototype of the modular platform system in the wireless sensor network testbed and analyzing its work. (Appendix 1, section 1.2.5)
2.Research and develop conception for use of cyber-physical systems in medical and telemedicine uses: 2.1. First period 2.1.1.Development of smart clothing platform (hardware, architecture and software) for development of easily wearable sensor networks; 2.1.2.Development of approach for data registration and analysis for medical cyber-physical systems. 2.2. Second period 2.2.1.Applications of body sensor network – virtual physical therapy;	Planned: Scientific report of the period Achieved: Scientific report of the period was written (Appendix 1, section 1.3) Additionally: Two experimental prototypes were developed (head position sensor (Appendix 1, section 1.3.4.1) and knee joint sensor for rehabilitation (Appendix 1, section 1.3.4.4). Prepared and publisjed one publication, indexed in SCOPUS database. ("Shape sensing based on acceleration and magnetic sensor system") One conference thesis presented. Planned: Preparation of publications Achieved: Prepared and published one journal publication (SCOPUS, SNIP>1) ("Acceleration and Magnetic Sensor Network for Shape Sensing"), as well as one publication (SCOPUS) ("Smart textiles for wearable sensor networks: review and early lessons")

2.2.2. Development of heart monitoring data gathering and analysis device for cyber-physical systems.	Planned: Mock-up development Achieved: Two mock-up systems developed – a system for head and body position monitoring (Appendix 1, section 1.3.4.3) and a system for heart data registration and analysis (Appendix 1, section 1.3.3.5)
3.Usage of smart sensors in intelligent transport systems: 3.1.First period: 3.1.1.Research of different approaches of data gathering of different types and dimensions about surrounding environment of the transport; 3.1.2.Intelligent transport system communication methods for cooperation between vehicles as well as vehicle to road infrastructure; 3.2. Second period: 3.2.1. Increase of the drivers' field of vision through monitoring, interpreting and reacting to the environment and using 3D and 2D image processing and generation methods; 3.2.2. Development of communication methods between intelligent transport systems, both standalone vehicles and specific road infrastructure;	Planned: Preparation of publication Achieved: Prepared and published a publication indexed in SCOPUS database ("RGB-D-T based Face Recognition") Planned: Scientific report of the period Achieved: Scientific report of the period was written (Appendix 1, section 1.4) Additionally: Prepared and published three additional publications, of which two more are indexed by SCOPUS ("Face recognition system on Raspberry Pi", "A Realistic Evaluation and Comparison of Indoor Location Technologies: Experiences and Lessons Learned" and "Development of 802.11p Testbed – Experiences"). One conference thesis presented. Planned: Preparation of publications Achieved: Prepared and published one publication, which is indexed by SCOPUS ("Complex matched filter for line detection")

Project 2:

Work tasks	Achieved
1. Development of ontology-, web technology- and controlled natural language-based fast ad-hoc query language that will be directly usable by domain experts (without involvement of the programmer.	Planned: Prepared scientific publication Achieved: Prepared scientific publication (see in Section 2.2.3 [1])
2. Approbation in medical domain (CCUH) of ontology-, web technology- and controlled natural language-based fast ad-hoc query language that will be directly usable by domain experts (without involvement of the programmer).	Planned: Approbation review Achieved: Approbation in CCUH – description in Annex 2, Section 2.1.7
3. Development of the theoretical background for the implementation of distributed ontology- and web technology-based controlled natural ad-hoc query	Planned: Prepared scientific publication or scientific review Achieved: scientific review in Annex 2, Section 2.1.8

language parallel execution.	
4. Further development of C6.0 classification algorithm and joining the international scientific research initiatives.	Planned: Prepared a scientific publication or prepared H2020 project application Achieved: **Prepared and won an H2020 project application (SUMMA) for H2020-ICT-16 BigData-research call.** Prepared scientific publications (see in Section 2.2.3 [2-3])
Research of competitive technologies for semantic graph parsing based on SemEval-2015 competition, and integrating them in semantic analysis toolchain for Latvian language, as used in LETA and elsewhere.	Planned: An enhanced version of the toolkit Achieved: An enhanced version of the toolkit was approbated in news agency LETA – description in Annex 2, Section 2.1.10
5. The extension of I4S functionality to evaluate the functional state of complex industrial control systems on the basis of their automated analysis.	Planned: Prepared scientific publication Achieved: Prepared scientific publications (see in Section 2.2.3 [4-6])
6. Development of approaches and methods for identification of knowledge structure and process compatibility.	Planned: Prepared scientific publication or scientific review Achieved: Prepared scientific publications (see in Section 2.2.3 [9-13]
7. Analysis of the related studies and researches that are necessary to define the basic steps of the Semantic Web service development methodology.	Planned: Prepared scientific publication or scientific review Achieved: Prepared scientific publications (see in Section 2.2.3 [14-17]
8. Development of technologies for large scale NoSQL data base exploration and visualization.	Planned: Prepared scientific publication Achieved: Prepared scientific publications (see in Section 2.2.3 [18-19]
9. Business process runtime verification.	Planned: Prepared scientific publication or scientific review Achieved: scientific review in Annex 2, Section 2.3.2

Project 3:

Work tasks	Achieved
1. Performing experimental measurements of the approbation of new imaging technology in laboratory conditions: 1.1. to acquire the several spectral images from a digital color image data. 1.2. for contactless monitoring of cardiac and circulatory parameters at near infrared spectral range. 1.3. for imaging of tissue moisture distribution at near infrared range (1-2 microns)	Planned: 3 conference reports and three publications of the experimental results. Reached: 3 prototype devices developed, 3 algorithms developed. Laboratory and clinical experimentl data were analyzed and described (Appendix No. 3). The study results presented at 5 international conferences and reported in 3 scientific articles, 2 of which are indexed in the database SCOPUS
2. Developing, installing and test the improved software for skin multimodal imaging by the prototype device "SkImager"	Planned: Improved prototype device Achieved: made improvements on mechanical and electronic part of prototype device "SkImager" and the improvements of the software.

Project 4.

Tasks	Results
1. Acquisition and analysis of large scale urban video and other signals using high performance computing (HPC) resources.	
1.1. Concept development for multicamera video processing and automatic analysis of the security situation.	Planned: System concept developed. Achieved: Presented in Appendix no.4 (section 4.2.)
1.2. Sample implementation of Deep Neural Network for two object classes on the EDI CUDA HPC server	Planned: HPC program. Achieved: software for HPC developed classifying marked images using Deep Learning.
2. Investigation of possibilities to use remote sensing (RS) data for solving city security tasks. 2.1. Selection of city security tasks. 2.2. Relevant satellite data selection and obtaining. 2.3. Literature studies of RS data processing methods. 2.4. Selection of parameters to be controlled for city monitoring. 2.5. Adjustment of UAV- based RS data acquisition system to city monitoring 2.6. Classification of land cover using data from different sensors 2.7. Vegetation mapping and change detection from satellite images 2.8. Ground elevation model development from LIDAR data	Planned: Interim scientific report. Achieved: Presented in Appendix no.4 (section 4.3.) Planned: Prepared publication. Achieved: article "Selection of informative spectral bands for classification of hyperspectral images" is under preparation. Planned: Master theses defended. Achieved: M.Puķītis defended Master theses "Application aspects of multidimension distributions for the analysis of multispectral images" on June 8, 2015.
3. Studies of ultra wideband (UWB) radar sensor application to city security monitoring: 3.1. Studies of (UWB) radar sensor application to room security systems. 3.2. Acquisition and processing of remote sensing data from thermal, visible light and multispectral sensors. 3.3. Indirect estimation of material parameters (thickness, conductivity, dielectric permeability) of using the pulse radar method: Ice thickness detection experiments and data processing. 3.4. Research of the signal processing methods for detection of changes and object movement in rooms. 3.5. Development of UWB radar sensor modules.	Planned: Interim scientific report; Achieved: Presented in Appendix no.4 (section 4.4.) Planned: 3 bachelor theses defended. Achieved: 3 bachelor theses defended in June 2015 (Maija Lielpinka, Ivars Mauriņš, Mārtiņš Abajs) Planned: Experimental mockup of the room security sensor. Achieved: developed, described in Appendix no.4 (section 4.4.) Planned: Scientific publication. Achieved: 3 publications indexed in SCOPUS.
4. Development of fiber optics transmission (FOT) technologies	
4.1. Analysis of different optical access network topologies, development of an experimental model by mathematical modelling	Planned: Model; Achieved: described in Appendix no.4 (section 4.5.)
4.2. Estimation of applicability and development of active optical elements for fiber optic network solutions	Planned: Prepared publication, Achieved: publication submitted and accepted Planned: Developed and submitted patent application Achieved: Patent application prepared and

	submitted.
4.3. Development of new FOT technologies for smart city data transmission	Planned: Presentation Achieved: presented in conference PIERS 2015
4.4. The optimal performance of the access network topology creation depending on the data rate, modulation format, coding methods in the wavelength and the frequency band with the mathematical modelling 4.5. With the experimental modelling of a new fibre optic transmission system technology for large-scale data transmission of the smart city and carried out each of the used element is tuned and parameters for the evaluation of their operational effectiveness 4.6. WDM fibre optic transmission systems to the solution of smart city for data transmission depending on the channel number, transmission speed, modulation method, encoding format, and other parameters	Planned: Developed and submitted patent application Achieved: under development. Planned: 1 doctoral thesis Achieved: defended doctoral thesis, Dr.sc.ing. Sandis Spolītis Planned: 3 Master thesis Achieved: defended 3 Master thesis: 1. Ms.sc.ing. Matīss Viekalis, "Analysis and Application of Dispersion Compensation Methods in High-speed WDM-PON Systems" , 2. Ms.sc.ing. Zane Upeslāce, "Analysis and Application of Dispersion Compensation Methods in High-speed WDM-PON Systems", 3. Ms.sc.ing. Alvis Meņģo, "All-Optical Wavelength Conversion in Wavelength Division Multiplexing Systems" Planned: 1 seminar Achieved: seminar held in RTU TI about the tendencies in FOTS. Planned: 3 scientific papers indexed in ERIH (A un B) Achieved: 3 scientific papers submitted to journals or conference proceedings indexed in ERIH: 1. "An Improvement of EDFA efficiency by using Ytterbium co-doped optical fibers", Ingrīda Lavrinoviča and Jurģis Poriņš, IEEE BlackSeaCom2016. 2. "Evaluation of Erbium Doped Fiber Amplifier Application in Fiber Optics Transmission Systems", Jūlija Putrina and Vjačeslavs Bobrovs, PIERS 2016. 3. "Performance Evaluation of a 40 Gbps WDM Transmission System with a Single-pump Raman Amplifier", Vladislavs Bičkovs and Vjačeslavs Bobrovs, PIERS 2016.
5. Development of the bacteriological quality control system for the city water supply system	
5.1. Testing and optimization of water quality control methods in batch experiments. Identification of applicable sensors.	Planned: Set of methods to be used in dynamic water control systems. Achieved: presented in Appendix no.4 (section 4.6.) Planned: Prepared publication Achieved: submitted 2 publications to journals *Water Science and Technology* and *Water Research*.
5.2. Adjustment of pilot level experimental	Planned: Experimental water supply system

system to support experiments planned for the project	Achieved: developed, presented in Appendix no.4 (section 4.6.)
5.3. Development of hydraulic model for the experimental system.	Planned: Hydraulic model Achieved: developed, presented in Appendix no.4 (section 4.6.)
5.4. Measurements within the experimental system	Planned: Results of experiments. Results of preliminary tests of the effectiveness of methods. Interim scientific report. Achieved: presented in Appendix no.4 (section 4.6.)
1.5. Approbation of water quality estimation methods in pilot scale experiments	Planned: approbated methods for application in pilot scale Achieved: presented in Appendix no.4 (section 4.6.)
1.6. Development and testing of a modelling tool of drinking water quality in the pilot scale water supply system and its matching to the hydraulic model developed before	Planned: Model of the quality of drinking water. Achieved: developed, presented in Appendix no.4 (section 4.6.)

The implementation of the programme has been performed in active collaboration with partners from industry and endusers, in particular:

• Children Clinical University Hospital (BKUS), where is approved performance of quick query language;

• SIA LETA, where is an approved the use of new effective semantics retrieval method;

• Consult Logitrans OU (Estonia), Tieto Latvia and Tartu University (Estonia) in parallel ongoing international project, resulting in synergies between research;

• SIA Eurolcds where is used segmentation algorithms for 3D imaging;

• SIA Pest Baltic, where is used wireless sensor networks and a small object detection algorithms.

An important achievement thanks to the implementation of the programme is also submitted and accepted project SUMMA (No 688139) within Horizon 2020 call ICT-16 -2015 „Big data – research" for a total amount of 9.85 mEUR, of which Latvia will receive 1.16 mEUR. This proposal has been prepared together with SIA „LETA" on the basis of the results obtained within the Project 2.

1.9. Results of the programme:

Performance indicator	Results					
	Planned	Achieved				
		Total	Period 1	Period 2	Period 3	Period 4
A.Scientific performance indicators						
1. Scientific publications:	80	44	17	27	-	-
1.1 number of original scientific articles (*SCOPUS*)(SNIP>1)	17	1	0	1	-	-
1.2 number of original scientific articles in journals or in proceedings of conferences in databases SCOPUS or Web of Science	63	35	13	22	-	-
1.3 number of reviewed scientific monographs	1	0	0	0	-	-
1.4 other original scientific articles	0	9	4	5	-	-
2. In the framework of the programme:					-	-
2.1 number of defended doctoral thesis	22	5	1	4	-	-
2.2 number of defended master's thesis	52	16	8	8	-	-
3. Number of improved courses	13	2	0	2	-	-
4. Research deliverables					-	-
4.1 Software prototypes	12	2	1	1	-	-
4.2 Methodology, descriptions	15	5	5	1	-	-
4.3 Mock-ups, prototypes, technologies	21	11	5	6	-	-
4.4 Involvement in international projects	6	3	1	2	-	-
B.Performance indicators of the promotion of the programme						
1. The number of interactive events to promote the process and results of the programme (target groups should include students):					-	-
1.1 Presentations in international conferences	50	28	13	15	-	-
1.2 Presentations in international seminars	4	1	0	1	-	-
1.3 organized seminars	25	13	5	8	-	-
1.4 popular-science publications, events, information in mass media	15	24	1	23	-	-
1.5 exhibitions	4	2	2	0	-	-
1.6 Organized international conferences	2	1	0	1	-	-
2. Press releases	0	5	2	3	-	-
3. Technological forecast	4	0	0	0	-	-
C.Economic performance indicators						
1. Amount of private funding attracted to the scientific institution in the framework of the programme, including:					-	-
1.1. co-funding from the private sector to implement the projects of the programme (EUR)	10000	0	0	0	-	-
1.2. income from commercializing the intellectual property created in the framework of the programme (alienation of industrial property rights, licensing, conferring exclusive rights or rights to use on a fee) (EUR)					-	-
1.3. income from contractual jobs that are based on results and experience acquired in the framework of the programme (EUR)	435000	1431545.98	232802.58	1198743.40	-	-
1.4 Co-funding from the scientific organizations to implement the projects of	368300	119131.76	22402	96729.76	-	-

the programme (EUR)						
2. Number of applied for, registered, and valid patents or plant varieties in the framework of the programme:	12	2	1	1	-	-
2.1 in the territory of Latvia	10	2	1	1	-	-
2.2 abroad	2	0	0	0	-	-
3. Number of new technologies, methods, prototypes or services that have been elaborated in the framework of the programme and approbated in enterprises	15	6	1	5	-	-
4. Number of new technologies, methods, prototypes, products or services that have been submitted for implementation (signed contracts on transfer of intellectual property)	3	0	0	0	-	-
5. Founded a new (spin-off) company	1	0	0	0	-	-
6. Earnings by the scientific institutions from other research projects in synergy (EUR)	4200000	108702.96	0	108702.96	-	-

Note: "s" in some cells means "submitted" but not yet accepted/reviewed.

In case of deviation from planned justification of deviation and planned activities to mitigate deviation.

The main problems in the first two phases of SOPHIS implementation are related to the considerable delays (five and seven months later than the planed start dates) of a contract signing and receiving of funding. The workplans were necessary to adjust, which partly impacted timely achievement of the results. In addition, a reduction in funding for approximately 15% of the planed amounts for second period led to necessity to release part of the employees, adjust workload of others. Due to such instability several employees have submitted resignations, including PhD students and young scientists.

Despite these problems, the achieved results of the programme are consistent with the planned if reduced funding is taken into account. Approximately 25% reducing of the funding for a next period is a source of next difficulties to ensure the timely implementation of the programme.

1.10. List of results of the programme
(*List of publications, conference thesis, etc.)*

List of of results of the Project No1
Publications.:

A.1.1.SCOPUS. SNIP>1:

1. Hermanis, A.; Cacurs, R.; Greitans, M., "Acceleration and Magnetic Sensor Network for Shape Sensing," in Sensors Journal, IEEE , vol.16, no.5, pp.1271-1280, March1, 2016 doi: 10.1109/JSEN.2015.2496283, URL:http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7312881&isnumber=7401148

A.1.2.SCOPUS, Web of Science:

1. Olegs Nikisins, , Kamal Nasrollahi, Modris Greitans and Thomas B. Moeslund "RGB-D-T based Face Recognition", 22nd International Conference on Pattern Recognition (ICPR), Stockholm Waterfront, Stockholm, Sweden, August 24-28, 2014, pp.1716-1721. DOI: 10.1109/ICPR.2014.302 ;

http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6977013&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6977013

2. A. Hermanis, R. Cacurs, M. Greitans, "Shape sensing based on acceleration and magnetic sensor system", 2015 IEEE International Symposium on Inertial Sensors and Systems (ISISS), 23-26 March 2015. DOI:10.1109/ISISS.2015.7102383 http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7102383&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D7102383
3. O.Nikisins, R.Fuksis, A. Kadikis and M. Greitans. "Face recognition system on Raspberry Pi" 2015 5th International Workshop on Computer Science and Engineering: Information Processing and Control Engineering, WCSE 2015-IPCE; Bauman Moscow State Technical UniversityMoscow; Russian Federation; 15 April 2015 through 17 April 2015; Code 112346. http://www.scopus.com/record/display.uri?eid=2-s2.0-84939511173&origin=resultslist&sort=plf-f&src=s&st1=Nikisins&st2=&sid=337DADE46B4D3788C19BD4B3BDC84
4. K.Nesenbergs, L. Selavo, "Smart textiles for wearable sensor networks: review and early lessons," Medical Measurements and Applications (MeMeA) 2015 Conference on, Torino, Italy, 7-9 May 2015. DOI:10.1109/MeMeA.2015.7145236 http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7145236&punumber%3D7128112%26filter%3DAND%28p_IS_Number%3A7145157%29%26pageNumber%3D4
5. Pudzs, Mihails; Fuksis, Rihards; Mucenieks, Agris; Greitans, Modris, "Complex matched filter for line detection," in Image and Signal Processing and Analysis (ISPA), 2015 9th International Symposium on , vol., no., pp.93-97, 7-9 Sept. 2015 doi: 10.1109/ISPA.2015.7306039, URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7306039&isnumber=7306014
6. Dimitrios Lymberopoulos and the participants of Microsoft Indoor localization Competition 2014 (including Leo Selavo), "A Realistic Evaluation and Comparison of Indoor Location Technologies: Experiences and Lessons Learned," the 14th ACM/IEEE International Conference on Information Processing in Sensor Networks (ACM/IEEE IPSN), CPSWEEK, Seattle, USA, April 13-16, 2015. DOI: 10.1145/2737095.2737726 http://research.microsoft.com/apps/pubs/default.aspx?id=241638
7. Artis Mednis. "Development of 802.11p Testbed – Experiences", Proceedings of the 14th Biennial Baltic Electronics Conference (BEC 2014), October 6-8, 2014, Tallin, Estonia, pp. 137-140. http://www.researchgate.net/publication/266950280_Development_of_802.11p_Testbed_-_Experiences
8. Ruskuls, R., Lapsa, D., & Selavo, L. (2015, November). EDI WSN TestBed: Multifunctional, 3D Wireless Sensor Network Testbed. In Advances in Wireless and Optical Communications (RTUWO), 2015 (pp. 50-53). IEEE. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7365718; DOI: 10.1109/RTUWO.2015.7365718 ;

Bachelors thesis:

A.2.3.Emil Syundyukov, bachelors thesis "Embedded hardware and software for health data monitoring during rehabilitation"

A.3. **Improved study courses**:

- "Introduction to digital programming", University of Latvia, R. Ruskuls. Course demonstrates development of digital devices, and uses TestBed adapter as an example for specific lessons.
- "Concepts of operating systems", University of Latvia, K. Nesenbergs. Course demonstrates concepts of operating systems, including lessons from development of the operating system for wireless sensor networks (MansOS).

A.4. **Research deliverables**:

A.4.1. **Software prototypes**:

- EDI testbed adapter management and connected software set has been developed for linking the adapter to the whole testbed
- Mobile application for heada position sensor has been developed
- Mobile application for knee joint sensor has been developed

A.4.2. **Methodology, descriptions**:

- Testbed architecture concept has been developed and described (Appendix 1, section 1.2.4.1.)

A.4.3. **Mock-ups, prototypes, technologies**:

- Experimental mock-up of EDI testbed adapter has been developed (Appendix 1, section 1.2.4.5)
- EDI testbed system prototype with integrated testbed adapter has been developed and tested
- Developed prototype for head position sensor (Appendix 1, section 1.3.4.1)
- Developed prototype for knee joint sensor for rehabilitation (Appendix 1, section 1.3.4.4)
- Developed mock-up for a system for head and body position monitoring (Appendix 1, section 1.3.4.3)
- Developed mock-up for heart data gathering and analysis system (Appendix 1, section 1.3.3.5)

A.4.4. **International projects**:

- H2020 ECSEL "Integrated Components for Complexity Control in Affordable Electrified Cars" (3Ccar) http://www.edi.lv/lv/projekti/starptautiskie-projekti/3ccar/
- „Health and Social Indicators of Participation in Physical Activities for Children with Disabilities" – HIPPAC http://edi.lv/lv/projekti/starptautiskie-projekti/hippac/

B. Resultative results of dissemination:

B.1. Interactive dissemination events:

B.1.1. Presentations in international conferenes:

- A.Hermanis, R. Cacurs, K. Nesenbergs, M. Greitans, E. Syundyukov, L. Selavo, "Demonstration Abstract: Wearable Sensor Grid Architecture for Body Posture and Surface Detection and Rehabilitation," The 14th ACM/IEEE International Conference on Information Processing in Sensor Networks (ACM/IEEE IPSN), CPSWEEK, Seattle, USA, April 13-16, 2015. pp.414-415. ISBN: 978-1-4503-3475-4 doi;10.1145/2737095.2742555 http://dl.acm.org/citation.cfm?id=2742555&dl=ACM&coll=DL&CFID=554964176&CFTOKEN=77562692
- Dimitrios Lymberopoulos and the participants of Microsoft Indoor localization Competition 2014 (including Leo Selavo), "A Realistic Evaluation and Comparison of Indoor Location Technologies: Experiences and Lessons Learned," The 14th ACM/IEEE International Conference on Information Processing in Sensor Networks (ACM/IEEE

IPSN), CPSWEEK, Seattle, USA, April 13-16, 2015. DOI: 10.1145/2737095.2737726 http://research.microsoft.com/apps/pubs/default.aspx?id=241638

- 09.-11.03.2015. M.Greitans participated in international event "ARTEMIS Co-Summit 2015" Berlin, Germany, where he presented and discussed ideas and results of the project.
- 03.-20.02.2015. Participants of the project participated in the 73rd scientific conference of the University of Latvia, where they held two presentations: "Localization inside buildings with digitally controlled directional antennas" (L.Selavo, I.Drikis, R.Balass) and "Development of heterogenous wireless communication poligon" (A.Mednis, J.Judvaitis, R.Ruskuls).
- 21.-22.01.2015. M.Greitans participated in KTI ARTEMIS "Brokerage Event 2015" Amsterdam, Netherlands, where he presented and discussed ideas and results of the project.
- 31.08.-06.09.2014. Program manager M.Greitans participated in European signal processing conference "EUSIPCO 2014" Lisabon, Portugal, where he presented and discussed ideas and results of the project.
- L.Selavo, I. Drikis, A. Mednis, R. Balass. "DiStAL: Digitally Steerable Antennas for Localization," Technical report, Microsoft Indoor Localization Competition, IPSN 2015,, April 13-17 2015, Seattle, WA,USA. http://research.microsoft.com/en-us/events/indoorloccompetition2015/
- Emil Syundyukov participated in conference and demo session „International Conference on Embedded Wireless Systems and Networks (EWSN) 2016" from February 15 till February 18 Graca (Austria).
- Emil Syundyukov participated in RSU ISC 2016 conference, March 2016, with presentation "Wearable sensor network and mobile application for knee joint dynamics monitoring during rehabilitation"
- 2015-09-16 A. Hermanis presents in conference "4th Baltic and North Sea Conference on Physical and Rehabilitation Medicine" the published abstract Atis Hermanis, Andra Greitane, Santa geidāne, Armands Ancāns, Ričards Cacurs, Modris Greitāns, „Wearable Head and Back Posture Feedback System For Children With Cerebral Palsy", Abstract: Journal of Rehabilitation Medicine (ISSN 1650-1977).

B.1.3. **Organized seminars**:

- 09.07.2015 Progress and results seminar of period 1 of project No.1. "Development of technologies for cyber physical systems with applications in medicine and smart transport"
- 07.10.2015 SOPHIS period 1 progress and result seminar
- 16.03.2016 Progress and results seminar of period 2 of project No.1. "Development of technologies for cyber physical systems with applications in medicine and smart transport"
- 30.03.2016 SOPHIS period 2 progress and result seminar

B.1.4**. Popular publications, events, information in mass media:**

- 2015-02-11 Latvian Radio broadcast "Monopols", discussion with Leo Selavo
- 2015-05-05 LTV1 broadcast "Zināmais nezināmajā" discussion with Ati Hermani
- 2015-05-15 Atis Hermanis presents his work in RTU contest for scientific research "ResearchSlam", 2015 and gains first place
- In the event of „Scientist night" on September 25, year 2015 at Institute of Electronics and Computer Science, the project results were presented. http://www.edi.lv/en/home/
- 2015-09-30 Emil Syundyukov presents his bachelors thesis "Embedded systems and software for health datamonitoring during the time of rehabilitation" in the annual stipend

contest of the best IT bachelors thesis organized by company Exigen Services Latvia and RTU Development fund, 2015 and gains second place

- 2015-08-08 researcher Atis Hermanis participates in the press conference of Riga IT demo center, and demonstrates the wearable sensor system developed in the project.
- 2015-10-27 Radio NABA broadcast "Studentu pietura", discussion with Emil Syndyukov
- 2015-11-17 In "Healthcare Technology and Enterpreneurship day" organized by "Health Hackers" with presentations participated Atis Hermanis and Emil Syndyukov
- 2015-05-21 In "Radio Pieci" broadcast "Domnīca", conversation with Atis Hermanis
- 2015-08-25 Junior Summer Entrepreneurship School 2015, Emil Syundyukov reads a guest lecture about project results.
- 2015-12-17 Presentation in 38th discussion of DevClub.lv about health, by Emil Syundyukov
- 2016-02-29 Participation with presentation in BioTech Meetup, Emil Syundyukov
- 2016-02-19 Lecture in the pedagogue professional competence improvement sesminar "News in computer science, programming and their applications in study process", Emil Syundyukov
- 2016-02-19 Lectures in Latvian Programmers day conference, Emil Syundyukov, Atis Hermanis
- 2016-02-25 Presentation in Riga Stradins University "Science afternoon", Emil Syundyukov
- 2016-02-27 Published interview in newspaper "Diena" with Emil Syundyukov, http://www.diena.lv/latvija/zinas/studenti-kuri-patiesam-aizravusies-14131628
- 2015-11-04 Published interview in journal "Ir" with Emil Syundyukov, http://www.irlv.lv/2015/11/4/urki-kas-pasauli-ieliek-telefona
- 2015-09-25 Presentation in the event of University of Latvia "Scientist Fight Club", Emil Syundyukov
- 2016.01.16. – 01-28. Atis Hermanis participated in international events "ARTEMIS Brockerage -Event for Call 2016" and "ECSEL Brokerage Event", Strasbourg France, where he presented and discussed results and ideas of the project.
- 2015.08.27. Presentation at „Summer School Smart Textiles for Healthcare", Atis Hermanis
- 2015.11.17. Presentation at Riga School of Economics "Healthcare Technology and Entrepreneurship Day", Atis Hermanis

B.1.5.Exhibitions:

- Participation in exhibition «School 2015», February 27-28, Riga.
- 10.-11.10.2014. A.Mednis participated in Riga Technical University exhibiton for inventions and innovations - MINOX 2014

List of of results of the Project No2:

List of publications:

1. J.Barzdins, E.Rencis, A.Sostaks. Self-service Ad-hoc Querying Using Controlled Natural Language. Submitted to the 12th International Baltic Conference on Databases and Information Systems, Riga, Latvia, 4-6 July 2016

2. G.Barzdins, S. Renals, D. Gosko. (2016). Character-level Neural Translation for NextGen Media Monitoring in the SUMMA Project. Accepted by LREC-2016, 23-28 May 2016, Portorož (Slovenia). (**to appear in Web of Science**)
3. A.Spektors, I. Auzina, R. Dargis, N. Gruzitis, P. Paikens, L. Pretkalnina, B. Saulite. (2016). Tezaurs.lv: the Largest Open Lexical Database for Latvian, Accepted by LREC-2016, 23-28 May 2016, Portorož (Slovenia). (**to appear in Web of Science**)
4. Grundspenkis J. Initial Steps towards the Development of Formal Method for Evaluation of Concept Map Complexity from the Systems Viewpoint. Submitted to the 12th International Baltic Conference on Databases and Information Systems, Riga, Latvia, 4-6 July 2016.
5. Lavendelis E. A Conceptual Approach for Knowledge Structure Update and Learning in Multi-Agent Systems. In Proceedings of 16th International Conference on Applied Computer Science (ACS '16), Istanbul, Turkey, April 15-17, 2016.
6. Petrovica S., Pudane M. Simulation of Affective Student-Tutor Interaction for Affective Tutoring Systems: Design of Knowledge Structure. Submitted to 7th International Conference on Education and Educational Technologies (EET '16), Istanbul, Turkey, April 15-17, 2016.
7. IFS User Manual v.1.0.
8. Depiction of structural models of control system for winch handling system (CSWHS)
9. Kirikova, M., Penicina, L., Gaidukovs, A. Ontology based Linkage between Enterprise Architecture, Processes, and Time. ADBIS 2015 short Papers and Workshops BigDap, DCSA, GID, MEBIS, OAIS, SW4CH, WISARD Proceedings. Poitiers - France, September 8-11, 2015. New Trends in Databases and Information Systems. CCIS, Vol. 539. Springer, pp.382-391. In database: (**SCOPUS**). DOI: http://dx.doi.org/10.1007/978-3-319-23201-0_39
10. Anita Finke. Requirements Inheritance in Continuous Requirements Engineering. Joint Proceedings of REFSQ-2016 Workshops, Doctoral Symposium, Research Method Track, and Poster Track co-located with the 22nd International Conference on Requirements Engineering: Foundation for Software Quality (REFSQ 2016), March 14-17, 2016, Gothenburg, Sweden. CEUR-WS.org, Vol. 1564. **(to appear in SCOPUS)**
11. Marite Kirikova. Continuous Requirements Engineering in FREEDOM Framework: a Position Paper. Joint Proceedings of REFSQ-2016 Workshops, Doctoral Symposium, Research Method Track, and Poster Track co-located with the 22nd International Conference on Requirements Engineering: Foundation for Software Quality (REFSQ 2016), March 14-17, 2016, Gothenburg, Sweden. CEUR-WS.org, Vol. 1564. **(to appear in SCOPUS)**
12. Dmitrijs Kozlovs, Kristine Cjaputa and Marite Kirikova. Towards Continuous Information Security Audit. Joint Proceedings of REFSQ-2016 Workshops, Doctoral Symposium, Research Method Track, and Poster Track co-located with the 22nd International Conference on Requirements Engineering: Foundation for Software Quality (REFSQ 2016), March 14-17, 2016, Gothenburg, Sweden. CEUR-WS.org, Vol. 1564. **(to appear in SCOPUS)**
13. Marite Kirikova, Raimundas Matulevičius, and Kurt Sandkuhl. The Enterprise Model Frame for Supporting Security Requirement Elicitation from Business Processes, submitted to the 12th Baltic Conference on Databases and Information Systems to be held 4-6 July 2016, Riga, Latvia.
14. Bartusevics, A., Lesovskis, A., Novickis, L. Semantic Web Technologies and Model-Driven Approach for the Development and Configuration Management of Intelligent Web-Based Systems. No: Proceedings of the 2015 International Conference on Circuits, Systems, Signal Processing, Communications and Computers, Austrija, Vienna, 15.–17. marts, 2015. Vienna:

2015, 32.–39.lpp. ISBN 978-1-61804-285-9. ISSN 1790-5117 (Springer, Web of Knowledge).

15. Novickis L., Vinichenko S., Sotnichoks M., Lesovskis A., Graph Models and GeoData Based Web Portal in Cargo Transportation. In : Scientific Journal of Riga Technical University. Applied Computer Systems, 2015/17, RTU Press, Riga, 2015, pp. 34-39. ISSN 2255-8683 (EBSCO, VINITI).

16. Novickis L., Mitasiunas A., Ponomarenko V. Towards Knowledge and Information Technology Transfer Concept and Its Validation. In: Procedia Computer Science, ICTE in Regional Development , 2015 , Valmiera, Elsevier, Volume 77, 2015, Pages 48–55 **(SCOPUS).**

17. Bartusevics, A., Novickis, L. Model–Based Approach for Implementation of Software Configuration Management Process. In: MODELSWARD 2015. Proceedings of the 3rd International Conference on Model-Driven Engineering and Software Development, France, Angers, 9-11 February, 2015, pp.177-184. ISBN 978-989-758-083-3 **(SCOPUS).**

18. Rudolfs Bundulis, Guntis Arnicans. Use of H. 264 real-time video encoding to reduce display wall system bandwidth consumption. In Information, Electronic and Electrical Engineering (AIEEE), 2015 IEEE 3rd Workshop on Advances in, pp. 1-6. IEEE, 2015.

19. Ingars Ribners, Guntis Arnicans. Concept of Client-Server Environment for Agent-Based Modeling and Simulation of Living Systems. In Computational Intelligence, Communication Systems and Networks (CICSyN), 2015 7th International Conference on, pp. 83-88. IEEE, 2015. DOI: 10.1109/CICSyN.2015.25 (**to appear in SCOPUS**)

List of of results of the Project No3:
Publications:

1. Janis Spigulis, Ilze Oshina, "3x3 Technique for RGB Snapshot Mapping of Skin C hromophores" (online publication:10.1364/BODA.2015.JT3A.39), Bio-Optics: Design and Application 2015, Vancouver Canada, 12–15 April 2015. ISBN: 978-1-55752-954-1. **[1st period] (SCOPUS)**
2. Saknite I, Zavorins A, Jakovels D, Spigulis J, Kisis J. "Comparison of single-spot technique and RGB imaging for erythema index estimation", Physiological Measurement, Volume 37 (2016), Number 3. pp.333-346. doi:10.1088/0967-3334/37/3/333. http://dx.doi.org/10.1088/0967-3334/37/3/333 **[2nd period] (SCOPUS)**
3. J.Spigulis, I.Oshina, Z.Rupenheits. Smartphone single-snapshot mapping of skin chromophores. OSA Technical Digests, *accepted*, (2016). **[2nd period] (SCOPUS)**
4. Inga Saknīte, Aleksejs Zavorins, Janis Spigulis, Janis Kisis "Skin Erythema Assessment by an RGB Imaging Device: a Clinical Study", (online publication) Conference OSA Frontiers in Optics and Laser Science, 18–22 October 2015, San Jose, CA, USA. Poster session **[2nd period]**

Presentation in conferences:

1. Jacob Bauer, Ville Heikkinen, Janis Spigulis "Spectral reflectance estimation with an optical non contact device for skin assessment", Northern Optics & Photonics 2015 (NOP 2015), 2-4 June 2015, Lappeenranta, Finland. **[1st period]**
2. Ilze Oshina, Janis Spigulis, "Snapshot mapping of skin chromophores at triple-wavelength illumination" , 11th International Young Scientist Conference, Developments in Optics and Communications 2015, Latvia, April 8-10, p.21, 2015. **[1st period]**
3. Gatis Tunens, Inga Saknite, Janis Spigulis, "Modeling diffuse reflectance spectrum of skin in the near-infrared spectral range by Monte Carlo simulations", 11th International Young

Scientist Conference, Developments in Optics and Communications 2015, Latvia, April 8-10, p.20, 2015. **[1st period]**

4. Jacob Bauer, Ville Heikkinen, Janis Spigulis, "Spectral reflectance estimation with an optical non contact device for skin assessment", 11th International Young Scientist Conference, Developments in Optics and Communications 2015, Latvia, April 8-10, p.12, 2015. **[1st period]**
5. Ilze Oshina, Janis Spigulis, "Image processing for snapshot RGB mapping of skin chromophores", Conference IONS Karlsruhe 2015, 26-29 June 2015. Poster session. **[1st period]**
6. J.Spigulis, I.Oshina "Monochomatic spectral imaging: principles and application for skin chromophore mapping". The 2nd Israeli Biophotonics Conference (IBPC-2), December 1-2, 2015, Bar-Ilan University, Ramat-Gan, Israel. Presentation **[2nd period]**
7. G.Tunens, I.Saknite, J.Spigulis. Modelling skin diffuse reflectance spectra in the near-infrared and visible range. 11th International Young Scientist Conference, Developments in Optics and Communications 2016, Latvia, March 21-23, p.28, 2016. **[2nd period]**
8. I.Oshina, Z.Rupenheits, J.Spigulis. Mapping of skin chromophores by snapshot taken with a smartphone. 11th International Young Scientist Conference, Developments in Optics and Communications 2016, Latvia Riga, March 21-23, p.31, 2016. **[2nd period]**
9. I. Saknite, G. Tunens, J. Spigulis. Study on near-infrared reflectance spectroscopy of skin for noninvasive estimation of skin hydration. LU 74.konference, 25.01.2016. Stenda referāts. **2nd period**
10. R. Janovskis, I. Saknite, J. Spigulis. Infrared spectroscopy and imaging for estimation of skin hydration. Developments in Optics and Communications, Riga, March 21-23, p.39, 2016. **[2nd period]**

Patent:

-METHOD AND DEVICE FOR CHROMOPHORE MAPPING UNDER ILLUMINATION OF SEVERAL SPECTRAL LINES. Authors: J.Spīgulis and I.Ošiņa. Latvian patent P-15-137, 20.02.2016. **[2nd period]**

PhD thesis:

-I.Saknīte, "Optical non-invasive determination and mapping of skin bilirubin, hemoglobin and water ". (Superviser J.Spīgulis) University of Latvia 11.12.2015. **[2nd period]**

Defended Master thesis **[1st period]:**

1. Olga Ļashuka. „Determination of pulse wave velocity by the non-contact photoplethysmography method", (Supervisor Dr. Uldis Rubīns.), University of Latvia.
2. Jacob Bauer. "Spectral reflectance estimation with an optical non contact device for skin assessment" – University of Eastern Finland, (Supervisors Prof. Ville Heikkinen and Prof. Janis Spigulis)

Bachelors thesis **[1st period]:**

1. I.Ošiņa, (2015) „The mapping of skin chromophores by three-chromatic laser illumination" (Supervisor Prof. J.Spīgulis), University of Latvia.

List of of results of the Project No4:

Publications:

1. K. Ozols "Implementation of reception and real-time decoding of ASDM encoded and wirelessly transmitted signals." Microwave and Radio Electronics Week 2015 (MAREW2015), Pardubice, Czech Republic, April 21-23, 2015 (+ conference presentation).

2. K. Krumin'sh , V. Peterson, V. Plotsin'sh. „The influence of thermal hysteresis of a clocked comparator on the operation of the comparator type sampling converter", Automatic Control and Computer Sciences, July 2015, Volume 49, Issue 4, pp. 245-253.
3. E. Hermanis, M. Greitans , V. Aristov. „Identification of characteristics of two-terminal networks from the pulse response of the current" Automatic Control and Computer Sciences, July 2015, Volume 49, Issue 4, pp 239-244.
4. Dejus S., Nescerecka A., Nazarovs S., Juhna T., „Review on Existing and Emerging Biological Contamination Detection Tools for Drinking Water Distribution Systems (DWDS) Online Monitoring", Proceedings of the 7th IWA Eastern European Water Professionals Conference, Belgrade, 2015, p.320-332 (+ conference presentation).
5. Aristov, V.; Shavelis, R.; Shupols, G.; Cirulis, R., "An investigation of non-traditional approach to narrowing the GPR pulses," in Radioelektronika, 2015 25th International Conference , vol., no., pp.373-375, 21-22 April 2015 (+ conference presentation).
6. S. Spolitis, L. Gegere, A. Alsevska, I. Trifonovs, J. Porins, and V. Bobrovs „Optical WDM-PON Access System with Shared Light Source" Progress In Electromagnetics Research Symposium, PIERS 2015 in Prague, Czech Republic, 06-09 July, 2015 (+ conference presentation).
7. Ingrīda Lavrinoviča un Jurģis Poriņš "An Improvement of EDFA efficiency by using Ytterbium co-doped optical fibers", IEEE BlackSeaCom'2016 (submitted).
8. Jūlija Putrina and Vjačeslavs Bobrovs "Evaluation of Erbium Doped Fiber Amplifier Application in Fiber Optics Transmission Systems", PIERS 2016 (submitted).
9. Vladislavs Bičkovs and Vjačeslavs Bobrovs "Performance Evaluation of a 40 Gbps WDM Transmission System with a Single-pump Raman Amplifier", PIERS 2016 (submitted).
10. Aivars Lorencs, Ints Mednieks, Juris Sinica-Sinavskis "On selection of informative bands for classification of hyperspectral images", Automatic Control and Computer Sciences (in preparation).

Presentation in conferences:

1. Vladimir Aristov, Rolands Shavelis, Gatis Shupols and Rudolfs Cirulis. „An Investigation of Non-traditional Approach to Narrowing the GPR Pulses". MAREW 2015. Microwave and Radio Electronics Week 2015. 25th International Conference "Radioelektronika 2015". Pardubice, Czech Republic, April, 21-22, 2015. Poster session.
2. Aivars Lorencs, Ints Mednieks, Juris Sinica-Sinavskis "Classification of Multisensor Images With Different Spatial Resolution". The 19th International Conference ELECTRONICS 2015, Palanga, Lithuania, 15-17 June, 2015.
3. Aivars Lorencs, Juris Siņica- Siņavskis "Spectral channel selection using variance", LU 74th conference, Riga, February, 2016.
4. Dejus S., Nescerecka A., Nazarovs S., Juhna T., „Review on Existing and Emerging Biological Contamination Detection Tools for Drinking Water Distribution Systems" (DWDS) Online Monitoring, Proceedings of the 7th IWA Eastern European Water Professionals Conference for young and senior water professionals, Belgrade, 2015, p.320-332.
5. Nescerecka A., The application of adenosine-triphosphate (ATP) measurements for determination of bacterial viability in chlorinated drinking water, How Dead is Dead Conference IV, Eawag, Swiss Federal Institute of Aquatic Science and Technology, Duebendorf/Zurich, Switzerland, 21–22 May 2015.
6. Nescerecka, A., Juhna, T., Hammes, F., 2015. „Automated Flow Cytometry Approaches for Assessment of Chlorination Efficacy on Aquatic Bacterial Communities", How Dead is Dead IV conference, Eawag, Swiss Federal Institute of Aquatic Science and Technology, Duebendorf/Zurich, Switzerland, 21–22 May 2015. Poster session.
7. Nescerecka, A., Juhna, T., Hammes, F., 2015. „The Application of Adenosine- Triphosphate Measurements for Determination of Bacterial Viability in Chlorinated Drinking Water", How Dead is Dead IV conference, Eawag, Swiss Federal Institute of Aquatic Science and Technology, Duebendorf/Zurich, Switzerland, 21–22 May 2015. Poster session.

Patents:

1. LR patent No.15068.Stroboscopic converter for detection of ultra-wideband radar signāls. Inventors: Kārlis Krūmiņš, Vilnis Pētersons, Valdemārs Plociņš, Aivars Ševerdaks. Applicant: Institute of Electronics and Computer Science.
2. Patent application submitted: Sandis Spolitis, Lilita Gegere, Anita Alsevska, Ilja Trifonovs, Jurgis Porins, Vjaceslavs Bobrovs „Implementation of WDM-PON technology".

Defended doctoral thesis:

1. "Development and evaluation of high-speed optical access systems", Dr.sc.ing. Sandis Spolitis. RTU.

Defended Master thesis:

1. Matīss Viekalis „ Compensation methods of dispersion and research in WDM – PON system", (Supervisor Prof. Dr.sc.ing. Ģirts Ivanovs);
2. Viktors Romans „ Research and Evaluation of Chromatic Dispersion Compensation Schemes for Long-Haul Fiber Links", (Supervisor Prof. Dr.sc.ing. Jurģis Poriņš);
3. Ilona Ābola „ Evaluation of Chromatic Dispersion Compensation Methods in WDM-PON Systems", (Supervisor Prof. Dr.sc.ing. Ģirts Ivanovs);
4. Alvis Meņģo „ All-Optical Wavelength Conversion in Wavelength Division Multiplexing Systems" (Supervisor Prof. Dr.sc.ing. Ģirts Ivanovs);
5. Zane Upeslace "Evaluation of DB and DSPK Modulation Formats in WDM Transmission Systems", Ms.sc.ing.;
6. Agris Sīlis „ Optical Signal Regeneration in Completely Optical Way", (Supervisor Prof. Dr.sc.ing. Jurģis Poriņš);
7. Mārtiņš Puķītis "Multidimensional distributions application aspects in analysis of multispectral images" (Supervisor Prof. Aivars Lorencs Defended LU FMF 08.06.2015).

Defended bachelor thesis:

1. Abajs, M. (2015). Ultra-Wideband Pulse Radar Sensor Application in Security Systems (Unpublished bachelor thesis). Riga Technical University. https://nda.rtu.lv/en/view/14134
2. Lielpinka, M. (2015). Remote Sensing Data Acquisition and Processing Using Unmanned Aircraft (Unpublished bachelor thesis). Riga Technical University. https://nda.rtu.lv/en/view/14023
3. Maurins, M. (2015). Non-dectructive Ice Thickness Monitoring (Unpublished bachelor thesis). Riga Technical University. https://nda.rtu.lv/en/view/14130.

3 public seminars organized about the results of the project no.4 obtained during the first and second period, we participated in 2 public seminars of SOPHIS programme.

PART 2: PROGRAMME PROJECT INFORMATION					
2.1.1.Project No. 1					
	Title		Development of technologies for cyber physical systems with applications in medicine and smart transport		
	Project leader's				
	name, surname		Leo Selavo		
	Degree		Dr.sc.comp.		
	Institution		Institute of Electronics and Computer Science, University of Latvia		
	Position		Institute of Electronics and Computer Science (EDI) Senior researcher, Head of Cyber Physical Systems Laboratory, University of Latvia, Faculty of Computing, Professor		
	Contacts		*Phone number*		+371 67558168
			E-mail		leo.selavo@edi.lv

2.1.2 Project goal and objectives
(Describe the project goals and objectives so that the achevements reported below could be placed in context and evaluated)

2.1.2 Project goal and objectives
(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)
The overall goal of the project is to develop solutions and tools for cyber-physical systems (CPS), and in doing so, to make them usable and accessible for a wide user base and society in general. To help solve problems in medicine, intelligent transport systems and other fields important to the society, thus promoting economics based on production of competitive innovative CPS based products.

CPS unite components, which are capable of communication, sensing of the environment, evaluating the situation and make decisions and (hopefully in a positive manner) affect the physical environment. System aspects require coordinated and synergetic action form components both on high and low levels. To achieve this, sensor networks, embedded systems, computers, communication systems and control theory are used. To develop these CPS components, as stated in the project goals, the objectives of the project are to do research, analyse and check results and performance, both analytically and empirically, by developing prototypes and testing them in problem environments of the real world.

To achieve this goal, new and competitive solutions will be developed for integration of physical and virtual world in cyber-physical systems while developing competitive smart sensor and their network innovative hardware and software platforms and their applications for modern information, things and people network environments, while benefiting transformation of the economy into products with high added value and bridging the digital divide, allowing everyday users to use cyber-physical systems easier and more effectively

In this scope, according to the goals of State research programme provisions for programme 2.2. “Next generation information and communication technology systems", specifically objectives 1, 3 and 4, specific work directions have been selected for the project, with specifically defined goals:

1. To ease the production, programming and usage of CPS, thus promoting competitive production of innovative CPS based products in economy, as well as facilitating their everyday usage and bridging the digital divide;
2. To improve the quality and ease of providing service in medical services, providing more effective prophylaxis, more timely diagnostics and more successful treatment and rehabilitation, based on innovative solutions, both locally and remotely in telemedicine;
3. To improve road traffic safety and ease of use of transport, by using intelligent transport system technologies;

While working on these goals, a strong connection between physical world, data gathered by smart sensors, processing and interpreting of this data as well as feedback back to physical world will be provided. A special care will be taken to improve efficiency and functionality of economic applications, through safe and autonomous measures, as well as a more convenient usage of CPS, and easier production of CPS based innovative systems.

In the first stage of the project, the foundation for achieving these goals was laid, to provide a strong connection between the physical world, data gathered by smart sensors, processing and interpretation of this data, as well as feedback back into physical world, thus making the development and use of CPS easier, as well as easing the production of CPS based innovative systems, thus bridging the digital divide. A special care was taken to improve efficiency and functionality of economic applications, in safe and autonomous way, e.g. work in innovative biomedical systems will allow more timely diagnostics, more efficient prophylaxis, more successful rehabilitation and treatment, both in person and remotely, and developed basis in the field of smart transport technologies will allow increased traffic safety and ease of use of cars in the future.

In the second stage of this project, to reach these goals, a more in depth development of the directions started in the first stage has been done, by integrating the reached results in prototypes, testing them, as well as disseminating the achieved results, both by publishing them in scientific and popular publications, and also by presenting them in conferences and other events. In addition to this, the development of new technologies is continued, together with research of new solutions and applications in all three specific work directions. Prototype development has been initated and the avenues for their approbation in the next stages are explored. Some of the project results have already resulted in contract research, thus resulting in gain to economic transformation and benefitting the acquisition of new projects.

Specific objectives were defined for the first stage as:
1. Development of experimental prototype for modular platform for embedded systems prototyping, profiling and debugging and evaluation and development of overall testbed system concept;
2. Work on development of smart clothing platform (hardware, architecture and software) for creation of easy to use wearable sensors, and development of data gathering and analysis approaches for medical cyber-physical systems;
3. Research data gathering of different types and dimensions about surrounding environment of the transport, and also intelligent transport system communication methods for cooperation between vehicles as well as vehicle to road infrastructure. Submit a research paper.

Specific objectives were defined for the second stage as:
1. Development of prototype system integrating the experimental prototype for modular platform for embedded systems prototyping, profiling and debugging and evaluation and data gathering and analysis, as well as integration the modular platform in the wireless sensor testbed;

2. Development of wearable sensor network applications in medicine – virtual physical therapy as well as development of prototype ECG data registration and analysis device for the wearable cyber-physical system; Submit a research paper.
3. Increase of the drivers' field of vision though monitoring, interpreting and reacting to the environment and using 3D and 2D image processing and generation methods, as well as development of communication methods between intelligent transport systems, both standalone vehicles and specific road infrastructure. Submit a research paper.

2.1.3 Description of gained scientific results

(Describe scientific results achieved during reporting period, give their scientific importance)

In depth project scientific results are described in the attached scientific report document (Appendix 1).

According to the goals of this project and specific objectives described in section 2.1.2. of this document, the work on these objectives within this project has been divided in three main groups:

1. **TestBed** (Appendix 1, section 1.2) – this group works on the objective of easing the development, programming and usage of CPS systems, by developing innovative hardware and software platform cyber-physical systems of smart sensors and their networks;
2. **MedWear** (Appendix 1, section 1.3) – this group works on the objective of improving the ease of serving and quality of medical services, by developing CPS for medical and telemedicine applications, and also by developing wearable sensor network technologies in general;
3. **SmartCar** (Appendix 1, section 1.4) – this group works on the objective of improving the read traffic safety and the ease of use of the cars, by developing uses of smart sensors in intelligent transport systems, as well as developing and testing advanced driver assistance systems (ADAS);

Each of these groups have reached the planned goals and objectives of this project as descrivbed in Appendix 1, by selecting specific tasks in each of the parts of the project and by concentrating the efforts on fulfilling these tasks, thus using the limited resources of the project efficiently.

Below the results of each of the groups together with the scientific and practical purpose as well as applications:

TestBed:

In the first period an experimental mock-up was developed for the modular platform for prototyping, profiling, debugging and development of embedded systems, a general concept of the test environment system was developed and one scientific article was published.

In the second period a system prototype for modular platform for prototyping, profiling, debugging and evaluation of embedded systems was developed together with the supporting software, and also the system concept was validated by integrating this prototype in the wireless sensor network testbed and by analysing its work.

Scientific purpose of the work: New types of thecnologies are being developed for sensor network testing and development, which also promote further scientific results in this field by making it easy to develop and test innovative sensor networks, the key results are published.

MedWear:

In the first period two experimental mock-ups have been developed (head position sensor and a sensor for knee rehabilitation) and one scientific publication has been published (indexed by SCOPUS), also the problems requiring solving have been researched and analysed in the field of health, including thorugh consultations by Latvian leading health specialists.

In the second period work continued on the research of the previous directions, as well as two more experimental mock-ups have been developed (system for body and head posture monitoring, as well as a system for heart data gathering and analysis). The reached results have been published in one scientific publication, which has been indexed by SCOPUS, as well as in one journal article which

has been indexed by SCOPUS (SNIP>1). In addition the results of this work have led to contract research project in this field.
Scientific purpose of the work: New medical data gathering methods and devices have been developed, on which new medical research can be based, also the key results have been published.

SmartCar:
In the first period the advanced driver assistance systems (ADAS) were researched, and also image and signal processing research was done with applications in monitoring of both external environment of the car and internal state of the car, such as the state of attention of the driver. In addition to this research, work on unified smart car test platform has been started for validation of these systems. Results have been published in four publications, of which three have been indexed by SCOPUS.
In the second period research on different signal and image processing methods for data gathering for smart cars has been continued, including further development of stereo vision system for smart cars, based on the results of the previouys State research programmetai skaitā, balstoties uz iepriekšējās Valsts Pētījumu Programmas rezultātiem. System for semi-automatic and automatic driving decision making from the gathered data has been developed, so that the smart car test platform can be used for testing of complex ITS scenarios and validation of the developed technologies. Results have been published in one scientific publication, which is indexed by SCOPUS.
Scientific purpose of the work: Developed image and other signal processing algorithms for uses in ITS fields, and the results have been published in scientific publications.

2.1.4. Further research and practical exploitation of the results
(Describe further research activities that are planned, describe possibilities to practically exploit results)

The further planned research activities and possibilities to exploit the results for each of the groups are described below:

TestBed:
Further research activities and solvable problems: In the next periods of the project, calibration problems of the modular test plafrom must be solved, so that all results gathered from the nodes could be comparable, and at the same time the platform must be further developed, by improving the application interface and making it easier to use for the end users, thus making it easy to program and test wireless sensor networks.
Practical purpose and applications of the results: The results promote faster road to market of research intensive, sensor network based technologies, by increasing the speed of the development cycle and making testing easier. Companies developing sensor network solutions are target exploitation audience, using the infrastructure for developing and testing their products.

MedWear
Further research activities and solvable problems: to continue developing the wearable sensor platform and its applications in telemedicine or rehabilitation, by solving problems with optimal sensor placement and placement withing clothing.
Practical purpose and applications of the results: Wearable sensor platforms provide benefits to the field of rehabilitation and telemedicine, by reducing the time, that patient spends traveling to the doctor and by reducing the time, the doctor spends for patient monitoring, thus allowing one specialist to take quality care of more patients, and at the same time improving the quality of the service through regular measurements which provide basis for treatment and feedback to the patient. Potential exploitation channels are medical and rehabilitation institutions, as well as companies producing medical equipment.

SmartCar
Further research activities and solvable problems: To finish the data gathering and decision making model, and validate the reached results by participating with the developed smart car test platform in the cooperative driving challenge i-Game GCDC in Netherlands, year 2016. To continue the work on ADAS, specifically looking at driver monitoring, expanding the field of senses of the driver and providing feedback to the driver.
Practical purpose and applications of the results: The smart car will be more secure and easier to use, because it can gather more data in a shorter period of time than the driver, thus allowing more efficient and more secure driving decisions. The developed technologies can prevent accidents on the road, both those caused by the external road conditions and other cars, and those caused by the tiredness or sleepiness of the driver. The developed smart car test platform will allow testing and validating of the developed technologies and to develop complex decision making algorithms for intelligent transport systems. Exploitation will be achieved by advertising our results through GCDC event and using them as a basis for other automotive projects and contract research by automotive companies.

All of these results will provide a stronger bond between the physical world, data gathered by smart sensors, processing and interpretation of this data, aswell as providing real time feedback back to physical world and in doing so making it easier to develop CPS and use them as well as produce technology based on innovations, thus bridging the digital divide. Special attention is given to increase of efficiency and functionality of economy in a safe and autonomous way, for example,work in innovative bio-medical systems will allow for a more timely diagnostics, more efficient prohilaxis and more successful rehabilitation and treatment both in person and remotely, but work in Intelligent transport systems will allow safer traffic and more convenient use of the transport.

2.1.5. Dissemination and outreach activities
(Describe activities that were performed during reporting period to disseminate project results)

List of publications:

A.1.3.SCOPUS. SNIP>1:

1. Hermanis, A.; Cacurs, R.; Greitans, M., "Acceleration and Magnetic Sensor Network for Shape Sensing," in Sensors Journal, IEEE , vol.16, no.5, pp.1271-1280, March1, 2016 doi: 10.1109/JSEN.2015.2496283, URL:http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7312881&isnumber=7401148

A.1.4.SCOPUS, Web of Science:

1. Olegs Nikisins, , Kamal Nasrollahi, Modris Greitans and Thomas B. Moeslund “RGB-D-T based Face Recognition”, 22nd International Conference on Pattern Recognition (ICPR), Stockholm Waterfront, Stockholm, Sweden, August 24-28, 2014, pp.1716-1721. DOI: 10.1109/ICPR.2014.302 ; http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6977013&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6977013
2. A. Hermanis, R. Cacurs, M. Greitans, "Shape sensing based on acceleration and magnetic sensor system", 2015 IEEE International Symposium on Inertial Sensors and Systems (ISISS), 23-26 March 2015. DOI:10.1109/ISISS.2015.7102383 http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7102383&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D7102383
3. O.Nikisins, R.Fuksis, A. Kadikis and M. Greitans. “Face recognition system on Raspberry Pi” 2015 5th International Workshop on Computer Science and Engineering: Information Processing and Control Engineering, WCSE 2015-IPCE;

Bauman Moscow State Technical UniversityMoscow; Russian Federation; 15 April 2015 through 17 April 2015; Code 112346. http://www.scopus.com/record/display.uri?eid=2-s2.0-84939511173&origin=resultslist&sort=plf-f&src=s&st1=Nikisins&st2=&sid=337DADE46B4D3788C19BD4B3BDC84

4. K.Nesenbergs, L. Selavo, "Smart textiles for wearable sensor networks: review and early lessons," Medical Measurements and Applications (MeMeA) 2015 Conference on, Torino, Italy, 7-9 May 2015. DOI:10.1109/MeMeA.2015.7145236 http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7145236&punumber%3D7128112%26filter%3DAND%28p_IS_Number%3A7145157%29%26pageNumber%3D4
5. Pudzs, Mihails; Fuksis, Rihards; Mucenieks, Agris; Greitans, Modris, "Complex matched filter for line detection," in Image and Signal Processing and Analysis (ISPA), 2015 9th International Symposium on , vol., no., pp.93-97, 7-9 Sept. 2015 doi: 10.1109/ISPA.2015.7306039, URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7306039&isnumber=7306014
6. Dimitrios Lymberopoulos and the participants of Microsoft Indoor localization Competition 2014 (including Leo Selavo), "A Realistic Evaluation and Comparison of Indoor Location Technologies: Experiences and Lessons Learned," the 14th ACM/IEEE International Conference on Information Processing in Sensor Networks (ACM/IEEE IPSN), CPSWEEK, Seattle, USA, April 13-16, 2015. DOI: 10.1145/2737095.2737726 http://research.microsoft.com/apps/pubs/default.aspx?id=241638
7. Artis Mednis. "Development of 802.11p Testbed – Experiences", Proceedings of the 14th Biennial Baltic Electronics Conference (BEC 2014), October 6-8, 2014, Tallin, Estonia, pp. 137-140. http://www.researchgate.net/publication/266950280_Development_of_802.11p_Testbed_-_Experiences
8. Ruskuls, R., Lapsa, D., & Selavo, L. (2015, November). EDI WSN TestBed: Multifunctional, 3D Wireless Sensor Network Testbed. In Advances in Wireless and Optical Communications (RTUWO), 2015 (pp. 50-53). IEEE. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7365718; DOI: 10.1109/RTUWO.2015.7365718 ;

Bachelors thesis:

A.2.3.Emil Syundyukov, bachelors thesis "Embedded hardware and software for health data monitoring during rehabilitation"

A.3. Improved study courses:

- "Introduction to digital programming", University of Latvia, R. Ruskuls. Course demonstrates development of digital devices, and uses TestBed adapter as an example for specific lessons.
- "Concepts of operating systems", University of Latvia, K. Nesenbergs. Course demonstrates concepts of operating systems, including lessons from development of the operating system for wireless sensor networks (MansOS).

A.4.Research deliverables:

A.4.1.Software prototypes:

- EDI testbed adapter management and connected software set has been developed for linking the adapter to the whole testbed

- Mobile application for heada position sensor has been developed
- Mobile application for knee joint sensor has been developed

A.4.2.Methodology, descriptions:

- Testbed architecture concept has been developed and described (Appendix 1, section 1.2.4.1.)

A.4.3.Mock-ups, prototypes, technologies:

- Experimental mock-up of EDI testbed adapter has been developed (Appendix 1, section 1.2.4.5)
- EDI testbed system prototype with integrated testbed adapter has been developed and tested
- Developed prototype for head position sensor (Appendix 1, section 1.3.4.1)
- Developed prototype for knee joint sensor for rehabilitation (Appendix 1, section 1.3.4.4)
- Developed mock-up for a system for head and body position monitoring (Appendix 1, section 1.3.4.3)
- Developed mock-up for heart data gathering and analysis system (Appendix 1, section 1.3.3.5)

A.4.4.International projects:

- H2020 ECSEL "Integrated Components for Complexity Control in Affordable Electrified Cars" (3Ccar) http://www.edi.lv/lv/projekti/starptautiskie-projekti/3ccar/
- „Health and Social Indicators of Participation in Physical Activities for Children with Disabilities" – HIPPAC http://edi.lv/lv/projekti/starptautiskie-projekti/hippac/

B.Resultative results of dissemination:

B.1.Interactive dissemination events:

B.1.1.Presentations in international conferenes:

- A.Hermanis, R. Cacurs, K. Nesenbergs, M. Greitans, E. Syundyukov, L. Selavo, "Demonstration Abstract: Wearable Sensor Grid Architecture for Body Posture and Surface Detection and Rehabilitation," The 14th ACM/IEEE International Conference on Information Processing in Sensor Networks (ACM/IEEE IPSN), CPSWEEK, Seattle, USA, April 13-16, 2015. pp.414-415. ISBN: 978-1-4503-3475-4 doi;10.1145/2737095.2742555 http://dl.acm.org/citation.cfm?id=2742555&dl=ACM&coll=DL&CFID=554964176&CFTOKEN=77562692
- Dimitrios Lymberopoulos and the participants of Microsoft Indoor localization Competition 2014 (including Leo Selavo), "A Realistic Evaluation and Comparison of Indoor Location Technologies: Experiences and Lessons Learned," The 14th ACM/IEEE International Conference on Information Processing in Sensor Networks (ACM/IEEE IPSN), CPSWEEK, Seattle, USA, April 13-16, 2015. DOI: 10.1145/2737095.2737726 http://research.microsoft.com/apps/pubs/default.aspx?id=241638
- 09.-11.03.2015. M.Greitans participated in international event "ARTEMIS Co-Summit 2015" Berlin, Germany, where he presented and discussed ideas and results of the project.
- 03.-20.02.2015. Participants of the project participated in the 73rd scientific conference of the University of Latvia, where they held two presentations: "Localization inside buildings with digitally controlled directional antennas" (L.Selavo, I.Drikis,

R.Balass) and “Development of heterogenous wireless communication poligon” (A.Mednis, J.Judvaitis, R.Ruskuls).

- 21.-22.01.2015. M.Greitans participated in KTI ARTEMIS “Brokerage Event 2015” Amsterdam, Netherlands, where he presented and discussed ideas and results of the project.
- 31.08.-06.09.2014. Program manager M.Greitans participated in European signal processing conference “EUSIPCO 2014” Lisabon, Portugal, where he presented and discussed ideas and results of the project.
- L.Selavo, I. Drikis, A. Mednis, R. Balass. “DiStAL: Digitally Steerable Antennas for Localization,” Technical report, Microsoft Indoor Localization Competition, IPSN 2015,, April 13-17 2015, Seattle, WA,USA. http://research.microsoft.com/en-us/events/indoorloccompetition2015/
- Emil Syundyukov participated in conference and demo session „International Conference on Embedded Wireless Systems and Networks (EWSN) 2016” from February 15 till February 18 Graca (Austria).
- Emil Syundyukov participated in RSU ISC 2016 conference, March 2016, with presentation "Wearable sensor network and mobile application for knee joint dynamics monitoring during rehabilitation"
- 2015-09-16 A. Hermanis presents in conference “4th Baltic and North Sea Conference on Physical and Rehabilitation Medicine” the published abstract Atis Hermanis, Andra Greitane, Santa geidāne, Armands Ancāns, Ričards Cacurs, Modris Greitāns, „Wearable Head and Back Posture Feedback System For Children With Cerebral Palsy”, Abstract: Journal of Rehabilitation Medicine (ISSN 1650-1977).

B.1.3. Organized seminars:

- 09.07.2015 Progress and results seminar of period 1 of project No.1. “Development of technologies for cyber physical systems with applications in medicine and smart transport”
- 07.10.2015 SOPHIS period 1 progress and result seminar
- 16.03.2016 Progress and results seminar of period 2 of project No.1. “Development of technologies for cyber physical systems with applications in medicine and smart transport”
- 30.03.2016 SOPHIS period 2 progress and result seminar

B.1.4. Popular publications, events, information in mass media:

- 2015-02-11 Latvian Radio broadcast “Monopols”, discussion with Leo Selavo
- 2015-05-05 LTV1 broadcast “Zināmais nezināmajā” discussion with Ati Hermani
- 2015-05-15 Atis Hermanis presents his work in RTU contest for scientific research “ResearchSlam”, 2015 and gains first place
- In the event of „Scientist night” on September 25, year 2015 at Institute of Electronics and Computer Science, the project results were presented. http://www.edi.lv/en/home/
- 2015-09-30 Emil Syundyukov presents his bachelors thesis “Embedded systems and software for health datamonitoring during the time of rehabilitation” in the annual stipend contest of the best IT bachelors thesis organized by company Exigen Services Latvia and RTU Development fund, 2015 and gains second place
- 2015-08-08 researcher Atis Hermanis participates in the press conference of Riga IT demo center, and demonstrates the wearable sensor system developed in the project.

- 2015-10-27 Radio NABA broadcast “Studentu pietura”, discussion with Emil Syndyukov
- 2015-11-17 In “Healthcare Technology and Enterpreneurship day” organized by “Health Hackers” with presentations participated Atis Hermanis and Emil Syndyukov
- 2015-05-21 In “Radio Pieci” broadcast “Domnīca”, conversation with Atis Hermanis
- 2015-08-25 Junior Summer Entrepreneurship School 2015, Emil Syundyukov reads a guest lecture about project results.
- 2015-12-17 Presentation in 38th discussion of DevClub.lv about health, by Emil Syundyukov
- 2016-02-29 Participation with presentation in BioTech Meetup, Emil Syundyukov
- 2016-02-19 Lecture in the pedagogue professional competence improvement sesminar “News in computer science, programming and their applications in study process”, Emil Syundyukov
- 2016-02-19 Lectures in Latvian Programmers day conference, Emil Syundyukov, Atis Hermanis
- 2016-02-25 Presentation in Riga Stradins University “Science afternoon”, Emil Syundyukov
- 2016-02-27 Published interview in newspaper “Diena” with Emil Syundyukov, http://www.diena.lv/latvija/zinas/studenti-kuri-patiesam-aizravusies-14131628
- 2015-11-04 Published interview in journal “Ir” with Emil Syundyukov, http://www.irlv.lv/2015/11/4/urki-kas-pasauli-ieliek-telefona
- 2015-09-25 Presentation in the event of University of Latvia “Scientist Fight Club”, Emil Syundyukov
- 2016.01.16. – 01-28. Atis Hermanis participated in international events "ARTEMIS Brockerage -Event for Call 2016" and "ECSEL Brokerage Event", Strasbourg France, where he presented and discussed results and ideas of the project.
- 2015.08.27. Presentation at „Summer School Smart Textiles for Healthcare”, Atis Hermanis
- 2015.11.17. Presentation at Riga School of Economics “Healthcare Technology and Entrepreneurship Day”, Atis Hermanis

B.1.5.Exhibitions:

- Participation in exhibition «School 2015», February 27-28, Riga.
- 10.-11.10.2014. A.Mednis participated in Riga Technical University exhibiton for inventions and innovations - MINOX 2014

Leader of the project No.1. _____ 04.2016

(signature and transcript) *(date)*

2.2.1. Project No. 2

Title	Ontology-based knowledge engineering technologies suitable for web environment		
Project leader's name, surname	Janis BARZDINS		
Degree	Dr.habil.sc.comp.		
Institution	The Institute of Mathematics and Computer Science, University of Latvia (IMCS UL)		
Position	Senior researcher		
Contacts	*Phone number*		+371 67224363
	E-mail		Janis.Barzdins@lumii.lv

2.2.2. Project goal and objectives

(Describe the project goals and objectives so that the achevements reported below could be placed in context and evaluated)

Goals of the project No.2 are to develop the scientific expertise of the next generation ICT systems by researching and further developing novel competitive model-based information and communication technologies and their applications in modern web environment and to transfer the created expertise and technologies to concrete domains of Latvia's economics by developing and creating novel ICT methods and tools, as well as introducing them into the higher education study process.

The objectives of the project No.2 in the 2nd stage of the SOPHIS program are:

1. Development of ontology-, web technology- and controlled natural language-based fast ad-hoc query language that will be directly usable by domain experts (without involvement of the programmer.
2. Approbation in medical domain (CCUH) of ontology-, web technology- and controlled natural language-based fast ad-hoc query language that will be directly usable by domain experts (without involvement of the programmer).
3. Development of the theoretical background for the implementation of distributed ontology- and web technology-based controlled natural ad-hoc query language parallel execution.
4. Further development of C6.0 classification algorithm and joining the international scientific research initiatives.
5. Research of competitive technologies for semantic graph parsing based on SemEval-2015 competition, and integrating them in semantic analysis toolchain for Latvian language, as used in LETA and elsewhere.
6. The extension of I4S functionality to evaluate the functional state of complex industrial control systems on the basis of their automated analysis.
7. Development of approaches and methods for identification of knowledge structure and process compatibility.
8. Analysis of the related studies and researches that are necessary to define the basic steps of the Semantic Web service development methodology.
9. Development of technologies for large scale NoSQL data base exploration and visualization.
10. Business process runtime verification.

2.2.3. Description of gained scientific results

(Describe scientific results achieved during reporting period, give their scientific importance)

1. Development of ontology-, web technology- and controlled natural language-based fast ad-hoc query language that will be directly usable by domain experts (without involvement of the programmer)

The ad-hoc querying process is slow and error prone due to inability of business experts of accessing data directly without involving IT experts. The problem lies in complexity of means used to query data. We propose a new natural language- and *semistar* ontology-based ad-hoc querying approach which lowers the steep learning curve required to be able to query data. The proposed approach would significantly shorten the time needed to master the ad-hoc querying and to gain the direct access to data by business experts, thus facilitating the decision making process in enterprises, government institutions and other organizations. These results are described in more detail in [1].

2. Approbation in medical domain (CCUH) of ontology-, web technology- and controlled natural language-based fast ad-hoc query language that will be directly usable by domain experts (without involvement of the programmer)

Approbation was performed on data of year 2015 of Riga Children's Clinical University Hospital for the needs of intensive care ward. Answers to all ad-hoc queries that were formulated for the needs of analysis of operation of the intensive care ward in year 2015 were obtained using the proposed query language in online mode. When the necessary question was formulated in natural language it took couple of minutes to reformulate it in the proposed language. All the queries were executed in less than 0.3 seconds on average.

3. Development of the theoretical background for the implementation of distributed ontology- and web technology-based controlled natural ad-hoc query language parallel execution.

Small businesses with sensitive data (like hospitals) require simple and cheap means for data analysis and ad-hoc queries. Traditional BI solutions are too expensive and heavyweight for them. We propose a solution based on the granular ontologies. We call a data ontology granular if its corresponding in-stances (data) can be divided into separate parts called slices. We propose an efficient implementation architecture for the parallel execution of ad-hoc queries based on distributed granular ontologies.

4. Further development of C6.0 classification algorithm and joining the international scientific research initiatives.

Based on the SemEval-2015 competition results and their practical application in the LETA media monitoring automation, we were able to join an international consortium submitting and winning a Horizon-2020 project "SUMMA" under H2020-ICT-16 BigData-research call. Building on the C6.0 classification algorithm expertise we have developed a character-level neural translation methodology [2] and automatic thesaurus corpus-sample selection methodology [3].

5. Research of competitive technologies for semantic graph parsing based on SemEval-2015 competition, and integrating them in semantic analysis toolchain for Latvian language, as used in LETA and elsewhere.

After a successful participation in SemEval-2015 competition, we were able to integrate these semantic graph parsing technologies and also the approaches used by other competitors in the Latvian language semantic analysis toolchain developed in the 1-st period of this project. Applying this research enabled a significant improvement in the accuracy of semantic frame extraction – an improvement of F1-score from 57.6% to 74.6% for semantic frame target word selection, and 70.4% to 77.0% for frame element classification.

A prototype of the system was approbated by LETA news agency.

6. The extension of I4S functionality to evaluate the functional state of complex industrial control systems on the basis of their automated analysis

A novel formal knowledge structure transformation method and algorithm has been developed. Morphological structure model (MSM) is transformed into a functional structure model in a behavior space (FSM BS) which is used as an intermediate model supporting the next step of transformation – construction of functional structure model in a parameters' space (FSM PS). The latter supports

evaluation of functional state of complex industrial control systems on the basis of experts' knowledge about changes of parameter values caused by different faults. The new functionality of I4S has been tested by the first year doctoral student E. Urtans. Using the I4S the structural models (MSM and FSM) of control system for winch handling system for the company "ICD Software" (Norway) has been developed [7][8]. The final goal – evaluation of functional state of abovementioned system has not been reached due to the fact that cooperation with experts from „ICD Software" was interrupted (the new management of the company decided to delay it). Therefore decision to widen the research of knowledge structures was made to enable new applications of the approach and I4S. First, the initital research phase on knowledge structures in the form of Concept Maps (CMs) has been carried out towards the development of formal method for evaluation of CM complexity based on criteria used in Systems Theory. It is proposed to interpret and use for CMs the four criteria applied for estimation of systems complexity – the number of system's elements and relationships between them, attributes of systems and their elements, and the organizational degree of systems [4]. Second, the research about the knowledge structures of Multi-Agent Systems (MASs) and Affective Tutoring Systems (ATSs) has been done to include them into a common repository and possibly to extend I4S. To enable changes in knowledge structures based on both user inputs and the results of machine learning a conceptual approach for learning and knowledge structure update is developed. The rule based learning approach was added to the previously created ontology based knowledge structure. A concept of a MAS management tool was introduced. The basic functionality of the tool is implemented, namely definition of the environment and ontology and configuration of the MAS [5]. Additionally, the architecture of agent-based ATS is proposed that involves emotion ontology sharing among agents simulating human-tutors and students for the evaluation of tutoring strategies adaptation [6].

7. Development of approaches and methods for identification of knowledge structure and process compatibility

On the basis of research done in the previous period [9], the understanding on knowledge structure and process compatibility was extended by analysis of related works where four compatibility criteria were identified. While the criteria concern both tacit and explicit knowledge, in this period, the main focus was on explicit knowledge, when working on the compatibility identification approach that concerns the identified criteria and well known workflow data patterns. For moving towards compatibility identification methods, the FREEDOM framework was developed that relates operational business processes to its development and management functions, thus forming the basis for requirements engineering for continuous process development [11]. The main requirements problems in multi-project environment were analyzed and an approach for their handling was developed in order to enable continuous requirements engineering [10]. In the context of operational business processes, possibilities to reflect knowledge about business object states were investigated. The method for document compatibility analysis was developed and approbated on educational processes [1] (PhD Thesis). The experiments with identification of security requirements patterns, as knowledge structure, and business process compatibility as well as possibilities to introduce continuous information security audit were done in cooperation with parallel international project thus gaining research synergy and promoting further collaboration with Tartu University [12] [13]. The FREEDOM framework [11] is intended to be related to the integrated model of business processes and enterprise architecture based on Bunge Wand and Weber information systems ontology that was developed under the grant Nr. 342/2012. The connection is conceptually already made between the integrated model and the time dimension [9], which, in related works and in our research [1] (Master Thesis), was recognized as important factor in knowledge structure and process compatibility.

8. Analysis of the related studies and researches that are necessary to define the basic steps of the Semantic Web service development methodology

Several solutions have been studied and analyzed before starting Semantic Web services development: OWL-S, Web Service Modelling Ontology (WSMO) and Semantic Automated Discovery and Integration (SADI). Following the results of study and analysis, SADI technology has been selected for implementation of semantic web services. It facilitates their implementation and maintenance.

Semantic web services which semantically annotate information received from traditional web services that are included in eLOGMAR portal (www.elogmar.eu) have been developed. Processed information is related to the e-logistics domain [15, 16]. Semantic web technologies have been integrated also into model driven software configuration management approach [2](PhDThesis). Modified MTM (Model – Transformation – Model) approach based on MDA (Model-Driven Architecture) and Semantic Web Technologies is developed. It makes easier to implement repeated usage and integration of Software Configuration Management data [14, 17].

9. Development of technologies for large scale NoSQL data base exploration and visualization

New possibilities are researched in large scale data set analysis and visualization for new type of hardware – high resolution displays wall, consisting of many (more than 20) standard displays. In this research client-server environment is developed. This environment supports agent based modelling and relational data exploration and migration to NoSQL database with browser, that works with display wall.

First stage of research was devoted to create a prototype of display wall. Main research problems were compatibility with popular operation systems and to keep cost of display wall as low as possible. Different solution architectures were analyzed and display wall prototype was developed partially according to raised requirements. Second stage of the research is devoted to improvement of the prototype of display wall. Main research problem is to optimize amount of data transferred between computer and display wall. Different software and hardware compression methods are explored. One of possible usage of the display wall was explored – development of agent based modeling and simulating environment. Results of the second stage are published in [18, 19]**.**

10. Business process runtime verification

Computerized system analysis and operation correctness evaluation during runtime in operational environment is understood as runtime verification in this research. Correctness evaluation can be done by tools built into system or by system events external monitoring. This research focuses on the last one. Verification is done according to each processes' verification description – model, where is defined events that confirm correctness of each process step, their execution sequence and execution time restrictions.

Prototype for runtime environment controlling system was developed in the first stage of the research. It fixes runtime environment events and via autonomous agents sent them to the controller. Controller monitors environment events and verifies them according to verification model.

In second stage of the research prototype developed in first stage was used for real life business process verification to measure additional workload to information system added by runtime verification process. Obtained measurements show, that additional workload for information system is negligible. It shows practical usability of proposed business process runtime verification mechanism. Results of the research are included in two publications submitted to publishing.

Publications:

1. J.Barzdins, E.Rencis, A.Sostaks. Self-service Ad-hoc Querying Using Controlled Natural Language. Submitted to the 12th International Baltic Conference on Databases and Information Systems, Riga, Latvia, 4-6 July 2016
2. G.Barzdins, S. Renals, D. Gosko. (2016). Character-level Neural Translation for NextGen Media Monitoring in the SUMMA Project. Accepted by LREC-2016, 23-28 May 2016, Portorož (Slovenia). (**to appear in Web of Science**)

3. A.Spektors, I. Auzina, R. Dargis, N. Gruzitis, P. Paikens, L. Pretkalnina, B. Saulite. (2016). Tezaurs.lv: the Largest Open Lexical Database for Latvian, Accepted by LREC-2016, 23-28 May 2016, Portorož (Slovenia). (**to appear in Web of Science**)
4. Grundspenkis J. Initial Steps towards the Development of Formal Method for Evaluation of Concept Map Complexity from the Systems Viewpoint. Submitted to the 12th International Baltic Conference on Databases and Information Systems, Riga, Latvia, 4-6 July 2016.
5. Lavendelis E. A Conceptual Approach for Knowledge Structure Update and Learning in Multi-Agent Systems. In Proceedings of 16th International Conference on Applied Computer Science (ACS '16), Istanbul, Turkey, April 15-17, 2016.
6. Petrovica S., Pudane M. Simulation of Affective Student-Tutor Interaction for Affective Tutoring Systems: Design of Knowledge Structure. Submitted to 7th International Conference on Education and Educational Technologies (EET '16), Istanbul, Turkey, April 15-17, 2016.
7. IFS User Manual v.1.0.
8. Depiction of structural models of control system for winch handling system (CSWHS)
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2.2.4. Further research and practical exploitation of the results

(Describe further research activities that are planned, describe possibilities to practically exploit results)

The approbation in medical domain (CCUH) of ontology-, web technology- and controlled natural language-based fast ad-hoc query language that will be directly usable by domain experts (without involvement of the programmer) showed the further research directions which are development of subclass and attribute definition features, as well as necessity for very advanced access rights mechanism, because the real hospital data are highly sensitive.

During the third stage of the project it is planned to develop a method and an algorithm for importance evaluation of knowledge structure elements based on multiple criteria for interconnected structures of different granularity. The formal complexity evaluation method for knowledge structure as a whole will be improved and validated. A previously developed rule based reasoning mechanism will be implemented into a premise cleaning multi-agent system for working in a simulated environment. In the area of agent based Affective Tutoring Systems (ATSs) it is planned to develop ontology based hierarchical structure of pedagogical model for the implementation of dynamically adapted tutoring process (based on learners knowledge and emotions), as well as to continue research on proposed agent-based ATS by developing knowledge structure for agents' interaction and communication.

Further validation of compatibility analysis framework and development of requirements engineering based approach for artifact compatibility, that promotes time aware propagation, usage, and acquisition of compatible information artifacts (explicit knowledge in terms of models, textual documents, data, etc).

Further validation and enhancing of general methodology and integrated software framework based on practical experience for introduction of semantic web services in the fields of e-Logistics (in cooperation with Logitrans Consult OU, Estonia) and software configuration management (in cooperation with Tieto Latvia) (the future research is closely related to Activity A 2.6).

2.2.5. Dissemination and outreach activities
(Describe activities that were performed during reporting period to disseminate project results)

- Based on the SemEval-2015 competition results and their practical application in the LETA media monitoring automation, we were able to join an international consortium submitting and winning a Horizon-2020 project "SUMMA" under H2020-ICT-16 BigData-research call.
- The results of the knowledge structure research, including the extended version of I4S have been presented in wide range of brokerage events. Representative examples of events are the following:
  - ICT Proposers days and ICT Exhibition Innovate, Connect, Transform, Lisbon, Portugal, October 20-22, 2015 (Presented by Assistant professor Egons Lavendelis and researcher Mara Pudane);
  - FLAG-ERA Networking Event, December 9, 2015, Rome, Italy. (Presented by Egons Lavendelis).
  - ICT COST Action IC1303 Algorithms, Architectures and Platforms for Enhanced Living Environments (AAPELE) MC meeting, Ohrid, Macedonia, September 30-October 2, 2015 (Presented by Assistant professor Egons Lavendelis).
- The extended version of the tool has been presented during the numerous negotiations with potential partners, including representatives of companies and research institutions. Some examples of meetings are the following:
  - Meeting with CEO and board members of ICD Industries in Alesund, Norway, November 26, 2015 (Presented by Assistant professor Egons Lavendelis);
  - Meeting with representatives of CERN in Riga November 25, 2015 (Presented by researchers Larisa Survilo and Mara Pudane).
- International eINTERASIA conference in innovative IT solutions, knowledge and technology transfer was held in Almaty (Kazakhstan) in August 27-28, 2015 (prof. L.Novickis from RTU, Latvia was the Conference chairman). About 100 participants from EU and Central Asian countries took part in the conference. The SOPHIS results devoted to the development of semantic web services based Software framework and intelligent agents approach were presented at the conference (authors: prof. J.Grundspenkis, prof.L.Novickis, as.prof.E.Lavendelis from RTU). www.einterasia.eu

Education:

Doctoral Thesis:

1. Pēteris Rudzājs. Development of Education Demand and Offer Information Monitoring System's Model. Defended RTU Promotion Council P-07, September 2015, Scientific supervisor - prof. M. Kirikova.
2. Artūrs Bartusevičs. The Development and Implementation of Model-Driven Software Configuration Management Solutions. Defended RTU Promotion Council P-07, September 2015, Scientific supervisor - prof. L.Novickis

Master Thesis:

1. Andrejs Gaidukovs. Time Dimension in Business Process and Enterprise Architecture Modelling. Master Thesis defended June 2015. Scientific supervisor - prof. M. Kirikova.

Leader of the project No.2. J.Bārzdiņš 04.2016
(signature and transcript) *(date)*

2.3.1. Project No. 3

Title	Biophotonics: imaging, diagnostics and monitoring		
Project leader's name, surname	Jānis Spīgulis		
Degree	Dr.habil.phys.		
Institution	Institute of Atomic Physics and Spectroscopy (IAPS) at University of Latvia.		
Position	Professor, Department of Physics at University of Latvia. Head, Biophotonics Laboratory of IAPS		
Contacts	*Phone number*		+371 29485347; +371 67228249
	E-mail		janis.spigulis@lu.lv

2.3.2. Project goal and objectives
(Describe the project goals and objectives so that the achevements reported below could be placed in context and evaluated)

The project aims at development of innovative technologies for non-invasive capturing and processing of the bio-object images, including elaboration and assessment of novel image-based methods for clinical diagnostics and monitoring. Their implementation in healthcare and other related areas in collaboration with industrial partners is another goal, in order to create the basis for competitive new products and services.

The main research objectives for the 2nd period:

1. Performing experimental measurements of the approbation of new imaging technology in laboratory conditions:
1.1. to acquire the several spectral images from a digital color image data.
1.2. for contactless monitoring of cardiac and circulatory parameters at near infrared spectral range.
1.3. for imaging of tissue moisture distribution at near infrared range (1-2 microns)
2. Developing, installing and test the improved software for skin multimodal imaging by the prototype device "SkImager".

2.3.3. Description of gained scientific results
(Describe scientific results achieved during reporting period, give their scientific importance)

The research activities in the following groups was done:

-A methodology for obtaining several monochromatic spectral images from the digital color image with further conversion into distribution maps of skin tissue compounds - skin chromophores was developed. As the first step, the prototype device for obtaining three spectral images illuminated by laser light at three spectral bands was developed. Then the algorithm of conversion of the digital color images into distribution maps for mapping of skin malformations (melanoma, vascular formations etc.) was developed. The results are published in scientific papers and presented at international conferences.

-A methodology for non-contact monitoring of cardiovascular parameters by means of non-contact photoplethysmography was developed. First, an experimental prototype device for non-contact monitoring of blood flow at near-infrared illumination was developed. Then the algorithm for real-time high resolution imaging of blood flow was developed and imlemented

into custom developed MATLAB software. The software was tested in laboratory and later validated for non-contact monitoring of regional anesthesia effectiveness.

- A methodology for assessment of skin moisture by means of infrared imaging was developed. The research of the e□ect of di□erent moisturizing creams on skin was done at first time. Next, device for estimation of skin moisture by near-infrared imaging was developed and it was tested in laboratory. Next, then the algorithm of Monte-Carlo simulation of light-skin interaction was developed and tested. The results are presented at international conferences.

- The technical improvements of previously developed multi-modal imaging prototype device, which is intended for non-contact assessment of skin malformations (melanoma, vascular formations etc.) was developed.

2.3.4. Further research and practical exploitation of the results
(Describe further research activities that are planned, describe possibilities to practically exploit results)

In the next project period laboratory and clinical experiments are planned to test and validate our development prototype devices, in particular:

1. Performing experimental measurements of the approbation of new imaging technology in laboratory/clinical conditions:
1.1. to acquire the several spectral images from a digital color image data.
1.2. for contactless monitoring of cardiac and circulatory parameters at near infrared spectral range.
1.3. for imaging of tissue moisture distribution at near infrared range (1-2 microns).

2. Testing and validating skin skin diagnostic device *SkImager* in laboratory and clinical environment.

2.3.5. Dissemination and outreach activities
(Describe activities that were performed during reporting period to disseminate project results)
List of of results of the Project No3:
Publications:

1. Janis Spigulis, Ilze Oshina, "3x3 Technique for RGB Snapshot Mapping of Skin C hromophores" (online publication:10.1364/BODA.2015.JT3A.39), Bio-Optics: Design and Application 2015, Vancouver Canada, 12–15 April 2015. ISBN: 978-1-55752-954-1. **[1st period] (SCOPUS)**
2. Saknite I, Zavorins A, Jakovels D, Spigulis J, Kisis J. "Comparison of single-spot technique and RGB imaging for erythema index estimation", Physiological Measurement, Volume 37 (2016), Number 3. pp.333-346. doi:10.1088/0967-3334/37/3/333. http://dx.doi.org/10.1088/0967-3334/37/3/333 **[2nd period] (SCOPUS)**
3. J.Spigulis, I.Oshina, Z.Rupenheits. Smartphone single-snapshot mapping of skin chromophores. OSA Technical Digests, *accepted*, (2016). **[2nd period] (SCOPUS)**
4. Inga Saknīte, Aleksejs Zavorins, Janis Spigulis, Janis Kisis "Skin Erythema Assessment by an RGB Imaging Device: a Clinical Study", (online publication) Conference OSA Frontiers in Optics and Laser Science, 18–22 October 2015, San Jose, CA, USA. Poster session **[2nd period]**

Presentation in conferences:

1. Jacob Bauer, Ville Heikkinen, Janis Spigulis "Spectral reflectance estimation with an optical non contact device for skin assessment", Northern Optics & Photonics 2015 (NOP 2015), 2-4 June 2015, Lappeenranta, Finland. **[1st period]**
2. Ilze Oshina, Janis Spigulis, "Snapshot mapping of skin chromophores at triple-wavelength illumination" , 11th International Young Scientist Conference, Developments in Optics and Communications 2015, Latvia, April 8-10, p.21, 2015. **[1st period]**
3. Gatis Tunens, Inga Saknite, Janis Spigulis, "Modeling diffuse reflectance spectrum of skin in the near-infrared spectral range by Monte Carlo simulations", 11th International Young Scientist Conference, Developments in Optics and Communications 2015, Latvia, April 8-10, p.20, 2015. **[1st period]**
4. Jacob Bauer, Ville Heikkinen, Janis Spigulis, "Spectral reflectance estimation with an optical non contact device for skin assessment", 11th International Young Scientist Conference, Developments in Optics and Communications 2015, Latvia, April 8-10, p.12, 2015. **[1st period]**
5. Ilze Oshina, Janis Spigulis, "Image processing for snapshot RGB mapping of skin chromophores", Conference IONS Karlsruhe 2015, 26-29 June 2015. Poster session. **[1st period]**
6. J.Spigulis, I.Oshina "Monochomatic spectral imaging: principles and application for skin chromophore mapping". The 2nd Israeli Biophotonics Conference (IBPC-2), December 1-2, 2015, Bar-Ilan University, Ramat-Gan, Israel. Presentation **[2nd period]**
7. G.Tunens, I.Saknite, J.Spigulis. Modelling skin diffuse reflectance spectra in the near-infrared and visible range. 11th International Young Scientist Conference, Developments in Optics and Communications 2016, Latvia, March 21-23, p.28, 2016. **[2nd period]**
8. I.Oshina, Z.Rupenheits, J.Spigulis. Mapping of skin chromophores by snapshot taken with a smartphone. 11th International Young Scientist Conference, Developments in Optics and Communications 2016, Latvia Riga, March 21-23, p.31, 2016. **[2nd period]**
9. Saknite, G. Tunens, J. Spigulis. Study on near-infrared reflectance spectroscopy of skin for noninvasive estimation of skin hydration. LU 74.konference, 25.janvāris, 2016. Stenda referāts. **2nd period**
10. R. Janovskis, I. Saknite, J. Spigulis. Infrared spectroscopy and imaging for estimation of skin hydration. Developments in Optics and Communications, Riga, March 21-23, p.39, 2016. **[2nd period]**

Patent:

-METHOD AND DEVICE FOR CHROMOPHORE MAPPING UNDER ILLUMINATION OF SEVERAL SPECTRAL LINES. Authors: J.Spīgulis and I.Ošiņa. Latvian patent P-15-137, 20.02.2016. **[2nd period]**

PhD thesis:

-I.Saknīte, "Optical non-invasive determination and mapping of skin bilirubin, hemoglobin and water ". (Superviser J.Spīgulis) University of Latvia 11.12.2015. **[2nd period]**

Defended Master thesis **[1st period]:**

1. Olga Ļashuka. „Determination of pulse wave velocity by the non-contact photoplethysmography method", (Supervisor Dr. Uldis Rubīns.), University of Latvia.
2. Jacob Bauer. "Spectral reflectance estimation with an optical non contact device for skin assessment" – University of Eastern Finland, (Supervisors Prof. Ville Heikkinen and Prof. Janis Spigulis)

Bachelors thesis **[1st period]:**

I.Ošiņa, (2015) „The mapping of skin chromophores by three-chromatic laser illumination" (Supervisor Prof. J.Spīgulis), University of Latvia.

Leader of the project No.3. Jānis Spīgulis 04.2016.
(signature and transcript) *(date)*

2.4.1. Project No. 4

Title	Development of technologies for secure and reliable smart-city		
Project leader's name, surname	Ints Mednieks		
Degree	Dr.sc.comp.		
Institution	Institute of Electronics and Computer Science		
Position	Senior researcher		
Contacts	*Phone number*		+371 67558112
	E-mail		mednieks@edi.lv

2.4.2. Project goal and objectives
(Describe the project goals and objectives so that the achevements reported below could be placed in context and evaluated)

The overall objective of the project is to develop a world-class expertise in the area of "smart" city technologies, which can be used for monitoring of environment and urban infrastructure to ensure safe and reliable living conditions for citizens, thus creating the basis for development of competitive services and products.

Within this framework and in accordance with the “Regulation of the competition for National Research Programmes in the period of 2014-2017”, namely tasks 9, 10, and 11 set for the 2.2 Programme "The next generation of information and communication technology systems", the following specific objectives are put forward:

1. Provide centralized urban monitoring for security needs, based on the collection of data from video and other sensors located throughout the urban area, fast data transmission and efficient processing using high performance computing technology for the identification of specific security threats and generate warnings about them;
2. Advance the use of satellite or airborne remote sensing (RS) data for the control of emergency situations and dynamic monitoring of environment by transforming the information provided by remote sensors to the form of maps illustrating parameters characterizing an emergency or environment and their changes;
3. Develop a mobile ultra-wideband (UWB) antenna array radar-based imaging technology for mapping urban underground infrastructure as well as for creation of advanced security systems working in conditions where the direct visibility is obstructed or impossible, including examining the possibility of wireless data transmission of radar images in the 60GHz range;
4. Solving the bacteriological safety problems of city's water supply by creating a specialized control system.

2.4.3. Description of gained scientific results
(Describe scientific results achieved during reporting period, give their scientific importance)

Five research groups are formed for the execution of the project with the following research topics:
-EDI BIGDATA group will develop methods and software for video and other sensor data processing to target urban security problems;
-EDI REMSENS group will develop remote sensing data processing techniques for monitoring of the urban environment;
-EDI RADAR group will develop ultra-wideband radar technology-based solutions for urban security systems’ needs;

-RTU TI group of researchers will develop optical networking solutions for smart cities data transmission;
-RTU BF team of researchers will develop solutions for controlling the urban water supply systems.
The main results of the project achieved so far are described in this summary form. The full scientific report is attached in Appendix No.4.

EDI BIGDATA group:
1. A concept for analysis and processing of large-scale video and other signals within the smart city was developed. It includes collection of data from video surveillance cameras and other sensors and their transmission to the data processing centre servers using high-speed communications networks. The main emphasis is on the video signal analysis with respect to their rich contents. According to the concept, the data will be stored in specialized servers, and the analysis system will run autonomously without human intervention. The analysis results will be available to authorized persons. BIGDATA research group's work will be focused on development of data processing methods and algorithms for analysis of signal contents in order to detect security- related events and violation of laws and regulations.
2. Artificial neural networks (ANN) based on the so-called "Deep learning" are recognised as the most appropriate video analysis tools. Deep Learning examples for classification were implemented using EDI High Performance Computing (HPC) server and TensorFlow Deep Learning framework. It allows to explore ANN architectures suitable for solving smart city safety and security tasks.
3. Development of EDI HPC resources. Environment for development of deep neural networks was prepared based on EDI HPC server configuration with 4 NVIDIA Tesla K20 graphical processor cards. The research group is in a way to use HPC cluster for Deep Learning training. Linux Rocks operating system is explored for necessary machine learning tasks.
4. Classification example of two classes was created using Deep Learning with labelled data. For this purpose “Cat or Rabbit” image detector has been prepared, achieving accuracy more than 80% when training it on ~1900 images and testing on ~600 images.
5. Exploration of unique object descriptors. For this task the human facial images were processed. The constructed descriptor converts any image with face into feature vector which can be compared to other vectors in order to find the class members. The descriptor is based on AlexNet ANN architecture and trained on COLOR-FERET image data set. The achieved precision is 52.3% while testing it on more than 100 classes.
6. Research on detection of moving objects using Recurrent neural networks RNN as a virtual detection line. The developed neural network counts objects crossing the line. The development has to be continued in next project period.
7. A data acquisition method was developed, presented in the conference and described in the publication: K. Ozols, "Implementation of reception and real-time decoding of ASDM encoded and wirelessly transmitted signals", IEEE MAREW 2015.

EDI REMSENS group:
1. The following tasks of the smart city were chosen which can be solved with the assistance of remote sensing data processing:
-urban land use mapping for the needs of different urban services;
-vegetation mapping, change detection and plant health monitoring;
-development of precise land surface elevation model from LiDAR data to assist authorities in flooding situations.
2. Possibilities to use LANDSAT-8 satellite data for vegetation mapping in Riga area were explored. It was concluded that these data have insufficient spatial resolution and focus on the Sentinel-2 satellite data should be set. Commercial satellite data with high resolution should be used for solving more important tasks. Sample Worldview-2 images of Riga and surrounding territories were acquired. Sample vegetation and its change maps were prepared from Worldview-2 and Sentinel-2A images.

3. LiDAR data of Riga city and surroundings were obtained from Latvian Geospatial Information Agency for development of precise city ground elevation models. Sample ground elevation models over the sea level were prepared from these data. It is planned to use such models for flooding prediction of the territories.
4. Fusion possibilities of multisensory data were studied, obtained by the sensors with different spatial resolution. Land use classifiers were developed, based on Bayesian classification principles. They were applied to the data presented for the IEEE Geoscience and Remote Sensing section data fusion competition. The task was to classify pixels of images into land use categories, where the data were obtained from the RGB sensor and hyperspectral thermal sensor for the same urban area. Classifiers were developed using multi-dimensional models based on Gaussian, Dirichlet and gamma distributions. The cases where only single RGB or thermal infrared (TI) image was used as well as cases where data of both images were used were examined. It was found that combined use of several multi-dimensional distributions within the data model is productive. By combining all three distributions and sharing of both sensor data, the highest overall accuracy of classification was obtained, namely 95.8%. The obtained results were presented at the conference "Electronics 2015" in Palanga.
5. Selection task of the informative spectral bands for classification of hyperspectral images was considered. Methods for band selection were developed and classification results of the popular “Indian Pines” hyperspectral data set (see https://purr.purdue.edu/publications/1947) were obtained using constructed sets of spectral bands and Bayes as well as SVM (Support Vector Machine) classifiers. Results of this study were presented in the 74th Conference of the University of Latvia and a scientific paper is under preparation to be submitted before of the end of the reporting period.
6. The experiments with UAV (octocopter) were performed to learn its remote control, acquire multispectral and thermal images, merge multispectral imaging frames to form a mosaic image.

EDI RADAR group was focused mainly on practical experiments for testing applicability of ultra-wide band (UWB) technologies for solving security tasks in buildings as well as development of enhanced sensor functional modules.
For safety systems, ultra-wideband technology standardization situation in Europe was studied and the following applications listed in standards were selected on which to focus in the project: 1) radars for inspection of ground and walls, 2) sensors and positioning of objects in buildings.
During the reporting period, experiments were conducted to test ultra-wideband sensor technology application possibilities for security systems. A special test stand was created for this purpose and installed in the middle of the room to minimize influence of reflections. The stand contained two specialized antennas, transmitters (<100ps short pulse generator), detectable metal object and the receiver, where the signal was observed using a 20 GHz bandwidth oscilloscope Tektronix DPO72004C. The distance detection experiments to the object were performed using measurement of reception time of emitted and reflected signals. Distance measurement error did not exceed 6 cm when the object was placed between 80 and 255 cm apart from the antennas. Experiments were also carried out for the case when a plywood sheet was placed between the investigated object and the antennas. Also in this case reflections from the metal object were obtained, allowing to measure the distance to it. Experiments for testing the possibility of measuring thickness of non-metallic object (ice) were also performed in laboratory. Measurement error did not exceed 2% when the 5-17 cm thick sheet of ice was measured.
Experiments for object motion detection indoors were also carried out, based on previously developed method that uses principal component analysis and compensates impact of larger stationary objects. Movement of a human person in the room was successfully detected using radar with a central frequency 3 GHz and bandwidth 1.3 GHz. As an example, simple paper notebook movements were detected. To improve radar resolution untraditional method were tested on experimental setup. Results published and presented at conference. Work continued with experimental, autonomous radar sensor and new test module development to verify separate sensor modules and tune them.

During the second period simulation model for indoors object localization and tracking was created using pulse radar sensor technology. Model allows to test system using either imitated pulse radar data or real sensor data. Model tests with real sensor data revealed problems at current radar sensor which are planned to fix at next phase. Improved and tested indoor security radar sensor module. At next phase it is planned to continue work at indoor security sensor system (reduces size and improved manufacturing possibilities), wide band antenna development and test options for radar sensor distance improvement.
Within this research direction, two papers were published in journals, results were presented in two conferences and three bachelor's works were defended.

RTU TI group:
1. Analysis of different topologies of fiber optics transmission systems as well as creation of an experimental model by means of mathematical modelling was performed.
2. Technological solutions of 8 and 16 channel SS-WDM PON systems with the transmission speed of up to 10 Gbit/s in a channel have been developed enabling them to be fully integrated in the existing optical access networks, based on ITU-T G.694.1 frequency plan.
3. The application of the semiconductor optical amplifier has been evaluated increasing the data transmission speed from 2.5 to 10 Gbit/s in 16-channel spectrum sliced WDM-PON systems.
4. A model of spectrum sliced transceiver has been developed, which, by using digital signal processing (DSP), enables the transmission of 1 Gbit/s NRZ sliced broadband electrical signal, using electrical and opto-electrical system components with 500 MHz bandwidth, thus enabling to achieve a higher-speed data transmission using the already existing transmission system infrastructure.
The electrical and opto-electrical components, which are found in the transmitter and receiver block (transceiver) of the high-speed fiber optical access transmission system, are considered to be its weak point or bottleneck due to the limited frequency bandwidth and the transmission speed. The transmission speed of electrical components and accordingly the throughput band is restricted by the switching speed of transistors contained therein, as well as the heat originating as a result of it, which must be released. The solution for the limited throughput bandwidth problem that does not require a complete transceiver replacement is an electro-optical spectrum sliced transceiver for high bitrate optical signal transmission and receiving in optical access networks, where, by using digital signal processing (DSP), the electrical baseband signal containing the transmitted information is sliced. Certain parts of the sliced signal are transmitted through the fiber optical access network and the initial signal is restored in the receiver. Such spectrum sliced transceiver can ensure faster transmission speeds by using the already existing transceivers with a limited frequency throughput bandwidth. This way, the telecommunications service provider can increase the frequency bandwidth of optical access network components multiple times and accordingly also the transmission speed. Next generation optical access networks must be adaptive with regard to the ensured data transmission frequency bandwidth, which can dynamically change depending on the user demand. Thus, spectrum sliced transceiver technology, using DSP, in the nearest future will be a potential solution for overcoming the restrictions imposed by the limited frequency bandwidth of electrical components.

RTU BF group:
1. Literature studies have been done on topics of the current project. At least 67 literature sources were investigated to understand the latest achievements in on-line drinking water monitoring methods, tools and data analysis. The information obtained from these sources was analysed, summarized and presented as a state-of-the-art report at the IWA 7th Eastern European Young Water Professionals Conference and afterwards submitted as a scientific paper ”Review on Existing and Emerging Biological Contamination Detection Tools for Drinking Water Distribution Systems” in journal Water Science and Technology (WST): Water Supply. Various physical, chemical and biological methods have been examined in order to apply them for water quality monitoring in a drinking water distribution system (DWDS), and a possibility to use these data for a model development for detection and prediction of contamination events. The principle of event detection

system operation has been reviewed in detail. It was concluded that the choice of water quality parameters used for analysis by an event detection software as well as adjustment and configuration of event detection software is critical and more research including case studies is needed to find the set of parameters that help to maximize event detection efficiency without unnecessary increase of monitoring station costs.
2. The investigation of adenosine triphosphate (ATP) measurements application in chlorinated water was described in the scientific paper "Behavior and stability of adenosine triphosphate (ATP) during chlorine disinfection" and submitted for publication in journal Water Research. The goal in terms of publicity is not fulfilled; the problem raised is the schedule of publication and reviewing of the chosen high ranked journals. So the actual publication is postponed to next stages of project.
3. Within the framework of the project the lab-scale drinking water supply system has been designed and built. The aim of the system was to reach hydraulic, biochemical and physical conditions that might exist in real DWDS and transfer batch scale experiments in an environment that is more similar to natural conditions in DWDS. The system was designed to meet maximum available size of it and laboratory dimensions. The system was equipped with online sampling points with online sensors for temperature, pH, electrical conductivity, chloride ions, oxidation-reduction potential, total organic carbon measurements. The sensors installed in the system are Hanna Instruments Inc. production. All of the data collected from the online sampling points were sent to the computer where it was analysed. Also electromagnetic flow meter and manometers were installed to monitor the hydraulic parameters of system.
4. According to lab-scale drinking water supply system the hydraulic model for the system has been developed. The model is compatible with the long term drinking quality monitoring data acquiring system and drinking water quality model that has been also developed in terms of project. This kind of compatible system allows to measure the on-line drinking water quality, to model the drinking water quality in advance, detect the contamination event of drinking water and predict the potential spreading of the contaminant in drinking water supply system. This kind of a system is going to be a cornerstone for a monitoring of drinking water quality in real scale drinking water supply systems.

2.4.4. Further research and practical exploitation of the results
(Describe further research activities that are planned, describe possibilities to practically exploit results)

Future work of the EDI BIGDATA group will focus on research and data collection aspects using enhanced Deep learning neural networks architecture. For the analysis of urban security situations, one of the main problems is the lack of training data that can interfere with successful implementation of Deep neural networks. Therefore data clustering and data labelling will be considered.

During the next periods, EDI REMSENS group will develop elaborated algorithms for land use classification, land elevation model creation, dynamic vegetation mapping from Sentinel 2 data. This work will form a basis for development of dynamic maps, services or software for government authorities or other clients.

During the next periods EDI RADAR group test the developed methods for detecting small changes in indoor environment, object displacements (trajectory) in hardware and improve the radar sensor hardware, increasing the sensor range and usability.
Security systems based on developed UWB sensor solutions will be offered to private companies.

Developed FOTS technology for data transmission will be offered to municipalities for use in data collection networks from video and other sensors.

Experiments with bacterial contamination and event detection will be carried out by the RTU BF group during the next periods. Developed system for control of bacterial contamination in water supply system will be offered to municipalities.

2.4.5. Dissemination and outreach activities
(Describe activities that were performed during reporting period to disseminate project results)

Publications:

1. K. Ozols "Implementation of reception and real-time decoding of ASDM encoded and wirelessly transmitted signals." Microwave and Radio Electronics Week 2015 (MAREW2015), Pardubice, Czech Republic, April 21-23, 2015 (+ conference presentation).
2. K. Krumin'sh , V. Peterson, V. Plotsin'sh. „The influence of thermal hysteresis of a clocked comparator on the operation of the comparator type sampling converter", Automatic Control and Computer Sciences, July 2015, Volume 49, Issue 4, pp. 245-253.
3. E. Hermanis, M. Greitans , V. Aristov. „Identification of characteristics of two-terminal networks from the pulse response of the current" Automatic Control and Computer Sciences, July 2015, Volume 49, Issue 4, pp 239-244.
4. Dejus S., Nescerecka A., Nazarovs S., Juhna T., „Review on Existing and Emerging Biological Contamination Detection Tools for Drinking Water Distribution Systems (DWDS) Online Monitoring", Proceedings of the 7th IWA Eastern European Water Professionals Conference, Belgrade, 2015, p.320-332 (+ conference presentation).
5. Aristov, V.; Shavelis, R.; Shupols, G.; Cirulis, R., "An investigation of non-traditional approach to narrowing the GPR pulses," in Radioelektronika, 2015 25th International Conference , vol., no., pp.373-375, 21-22 April 2015 (+ conference presentation).
6. S. Spolitis, L. Gegere, A. Alsevska, I. Trifonovs, J. Porins, and V. Bobrovs „Optical WDM-PON Access System with Shared Light Source" Progress In Electromagnetics Research Symposium, PIERS 2015 in Prague, Czech Republic, 06-09 July, 2015 (+ conference presentation).
7. Ingrīda Lavrinoviča un Jurģis Poriņš "An Improvement of EDFA efficiency by using Ytterbium co-doped optical fibers", IEEE BlackSeaCom'2016 (submitted).
8. Jūlija Putrina and Vjačeslavs Bobrovs "Evaluation of Erbium Doped Fiber Amplifier Application in Fiber Optics Transmission Systems", PIERS 2016 (submitted).
9. Vladislavs Bičkovs and Vjačeslavs Bobrovs "Performance Evaluation of a 40 Gbps WDM Transmission System with a Single-pump Raman Amplifier", PIERS 2016 (submitted).
10. Aivars Lorencs, Ints Mednieks, Juris Sinica-Sinavskis "On selection of informative bands for classification of hyperspectral images", Automatic Control and Computer Sciences (in preparation).

Presentation in conferences:

1. Vladimir Aristov, Rolands Shavelis, Gatis Shupols and Rudolfs Cirulis. „An Investigation of Non-traditional Approach to Narrowing the GPR Pulses". MAREW 2015. Microwave and Radio Electronics Week 2015. 25th International Conference "Radioelektronika 2015". Pardubice, Czech Republic, April, 21-22, 2015. Poster session.
2. Aivars Lorencs, Ints Mednieks, Juris Sinica-Sinavskis "Classification of Multisensor Images With Different Spatial Resolution". The 19th International Conference ELECTRONICS 2015, Palanga, Lithuania, 15-17 June, 2015.
3. Aivars Lorencs, Juris Siņica- Siņavskis "Spectral channel selection using variance", LU 74th conference, Riga, February, 2016.
4. Dejus S., Nescerecka A., Nazarovs S., Juhna T., „Review on Existing and Emerging Biological Contamination Detection Tools for Drinking Water Distribution Systems" (DWDS) Online Monitoring, Proceedings of the 7th IWA Eastern European Water Professionals Conference for young and senior water professionals, Belgrade, 2015, p.320-332.
5. Nescerecka A., The application of adenosine-triphosphate (ATP) measurements for determination of bacterial viability in chlorinated drinking water, How Dead is Dead Conference

IV, Eawag, Swiss Federal Institute of Aquatic Science and Technology, Duebendorf/Zurich, Switzerland, 21–22 May 2015.

6. Nescerecka, A., Juhna, T., Hammes, F., 2015. „Automated Flow Cytometry Approaches for Assessment of Chlorination Efficacy on Aquatic Bacterial Communities", How Dead is Dead IV conference, Eawag, Swiss Federal Institute of Aquatic Science and Technology, Duebendorf/Zurich, Switzerland, 21–22 May 2015. Poster session.
7. Nescerecka, A., Juhna, T., Hammes, F., 2015. „The Application of Adenosine- Triphosphate Measurements for Determination of Bacterial Viability in Chlorinated Drinking Water", How Dead is Dead IV conference, Eawag, Swiss Federal Institute of Aquatic Science and Technology, Duebendorf/Zurich, Switzerland, 21–22 May 2015. Poster session.

Patents:

1. LR patent No.15068.Stroboscopic converter for detection of ultra-wideband radar signāls. Inventors: Kārlis Krūmiņš, Vilnis Pētersons, Valdemārs Plociņš, Aivars Ševerdaks. Applicant: Institute of Electronics and Computer Science.
2. Patent application submitted: Sandis Spolitis, Lilita Gegere, Anita Alsevska, Ilja Trifonovs, Jurgis Porins, Vjaceslavs Bobrovs „Implementation of WDM-PON technology".

Defended doctoral thesis:

1. "Development and evaluation of high-speed optical access systems", Dr.sc.ing. Sandis Spolitis. RTU.

Defended Master thesis:

1. Matīss Viekalis „ Compensation methods of dispersion and research in WDM – PON system", (Supervisor Prof. Dr.sc.ing. Ģirts Ivanovs);
2. Viktors Romans „ Research and Evaluation of Chromatic Dispersion Compensation Schemes for Long-Haul Fiber Links", (Supervisor Prof. Dr.sc.ing. Jurģis Poriņš);
3. Ilona Ābola „ Evaluation of Chromatic Dispersion Compensation Methods in WDM-PON Systems", (Supervisor Prof. Dr.sc.ing. Ģirts Ivanovs);
4. Alvis Meņģo „ All-Optical Wavelength Conversion in Wavelength Division Multiplexing Systems" (Supervisor Prof. Dr.sc.ing. Ģirts Ivanovs);
5. Zane Upeslace "Evaluation of DB and DSPK Modulation Formats in WDM Transmission Systems", Ms.sc.ing.;
6. Agris Sīlis „ Optical Signal Regeneration in Completely Optical Way", (Supervisor Prof. Dr.sc.ing. Jurģis Poriņš);
7. Mārtiņš Puķītis "Multidimensional distributions application aspects in analysis of multispectral images" (Supervisors Prof. Aivars Lorencs Defended LU FMF 08.06.2015).

Defended bachelor thesis:

1. Abajs, M. (2015). Ultra-Wideband Pulse Radar Sensor Application in Security Systems (Unpublished bachelor thesis). Riga Technical University. https://nda.rtu.lv/en/view/14134
2. Lielpinka, M. (2015). Remote Sensing Data Acquisition and Processing Using Unmanned Aircraft (Unpublished bachelor thesis). Riga Technical University. https://nda.rtu.lv/en/view/14023
3. Maurins, M. (2015). Non-dectructive Ice Thickness Monitoring (Unpublished bachelor thesis). Riga Technical University. https://nda.rtu.lv/en/view/14130.

3 public seminars organized about the results of the project no.4 obtained during the first and second period, we participated in 2 public seminars of SOPHIS programme.

Leader of the project No.4. I. Mednieks 04.2016

(signature and transcript) *(date)*

PART 3: INFORMATION ABOUT PROGRAM FINANCE

The short information about the use of program finance

The total planned funding for the whole programme 2 250 000 EUR.
Funding of the programm for 2.period **516609.7****EUR

Use of the funding:

		1. period	2. period	3. period	4. period
	TOTAL	433677.00	**516609.7****		
	Personal costs	278264.3	**440230.31****		
	Travel	31718.84	**59466.39****		
	Consumables and services	53326.92	**15016.89****		
	Equipment	19972.91	**51086.5****		

** *The exact amount will be known after the second phase*

Leader of the programme M.Greitāns 04.2016.
(signature and transcript) *(date)*