Izglītības un zinātnes ministrija

Studiju un zinātnes administrācija

National Research Programme

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

Periodic progress report for the period 1.06.2014-30.04.2015

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 1. 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 acronim **SOPHIS**
1.3. Programme web page address, http://sophis.edi.lv/;
http://www.edi.lv/lv/projekti/vpp-projekti/vpp-sophis
1.4. Programme principal investigator (PI): Dr.sc.comp. Modris Greitāns, +371_67558155, modris_greitans@edi.lv.
(name, surname, phone, e-mail)

1.5. Contact person: Dr.sc.comp. Modris Greitāns , +371 67558155, modris_greitans@edi.lv.
(name, surname, phone, e-mail)
1.6. Report for a period from 2014_ June 1 till 2015 April 30

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 and 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".
Activities of the project contain research, technology validation and transfer, investment in education, publicity and technological forecasting. SOPHIS is implemented by internationally recognized research teams with expertise in national 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, PhD students and undergraduate students. The cooperation partners from economic sector represent end-users, industry and technology transfer companies. Strategic steering board includes the world-class scientists from the relevant areas as well as leading industry representatives.

1.8. Executive summary of the programme

The main activities, fulfilled tasks and achieved results are summarized in the following tables.

Project 1:

Tasks	Planned results	Achieved results
1. Development of cyber-physical systems of smart sensor and their network innovative hardware and software platform:		
1.1. Development of experimental prototype of modular platform for embedded systems prototyping, profiling and debugging and evaluation;	Experimental prototype;	Experimental prototype of EDI Testbed adapter was developed (appendix 1, section 1, "Testbed Adapter")
1.2. Development of testbed for wireless sensor networks	System concept developed;	Testbed architecture concept was developed (appendix 1, section 1, "EDI TestBed Architecture")
2. Research and develop conception for use of cyber-physical systems in medical and telemedicine uses:	Scientific report of the period	Scientific report of the period was written (appendix 1, sections 2, 3 and 4)
2.1. Development of smart clothing platform (hardware, architecture and software) for development of easily wearable sensor networks;		In addition: Two experimental prototypes were developed (head position sensor (appendix 1, section 2) and knee joint sensor for rehabilitation (appendix 1, section 3).
2.2. Development of approach for data registration and analysis for medical cyber-physical systems.		Prepared and published two publications, which are indexed by SCOPUS. One presentation in ACM/IEEE IPSN conference
3. Usage of smart sensors in intelligent transport systems:		
3.1. Research of different approaches of data gathering of different types and dimensions about surrounding environment of the transport.	Preparation of publication	Prepared and published one publication which is indexed by SCOPUS
3.2. Intelligent transport system communication methods for cooperation	Scientific review of the specific stage	Scientific report of the period (appendix 1, sections 5 and 6)

between vehicles as well as vehicle to road infrastructure;		In addition: four additional publications, of which two are indexed by SCOPUS database. Presented one thesis in conference.

Project 2:

Work tasks	Planned	Achieved
1. Development of the theoretical background for the ontology- and web technology-based graphical ad-hoc query language.	Prepared scientific publication	Published scientific publication: J. Barzdins, E. Rencis and A. Sostaks, **Fast Ad Hoc Queries Based on Data Ontologies**. In: H.M. Haav, A. Kalja, T. Robal (Eds.), Frontiers of AI and Applications, Vol. 270, Databases and Information Systems VIII, IOS Press, pp. 43-56, 2014.
2. Development of the ontology- and web technology-based controlled natural ad-hoc query language which can be used directly by end-user (without involvement of the programmer).	Description of query language	Developed query language. Description in Annex 2.1. (in Latvian)
3. Development of the web technology-based tool building technologies and methods for modeling of complex, hard-to-formalize systems.	Methodology	Methodology described in Annexes 2.2.1 and 2.2.2 (in Latvian)
4. Research of the ontology-based linked data technologies for applications of e-government and e-health.	Description of current *state of art* in the field.	Research on the best practice of application of linked data in various domains. Annex 2.3 (in Latvian)
5. Developing new methods for natural language parsing into the form of semantic graphs based on n-ary predicate approach (such as AMR, FrameNet, BabelNet) for information extraction from natural language texts (natural language understanding tasks).	Prepared scientific publication	Published scientific publication: Barzdins G., Paikens P., Gosko D.. Riga: from FrameNet to Semantic Frames with C6.0 Rules. SemEval 2015 Task 18: Semantic Dependency Parsing. Proceedings of the 9th International Workshop on Semantic Evaluation (SemEval 2015), Association for Computational Linguistics, pp. 960–964. (http://www.aclweb.org/anthology/S15-2160)
6. Development of methods, algorithms and their support software for analysis of knowledge structure models.	Description of the method and algorithm. Prepared	PhD thesis: Armands Šlihte. THE INTEGRATED DOMAIN MODELING: AN APPROACH & TOOLSET FOR ACQUIRING A

	scientific publication	TOPOLOGICAL FUNCTIONING MODEL. (Defended in *RTU* Promotion Council P-07 8.06.2015). Methods, algorithms and their support tool have been described in "IFS User Manual v.1.0". Accessible on demand in RTU Department of Artificial Intelligence and System Engineering.
7. Study of related works in the domain of structural compatibility between processes, enterprise architectures and knowledge, as well as development of initial draft for ideal linkage model	Scientific report	Published scientific publication: Kirikova, M. Enterprise Architecture and Knowledge Perspectives on Continuous Requirements Engineering. Proceedings of REFSQ-2015 Workshops, Research Method Track, and Poster Track co-located with the 21st International Conference on Requirements Engineering: Foundation for Software Quality. Essen, Germany, March 23, 2015. CEUR-WS.org, Vol. 1342, ISSN 1613-0073, pp. 44-51. (**SCOPUS**). accessible: http://ceur-ws.org/Vol-1342/05-CRE.pdf
8. Development of demonstration prototype for integration of semantic network services into e-logistics portal.	Prepared scientific publication	Published scientific publications: Bartusevičs, A., Novickis, L., Lesovskis, A. Model-Driven Software Configuration Management and Semantic Web in Applied Software Development. No: Recent Advances in Telecommunications, Informatics and Educational Technologies: Proceedings of the 13th International Conference on Telecommunications and Informatics (TELE-INFO '14) , Turkey, Istambul, 15.-17. december, 2014. Istambul: WSEAS Press, 2014, 108.-116.lpp. ISBN 978-1-61804-262-0. Bartusevičs, 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. March, 2015. Vienna: 2015, 32.-39.lpp. ISBN 978-1-61804-285-9. ISSN 1790-5117.
9. Develop on data models and ontologies based methods for big data accessibility; propose new suitable for internet methods for data query and visualization.	Prepared scientific publication	Published scientific publications: Rudolfs Bundulis, and Guntis Arnicans, Concept of virtual machine based high resolution display wall. Information, Electronic and Electrical Engineering (AIEEE), 2014 IEEE 2nd Workshop on Advances in. pp. 1-6, IEEE, 2014. DOI: 10.1109/AIEEE.2014.7020317, Rudolfs Bundulis, and Guntis Arnicans. Virtual Machine Based High Resolution Display Wall: Experiments on Proof of Concept. International Conference on Systems, Computing Sciences and Software Engineering (SCSS 14) , Electronic CISSE 2014 Conference Proceedings, 2014. (to be published Innovations and Advances in Computer, Information, Systems Sciences, and Engineering. LNEE, Springer) Posters: Rudolfs Bundulis, Guntis Arnicans, and Rihards Gailums. NVENC Based H.264 Encoding for Virtual Machine Based Monitor Wall Architecture, GPU Technology Conference, San Jose, March 17-20, 2015
10. Develop business process model usage in program runtime event analysis to increase information systems security level.	Prepared scientific publication	Published scientific publication: I.Oditis, J.Bicevskis Asynchronous Runtime Verification of Business Processes 7th International Conference on Computational Intelligence, Communication Systems and Networks (CICSyN'2015) pp. 103-108, 2015

Project 3:

Work tasks	Planned	Achieved
1. To elaborate methodologies of experimental measurements for laboratory approbation of the new imaging technologies: 1.1. for obtaining several	Two methodologies of experimental	Two methodologies of experimental measurements elaborated – for obtaining three monochromatic spectral images from the data of single digital color image, and for non-

monochromatic spectral images from the data of single digital color image. 1.2. for non-contact monitoring of cardiovascular parameters at the near-infrared spectral range.	measurements	contact monitoring of cardiovascular parameters at the spectral range 700-900nm (Annex 3, in Latvian).
2. To prepare and submit a post-deadline application for a conference report on project topic at SPIE/BIOS'2015 (7-12/02/2015, San Francisco).	Abstract of the report	Due to delayed start of the project, the post deadline application was submitted too late and was not accepted; instead, the prepared material was presented at a conference of similar level, OSA conference *Optics in the Life Sciences* (Vancouver, CA, 12-15/04/2015) and published in SCOPUS-cited conference proceedings https://www.osapublishing.org/abstract.cfm?uri=boda-2015-JT3A.39&origin=search

Project 4

Work tasks	Planned	Achieved
1. Concept development for multicamera video processing and automatic analysis of the security situation.	System concept developed	Presented in Appendix no.4 (section 1)
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	Interim scientific report	Presented in Appendix no.4 (section 2)
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. Research of the signal processing methods for detection of changes and object movement in rooms. 3.3. Development of UWB radar	Interim scientific report	Presented in Appendix no.4 (section 3)

sensor modules.	Experimental mockup	Described in Appendix no.4 (section 3.3)
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.	Model	Described in Appendix no.4 (section 4)
4.2. Estimation of applicability and development of active optical elements for fiber optic network solutions	Prepared publication; Developed and submitted patent application	Publication submitted and accepted Patent application prepared and submitted.
4.3. Development of new FOT technologies for smart city data transmission	Presentation	Presentation prepared for the conference PIERS 2015
5. Development of the bacterio-logical quality control system for city water supply system		
5.1. Testing and optimization of water quality control methods in batch experiments. Identification of applicable sensors.	Set of methods to be used in dynamic water control systems. Prepared publication	Described in Appendix no.4 (section 5) Prepared publication for IWA journal - Water Science and Technology.
5.2. Adjustment of pilot level experimental system to support experiments planned for the project	Experimental water supply system	Developed, described in Appendix no.4 (section 5)
5.3. Development of hydraulic model for the experimental system	Hydraulic model	Developed, described described in Appendix no.4 (section 5)
5.4. Measurements within the experimental system	Results of experiments. Results f preliminary tests of the effectiveness of methods.	Described in Appendix no.4 (section 5)

1.9. Results of the programme

Nr. p.k.	Programme Activities							
		Planned for whole programme	Unit of measurement	Achieved in the first period of projects				
				Pr.1	Pr.2	Pr.3	Pr.4	*Total*
1.	Research	12	Software prototypes					

		15	Methodology, descriptions		2	2		4
		21	Mock-ups, prototypes, Technologies	3		2		5
		6	Involvement in international projects	1				1
2.	Technology Trasfer	15	Approbated technologies and prototypes			1		1
		12	Patents				s.*	1
3.	Investment in education	22	Defended doctoral thesis		1	s.*		1
		52	Defended Master thesis		6	2	5	13
		13	Improved courses					
4.	Dissemination and long-term technological forecast	80	Scientific publications	7	8	3	7	23
		54	Presentations in international conferences	10	3	3	5	21
		4	Participation in exhibitions	2				2
		25	Organized public seminars	1.25	1.25	1.25	1.25	5
		2	Organized conferences					
		40	Popular-scientific papers/events	2				2
		4	Technological forecast					

* s. - submitted

Performance indicator	Results	
	Planned	Achieved
Scientific performance indicators		
1. Scientific publications:	80	23
number of original scientific articles (*SCOPUS*)(SNIP>1)	17	
number of original scientific articles in journals or in proceedings of conferences of the databases SCOPUS and WoS	63	15
number of reviewed scientific monographs	1	
Other original scientific articles		8
2. In the framework of the programme:		
number of defended doctoral thesis	22	1
number of defended master's thesis	52	13
3. Elaborated methods for establishment of epigenetic effects of selected species under certain biotic and abiotic conditions	13	
4. Developed in vitro system for cultures in order to conserve protected species		
Performance indicators of the promotion of the programme		

1. Interactive events to promote the process and results of the programme. Target groups should include students and the number of:		
conferences	50	21
seminars	4	0
organized seminars	25	5
popular-science publications	4	
exhibitions	4	2
2. Press releases		
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	10000	
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)		
1.3. income from contractual jobs that are based on results and experience acquired in the framework of the programme	435000	44576
2. Number of applied for, registered, and valid patents or plant varieties in the framework of the programme:	12	
in the territory of Latvia	10	1
abroad	2	
3. Number of new technologies, methods, prototypes or services that have been elaborated in the framework of the programme and approbated in enterprises	15	
4. Number of new technologies, methods, prototypes, products or services that have been submitted for implementation (signed contracts on transfer of intellectual property)	3	

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

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

Publications in SCOPUS and/or WoS:

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.url?eid=2-s2.0-84939511173&origin=resultslist&sort=plf-f&src=s&st1=Nikisins&st2=&sid=337DADE46B4D3788C19BD4B3BDC84D37.WeLimyRvBMk2ky9SFKc8Q%3a20&sot=b&sdt=b&sl=21&s=AUTHOR-NAME%28Nikisins%29&relpos=2&relpos=2&citeCnt=0&searchTerm=AUTHOR-NAME%28Nikisins%29
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. J. Barzdins, E. Rencis and A. Sostaks, Fast Ad Hoc Queries Based on Data Ontologies. In: H.M. Haav, A. Kalja, T. Robal (Eds.), Frontiers of AI and Applications, Vol. 270, Databases and Information Systems VIII, IOS Press, pp. 43-56, 2014. (SCOPUS) http://ebooks.iospress.nl/volumearticle/38187
7. Kirikova, M. Enterprise Architecture and Knowledge Perspectives on Continuous Requirements Engineering. Proceedings of REFSQ-2015 Workshops, Research Method Track, and Poster Track co-located with the 21st International Conference on Requirements Engineering: Foundation for Software Quality. Essen, Germany, March 23, 2015. CEUR-WS.org, Vol. 1342, ISSN 1613-0073, pp. 44-51. (SCOPUS) Pieejams: http://ceur-ws.org/Vol-1342/05-CRE.pdf
8. Janis Spigulis, Ilze Oshina, “3x3 T echnique 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

9. 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. http://link.springer.com/article/10.3103%2FS0146411615040070
10. 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. http://link.springer.com/article/10.3103%2FS0146411615040057
11. Aristov, V.; Shavelis, R.; Shupols, G.; Cirulis, R., "An investigation of non-traditional approach to narrowing the GPR pulses," in Radioelektronika (RADIOELEKTRONIKA), 2015 25th International Conference , vol., no., pp.373-375, 21-22 April 2015 doi: 10.1109/RADIOELEK.2015.7129043 (MAREW 2015) http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=7129043&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel7%2F7115433%2F7128969%2F07129043.pdf%3Farnumber%3D7129043
12. 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. DOI: 10.1109/RADIOELEK.2015.7129020 http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7129020
13. Bartusevičs, A., Novickis, L., Lesovskis, A. Model-Driven Software Configuration Management and Semantic Web in Applied Software Development. No: Recent Advances in Telecommunications, Informatics and Educational Technologies: Proceedings of the 13th International Conference on Telecommunications and Informatics (TELE-INFO '14) , Turkey, Istambul, 15.-17. december, 2014. Istambul: WSEAS Press, 2014, 108.-116.lpp. ISBN 978-1-61804-262-0.
14. Bartusevičs, 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, Austria, Vienna, 15.-17. March, 2015. Vienna: 2015, 32.-39.lpp. ISBN 978-1-61804-285-9. ISSN 1790-5117.
15. Rudolfs Bundulis, and Guntis Arnicans, Concept of virtual machine based high resolution display wall. Information, Electronic and Electrical Engineering (AIEEE), 2014 IEEE 2nd Workshop on Advances in. pp. 1-6, IEEE, 2014. DOI: 10.1109/AIEEE.2014.7020317, http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7020317

Publications

1. 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

2. 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

3. Barzdins G., Paikens P., Gosko D.. Riga: from FrameNet to Semantic Frames with C6.0 Rules. SemEval 2015 Task 18: Semantic Dependency Parsing. Proceedings of the 9th International Workshop on Semantic Evaluation (SemEval 2015), Association for Computational Linguistics, pp. 960–964. (http://www.aclweb.org/anthology/S15-2160)

4. Sandis Spolitis, Lilita Gegere, Anita Alsevska, Ilja Trifonovs, Jurgis Porins, and Vjaceslavs 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. pp.1–5.
5. Rudolfs Bundulis, and Guntis Arnicans. “Virtual Machine Based High Resolution Display Wall: Experiments on Proof of Concept” International Conference on Systems, Computing Sciences and Software Engineering (SCSS 14) , Electronic CISSE 2014 Conference Proceedings, 2014. (to be published Innovations and Advances in Computer, Information, Systems Sciences, and Engineering. LNEE, Springer)
6. 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.
7. 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, 2015.
8. 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.

Conferences thesis and presentations:

1. 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

2. 31.08.-06.09.2014. Program manager M.Greitāns participated in European signal processing conference "EUSIPCO 2014", Lisbon, Portugal, where VPP SOPHIS ideas and results were discussed.
3. 21.-22.01.2015. Program manager M.Greitāns participated in KTI ARTEMIS "Brokerage Event 2015" Amsterdam, Netherlands, where he presented and discussed VPP SOPHIS ideas and results.
4. 03.-20.02.2015. Project members participated in 73rd scientific conference of the University of Latvia, where they presented two reports: "Localization within buildings with digitally controllable antennas" (L.Seļāvo, I.Driķis, R.Balašs) and "Creation of heterogenous wireless communications range" (A.Mednis, J.Judvaitis, R.Ruskuls).
5. 09.-11.03.2015. Program manager M.Greitāns participated in international event "ARTEMIS Co-Summit 2015" Berlin, Germany, where he presented and discussed VPP SOPHIS ideas and results.
6. Atis Hermanis presented his work in scientific research contest "ResearchSlam" organized by RTU on year 2015 and gained 1st place
7. Emil Syundyukov presented his bachelors thesis "Embedded hardware and software for health data monitoring during rehabilitation" in the annual stipend contest for best IT bachelors thesis by company Exigen Services Latvia and RTU Development fund on year 2015 and gained 2nd place
8. August 8, 2015, researcher Atis Hermanis participated in Riga IT Demo center press conference and demonstrated wearable sensor system developed in EDI.
9. 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/
10. 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.
11. 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 (arī prezentācija).
12. 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 (arī prezentācija).
13. 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 (arī prezentācija).
14. 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/
15. 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, 2015. 20. lpp. and Poster.

16. Bartusevičs, 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, Austria, Vienna, 15.-17. March, 2015. Vienna: 2015.
17. Bartusevičs, A., Novickis, L., Lesovskis, A. Model-Driven Software Configuration Management and Semantic Web in Applied Software Development. No: Recent Advances in Telecommunications, Informatics and Educational Technologies: Proceedings of the 13th International Conference on Telecommunications and Informatics (TELE-INFO '14) , Turkey, Istambul, 15.-17. december, 2014.
18. 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, 2015.

Poster sessions.

1. Rudolfs Bundulis, Guntis Arnicans, and Rihards Gailums. "NVENC Based H.264 Encoding for Virtual Machine Based Monitor Wall Architecture", GPU Technology Conference, San Jose, Mart 17-20, 2015. Posters:*http://ondemand.gputechconf.com/gtc/2015/posters/GTC_2015_Visualization_Large_Scale___Multi_Display_01_P5174_WEB.pdf*
2. Ilze Oshina, Janis Spigulis, "Image processing for snapshot RGB mapping of skin chromophores", Conference IONS Karlsruhe 2015, 26-29 June 2015. Poster session.
3. 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.

IFS User Manual v.1.0. Available on request from RTU Department of Artificial intelligence.

Patent:
Submitted application for Latvian Patent: Sandis Spolitis, Lilita Gegere, Anita Alsevska, Ilja Trifonovs, Jurgis Porins, Vjaceslavs Bobrovs "Realization of WDM-PON technology".

Exhibitions:

- Participation in exhibition «Skola 2015», February 27-28, Riga
- 10.-11.10.2014. A.Mednis participated in Exhibition MINOX 2014 organized by Riga Technical University.

Popular publications:

- 2015-05-05 Latvia Radio1 show "Zināmais nezināmajā" interview with Ati Hermani
- 2015-02-11 Latvia Radio1 show "Monopols" interview with Leo Seļāvo

Involment in education:

PhD thesis:

1. Armands Šlihte. "THE INTEGRATED DOMAIN MODELING: AN APPROACH & TOOLSET FOR ACQUIRING A TOPOLOGICAL FUNCTIONING". (Defended RTU Promotion Council P-07 8.06.2015)

Defended Master thesis:

1. Svetlana Otto. Daudzaģentu sistēmu un ontoloģiju projektēšanas metožu integrēšanas metodoloģiju analīze (Supervisor prof. J.Grundspeņķis. Defended RTU DITF 15.06.2015)
2. Emil Bikjanov. Zināšanu bāzu un deduktīvo datu bāzu salīdzināšanas analīze (Supervisor prof. J.Grundspeņķis. Defended RTU DITF 15.06.2015)
3. Andrejs Gaidukovs. Laika dimensija biznesa procesu un uzņēmumu arhitektūras modelēšanā (Supervisor prof. M.Kirikova. Defended RTU DITF 16.06.2015)
4. Edgars Kirkiļevičs. Sadarbojošos procesu testēšana (Supervisor prof. J.Bičevskis. Defended LU DF 02.06.2015)
5. Dace Damberga. Uzraudzītas mašīnmācīšanās klasifikatoru izpēte un empīriska salīdzināšana (Supervisor prof. Guntis Bārzdiņš. Defended LU DF 05.06.2015)
6. Zane Siliņa. Latviešu valodas sintaktiskā analizatora 'Čankeris' modernizācija (Supervisor prof. Guntis Bārzdiņš. Defended LU DF 01.06.2015)
7. Matīss Viekalis „ Compensation methods of dispersion and research in WDM – PON system", (Supervisor Prof. Dr.sc.ing. Ģirts Ivanovs);
8. Viktors Romans „ Research and Evaluation of Chromatic Dispersion Compensation Schemes for Long-Haul Fiber Links", (Supervisor Prof. Dr.sc.ing. Jurģis Poriņš);
9. Ilona Ābola „ Evaluation of Chromatic Dispersion Compensation Methods in WDM-PON Systems", (Supervisor Prof. Dr.sc.ing. Ģirts Ivanovs);
10. Alvis Meņģo „ All-Optical Wavelength Conversion in Wavelength Division Multiplexing Systems" (Supervisor Prof. Dr.sc.ing. Ģirts Ivanovs);
11. Agris Sīlis „ Optical Signal Regeneration in Completely Optical Way", (Supervisor Prof. Dr.sc.ing. Jurģis Poriņš);
12. Olga Ļashuka. „Determination of pulse wave velocity by the non-contact photoplethysmography method", (Supervisor Dr. Uldis Rubīns.)
13. 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:

1. Emil Syundyukov, bachelors thesis “Embedded hardware and software for health data monitoring during rehabilitation”
2. 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
3. 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
4. Maurins, M. (2015). Non-dectructive Ice Thickness Monitoring (Unpublished bachelor thesis). Riga Technical University. https://nda.rtu.lv/en/view/14130
5. Oshina, I. (2015), „Mapping of skin chromophores at tri-chromatic laser illumination”, University of Latvia, supervisor Prof. J.Spigulis.

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

2.2.1 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 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, intellignet transport systems and other fields important to the society, thus promoting economics based on production of competetive 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, analyze 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 competetive solutions developed for integration of physical and virtual world in cyberphysical systems while developing competetive 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 easo of providing service in medical services, providing more effective prophilaxis, 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 intelligen transport system technologies;

Specific objectives for the first term of the project were defined:

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 wehicle to road infrastructure. Submit a research paper.

2.3.1 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.

In short, research in the following groups was done:

- Smart sensor and their network innovative hardware and software platform:
  1. TestBed – test environment for wireless sensor system development and testing. An experimental prototype of the test bed node has been developed, as well as the required software for programming it. Test bed makes it easier to develop and debug CPS.
- Medicine and telemedicine uses of cyber-physical systems:
  1. BoASen – Smart sensors for determining human bio-mechanics. Developed experimental prototypes, for measuring back surface shape in 3 dimensions in real time, thus helping in scoliosis prohylaxis, as well as determining the position of head and neck. For example, for children, who require corrections of this position for improvement of health. The results are published in scientific papers and presented at international conferences.
  2. JoSen – Sensor system for knee joint management during the time of rehabilitation. An experimental prototype has been developed for determining the angle of knee joint in real time, thus helping the knee rehabilitation after a trauma or operation. The results have been published in scientific papers and presented in and international conference.
  3. MECG – mobile smart sensor system for measurement of health parameters including hearth operation monitoring. Latvian leading health

treatment institution doctors have been interviewed about the requirements and possibilities for using in mobile human vital parameter sensors. Work has been done for development of experimental prototype of mobile cardiograph. The work continues.

- Intelligent transport systems:
  1. ImPro – signal (including image) processing for evaluation of the environment of intelligent transport systems. Image processing algorythms, which are able to monitor the environment while the car drives on road or track, and also the attention state of the drive. Results are described in a publication.
  2. GCDC – intelligent transport system for safer and more efficient driving. Currently work is being done on retrofitting a car with sensors, including 3D lidar and RTK GPS device. Model for decision making is being developed for a semi-automatic and completely automatic car. This is done with the goal in mind to participate in the international challenge for intelligent transport systems i-Game GCDC, Netherlands, year 2016. Results are demonstrated in a popular seminar.

2.4.1. Further research and practical exploitation of the results

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

The first stage of the work done in this stage of the project has these practical applications of the results and further research goals:

- Smart sensor and their network innovative hardware and software platform:
  - Practical applications and meaning: Promotes faster time to market of technologies which are knowledge based and based on sensor networks, by reducing the time spent developing prototypes and helping with testing.
  - Further goals and solvable problems: To continue developing smart sensor and their network platform, to improve the user interface of the platform.
- Medicine and telemedicine uses of cyber-physical systems:
  - Practical applications and meaning: Wearable sensor platforms will bring benefit to rehabilitation and telemedicine fields of medicine, by reducing time spent by patients travelling to or consulting with health specialists, thus reducing the costs of medical help. At the same time, improved monitoring will help increase the quality of medical data available to the health specialist thus improving the medical decisions, while at the same time providing real time feedback to the patient.
  - Further goals and solvable problems: to continue developing the wearable sensor platform and its uses in telemedicine and rehabilitation.
- Intelligent transport systems:
  - Practical applications and meaning: Intelligent transport system will be more convenient and safe to use because the data of surrounding can be gathered from more sources and in shorter time than a human can, thus allowing for more efficient and safer decisions.
  - Further goals and solvable problems: To finish developing the model for decision making and participate in i-Game GCDC Netherlands, year 2016.

All of these results will provide a stronger bond between the physical world, data gathered by smart sensors, processing and interpretation of this data, as well 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.

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

List of publications:

1. 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
2. (SCOPUS) 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
3. (SCOPUS) 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
4. 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: 10.1145/2737095.2737726http://research.microsoft.com/apps/pubs/default.aspx?id=241638
5. (SCOPUS) 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.url?eid=2-s2.0-84939511173&origin=resultslist&sort=plf-f&src=s&st1=Nikisins&st2=&sid=337DADE46B4D3788C19BD4B3BDC84D37.WeLimyRvBMk2ky9SFKc8Q%3a20&sot=b&sdt=b&sl=21&s=AUTHOR-

NAME%28Nikisins%29&relpos=2&relpos=2&citeCnt=0&searchTerm=AUTHOR-NAME%28Nikisins%29

6. (SCOPUS) 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
7. (SCOPUS) 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

Bachelors thesis:

- Emil Syundyukov, bachelors thesis “Embedded hardware and software for health data monitoring during rehabilitation”

Exhibitions:

- Participation in exhibition «Skola 2015», February 27-28, Riga
- 10.-11.10.2014. A.Mednis participated in Exhibition MINOX 2014 organized by Riga Technical University

Popular publications:

- 2015-05-05 Latvia Radio1 show “Zināmais nezināmajā” interview with Ati Hermani
- 2015-02-11 Latvia Radio show “Monopols” interview with Leo Seļāvo

Conferences and presentations:

- 31.08.-06.09.2014. program manager M.Greitāns participated in European signal processing conference “EUSIPCO 2014”, Lisbon, Portugal, where VPP SOPHIS ideas and results were discussed.
- 21.-22.01.2015. M.Greitāns particiapted in KTI ARTEMIS “Brokerage Event 2015” Amsterdam, Netherlands, where he presented and discussed VPP SOPHIS ideas and results.
- 03.-20.02.2015. project members participated in 73rd scientific conference of the University of Latvia, where they presented two reports: “Localization within buildings with digitally controllable antennas” (L.Seļāvo, I.Driķis, R.Balašs) and “Creation of heterogenous wireless communications range” (A.Mednis, J.Judvaitis, R.Ruskuls).
- 09.-11.03.2015. M.Greitāns participated in international event “ARTEMIS Co-Summit 2015” Berlin, Germany, where he presented and discussed VPP SOPHIS ideas and results.
- Atis Hermanis presented his work in scientific research contest “ResearchSlam” organized by RTU on year 2015 and gained 1st place
- Emil Syundyukov presented his bachelors thesis “Embedded hardware and software for health data monitoring during rehabilitation” in the annual stipend contest for best IT bachelors thesis by company Exigen Services Latvia and RTU Development fund on year 2015 and gained 2nd place

- August 8, 2015, researcher Atis Hermanis participated in Riga IT Demo center press conference and demonstrated wearable sensor system developed in EDI.
- In the event of „Scientist night" on September 25, year 2015 at Institute of Electronics and Computer Science, the project results were presented.
- 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
- 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/

Leader of the project No.1. _____ _____.11.2015__
(signature and transcript) *(date)*

2.1.2. 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 achievements 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 1st stage of the SOPHIS program are:

1. Development of the theoretical background for the ontology- and web technology-based graphical ad-hoc query language. Scientific publication is the expected result.
2. Development of the ontology- and web technology-based controlled natural ad-hoc query language which can be used *directly* by end-user (without involvement of the programmer).
3. Development of the web technology-based tool building technologies and methods for modeling of complex, hard-to-formalize systems.
4. Research of the ontology-based linked data technologies for applications of e-government and e-health.
5. Developing new methods for natural language parsing into the form of semantic graphs based on n-ary predicate approach (such as AMR, FrameNet, BabelNet) for information extraction from natural language texts (natural language understanding tasks). Scientific publication is the expected result.
6. Development of methods, algorithms and their support software for analysis of knowledge structure models. Scientific publication is the expected result.
7. Study of related works in the domain of structural compatibility between processes, enterprise architectures and knowledge, as well as development of initial draft for ideal linkage model
8. Development of demonstration prototype for integration of semantic network services into e-logistics portal. Scientific publication is the expected result.
9. Develop on data models and ontologies based methods for big data accessibility; propose new suitable for internet methods for data query and visualization. Scientific publication is the expected result.

10. Develop business process model usage in program runtime event analysis to increase information systems security level. Scientific publication is the expected result.

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

1. Development of the theoretical background for the ontology- and web technology-based graphical ad-hoc query language.
So called "3-How" problem has been explored:
1) how to depict a data ontology for it to be easily understandable by a domain expert;
2) how to use such ontology as a base, on which one can build easy-to-use query language that can be exploited by the domain expert directly (without involving a programmer);
3) how to implement such a language efficiently so that one can get answers to typical queries in time less than a second (on data volume of several GBs, e.g., Children's Clinical University Hospital's (CCUH) one year data).
For this purpose we have further developed the concept of granular data ontology that gives us a possibility to divide large volume data into separate pellets (which we call slices). We have demonstrated a way of slicing traditional data ontologies (ER models), offered an experimental graphical query language that is based on the concept of granularity and explored the performance of query execution that has been achieved thanks to granularity. We have also researched the topology of granular data ontologies – it turns out that in natural conditions an ontology is granular if and only if it is *a star ontology*. This topology gives us a possibility to create essentially more convenient query language for domain experts. The results have been described in [2].

2. Development of the ontology- and web technology-based controlled natural ad-hoc query language which can be used directly by end-user (without involvement of the programmer)
The first and most essential result: we have found six controlled natural language query templates (supplemented with a formal concept of scalar expression) that covers practically all ad-hoc queries one can think of for needs of hospital management (we assume the managers have sufficient MS Excel skills). We have tested this hypothesis on real CCUH data (year 2014) and real queries that were needed to generate the review and analysis of year 2014 in one particular CCUH clinic (intensive therapy clinic). The experiment approved the hypothesis – 100% of necessary query coverage was achieved.

3. Development of the web technology-based tool building technologies and methods for modeling of complex, hard-to-formalize systems.
We have formalized the requirements of modeling tools for such systems. According to these requirements we have developed a metamodel for defining DSLs and tools. According to this metamodel we have developed experimental graphical tool-building platform that can be used to modelling in web such systems that are difficult to formalize. The platform provides interactivity, collaboration, different machines support (computers, tablets, and smartphones), reactivity and live HTML. Exploited

technologies: Meteor (web application development platform), MongoDB (database), KonvaJS (depicting diagrams), and Bootstrap (HTML, CSS, and JavaScript).

4. Research of the ontology-based linked data technologies for applications of e-government and e-health.

Conclusion: Use-cases of ontology-based linked data grow fairly rapidly in the world (around 30% in a year). These use-cases are generally based on open data in form of RDF, they mainly refer to providing different (not known a priori) research, statistics, reviews.

Linked data technologies are not widely used in fields of e-management and e-medicine. The main problem: data of e-management and e-medicine are strictly regulated by the law and have restricted access that contradicts the technologies of ontology-based linked data. However, by widening the volume of open date in state level the technologies of linked data could be used at least partially also in fields of management and medicine – mainly in aspects of statistics and research.

5. Developing new methods for natural language parsing into the form of semantic graphs based on n-ary predicate approach (such as AMR, FrameNet, BabelNet) for information extraction from natural language texts (natural language understanding tasks).

By integrating FrameNet n-ary relation extraction and BabelNet inspired Named Entity Linking approaches we have developed a unified linguistic ontology suitable for extracting Curriculum Vitae like semantic information (a semantic graph) about persons and organizations mentioned in unstructured newswire texts. We have also developed a new classification algorithm nicknamed C6.0 and used for implementing a semantic parser for Latvian, English, Czech and Chinese, with which we participated in SemEval-2015 competition where it performed on par with other state-of-the-art parsers and was among the three winning parsers in various testing categories. These scientific results are described in our SemEval-2015 paper [1].

6. Development of methods, algorithms and their support software for analysis of knowledge structure models.

During accomplishment of this task research has been done on several knowledge structure models and their applications, including the structural modeling, intelligent agents and intelligent tutoring systems. Most important scientific and practical result is the development of several methods and algorithms for system's structure formalisation and transformation necessary for knowledge structure models used in structural modeling, as well as implementation of software prototype I4S (also IFS) for model representation and analysis. Methods, algorithms and their support tool have been described [10] as the result of this research. The first year students of RTU Doctoral program "Computer Systems" M.Pudāne, S.Šķēle and H.Grīnbergs participated in I4S testing. Methodological and technological support for acquiring a topological model has been developed [1p]. Scientific results of this research provide formal description and analysis of different kinds of systems without complex mathematical formalisms allowing to reason about systems' functionality and possible faults. Models of nontechnical systems are applicable for software code generation. Future research is focussed on extension of I4S functionality to evaluate a functional state of industrial control systems by their automated analysis, as well as for concept map analysis. This would allow examining and using of theoretical results in practice. During research on knowledge structures used in intelligent agents, the mechanism

for introduction of knowledge structure changes has been developed. This includes the general conceptual mechanism for introduction of changes, the ontology for experimental needs and the mechanism for adapting of existing rules to new/incomplete data. Analysis of methodologies for integrated design of multiagent systems and ontologies was done at introductory stage of this research [1m]. For achievement of research goals and providing experiments the prototype of room cleaning multirobot system simulator which supports manual introduction of changes of knowledge structure into ontologies and rule bases of agents that simulate robots is developed. Some research has been done to carry out the comparative analysis of knowledge structures used in knowledge bases and deductive data bases [2m]. For the next stage it is planned to develop mechanisms for changes in knowledge structures initiated by agents themselves, as well as to extend it with machine learning methods for creating new rules or selecting more precise already existing rules. Experimental justification of this concept will be performed in real multirobot systems in the successive research. The developed mechanism could significantly increase autonomy and adaptivity of multirobot systems which still is a topical problem in practical use of multirobot systems. The method for identifying knowledge change source in pedagogical model (part of pedagogical module) which is a component of intelligent tutoring systems is developed. This method allows more precisely to choose and to adapt tutoring strategies. During the next stage it is planned to develop an ontology based hierarchical structure of pedagogical model for implementation of a personalized learning.

7. Study of related works in the domain of structural compatibility between processes, enterprise architectures and knowledge, as well as development of initial draft for ideal linkage model.

Several new theoretical results have been achieved during analysis of role of time dimension and knowledge structures describing time. They allow introducing time dimension in enterprise architectures and their management. New theoretical results have been reached, including extended and enriched time model which could be linked with enterprise architectures and Bunge ontology [3m]. During studies on processes important links which are necessary to provide continuous requirement engineering have been identified, which is important practical result for software development [5]. Future research is related to development of approaches and methods for identification and representation of process and knowledge structure compatibility.

8. Development of demonstration prototype for integration of semantic network services into e-logistics portal.

Several practical results are obtained during accomplishing this task. SADI (Semantic Automated Discovery and Integration) technology is used for implementation of semantic web services. It facilitates their implementation and maintenance. The service preparation template is developed to provide automated generation of plug-ins and additional files thus facilitating and accelerating a service development. Semantic web services which semantically annotate information received from traditional web services that are included in e-LOGMAR portal have been developed. Processed information is related to the logistics domain (available routes and their types, cargo expenses etc.). The logistics domain ontology which is built using OWL language supports annotation. OpenCalais is used in services to integrate natural language processing methods with semantic web technologies, allowing to retrieve semantic

metadata from the text. The service returns semantically annotated document to the client. Semantic web technologies have been integrated also into model driven software configuration approach [6,7]. In the future research it is planned to develop a general methodology based on past practical experience for introduction of semantic web services.

9. Develop on data models and ontologies based methods for big data accessibility; propose new suitable for internet methods for data query and visualization

Big data analysis and visualization methods is analyzed for situation when new type of infrastructure – display wall consisting of more than 20 high resolution displays exists. Development of low-cost display wall compatible with major operating systems is the first step of the research. Different architectures are analyzed and prototype of display wall is developed during first phase of the Project. Results of the first phase is published in [3,8,9]

10. Develop business process model usage in program runtime event analysis to increase information systems security level.

This research is dedicated to business process execution runtime verification. In this research runtime verification means analysis of computer system and evaluation of its runtime correctness in runtime environment. Built-in framework or external observations can be used to monitor runtime correctness. This research concentrates mostly on external system runtime observations. Verification is done according to model of verified business process. Usage of domain specific verification description language is proposed. Description of events confirming correct process evaluation, sequence of events and time constraints are defined. Verification mechanism observes events and verifies their according to developed process model. [4, 4m]

Publications:

[1] Barzdins G., Paikens P., Gosko D.. **Riga: from FrameNet to Semantic Frames with C6.0 Rules.** SemEval 2015 Task 18: Semantic Dependency Parsing. Proceedings of the 9th International Workshop on Semantic Evaluation (SemEval 2015), Association for Computational Linguistics, pp. 960–964. (http://www.aclweb.org/anthology/S15-2160)

[2] J. Barzdins, E. Rencis and A. Sostaks, **Fast Ad Hoc Queries Based on Data Ontologies**. In: H.M. Haav, A. Kalja, T. Robal (Eds.), Frontiers of AI and Applications, Vol. 270, Databases and Information Systems VIII, IOS Press, pp. 43-56, 2014.

[3] Rudolfs Bundulis, and Guntis Arnicans, **Concept of virtual machine based high resolution display wall.** Information, Electronic and Electrical Engineering (AIEEE), 2014 IEEE 2nd Workshop on Advances in. pp. 1-6, IEEE, 2014. DOI: 10.1109/AIEEE.2014.7020317, http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7020317

[4] I.Oditis, J.Bicevskis Asynchronous Runtime Verification of Business Processes 7th International Conference on Computational Intelligence, Communication Systems and Networks (CICSyN'2015) pp. 103-108, 2015

[5] Kirikova, M. Enterprise Architecture and Knowledge Perspectives on Continuous Requirements Engineering. Proceedings of REFSQ-2015 Workshops, Research Method Track, and Poster Track co-located with the 21st International Conference on

Requirements Engineering: Foundation for Software Quality. Essen, Germany, March 23, 2015. CEUR-WS.org, Vol. 1342, ISSN 1613-0073, pp. 44-51.
[6] Bartusevičs, A., Novickis, L., Lesovskis, A. Model-Driven Software Configuration Management and Semantic Web in Applied Software Development. No: Recent Advances in Telecommunications, Informatics and Educational Technologies: Proceedings of the 13th International Conference on Telecommunications and Informatics (TELE-INFO '14) , Turkey, Istambul, December, 2014. Istambul: WSEAS Press, 2014, 108.-116.lpp. ISBN 978-1-61804-262-0.
[7] Bartusevičs, 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. march, 2015. Vienna: 2015, 32.-39.lpp. ISBN 978-1-61804-285-9. ISSN 1790-5117.
[8] Rudolfs Bundulis, and Guntis Arnicans. **Virtual Machine Based High Resolution Display Wall: Experiments on Proof of Concep**t. International Conference on Systems, Computing Sciences and Software Engineering (SCSS 14) , Electronic CISSE 2014 Conference Proceedings, 2014. (to appear in Innovations and Advances in Computer, Information, Systems Sciences, and Engineering. LNEE, Springer)
[9] Posters: Rudolfs Bundulis, Guntis Arnicans, and Rihards Gailums. **NVENC Based H.264 Encoding for Virtual Machine Based Monitor Wall Architecture,** GPU Technology Conference, San Jose, Mart 17-20, 2015.
http://ondemand.gputechconf.com/gtc/2015/posters/GTC_2015_Visualization_Large_Scale___Multi_Display_01_P5174_WEB.pdf

2.4.2. Further research and practical exploitation of the results
(Describe further research activities that are planned, describe possibilities to practically exploit results)
The ad-hoc query language experiment on real data need to be continued during the second phase of the project, when we plan to work on practically implementing the query language in web environment. Another direction of further research in the field of ad-hoc query languages is to provide the critical performance (getting answer in time no more than a second thus not letting the user to have a feeling of `annoying` waiting) on practically all queries in the experimental implementation on CCUH data (year 2014). We have made all necessary preparations for the second phase of the project to get the query language and its web implementation to the state of “Count of new technologies, methods, prototypes or services developed during the program that has been approbated in companies” (the approbation will be done in CCUH).

The FrameNet and NEL based semantic parsing technology developed within this project is already exploited industrially through partnership project with Latvian News Agency (LETA) “Identification of relations in newswire texts and graph visualization of the extracted relation database” European Regional Development Fund Project Nr.2DP/2.1.1.1.0/13/APIA/VIAA/014 (2014-2015, total budget 395KEUR). Further research directions include continuing development of our C6.0 classification algorithm in the context of Deep Learning neural network based machine learning approaches, as well as extending our semantic parsing techniques

for wider use through submitting a proposal together with Latvian News Agency LETA to European Horizon-2020 ICT-16-2015 „Big data – research" call.

For research related to knowledge structure models several future research activities have been planned:
- It includes research related to extending support for the systems structural modelling approach, involving extension of functionally of I4S software as well as study of specific approaches needed for industrial control system analysis and fault prediction and detection. The obtained results are planned to use in cooperation with ICD Software AS company.
- For the next stage it is planned to develop mechanisms for changes in knowledge structures initiated by agents themselves, as well as to extend it with machine learning methods for creating new rules or selecting more precise existing rules. Experimental justification of concept will be performed in real multirobot systems in the successive research. The developed mechanism could significantly increase autonomy and adaptivity of multirobot systems which still is a topical problem in practical use of multirobot systems.
- It is planned to develop an ontology based hierarchical structure of pedagogical model for implementation of personalized learning. The results are planned to use for extension of e-learning systems.
- Besides the future research is related to the development of approaches and methods for identification and representation of process and knowledge structure compatibility and the development of general methodology based on past practical experience for introduction of semantic web services.

While chasing new applications of the display wall, the client-server environment will be developed that will provide agent based model development. It will be migrated to NoSQL database and will use data browser that will work with display wall.

2.5.2. Dissemination and outreach activities
(Describe activities that were performed during reporting period to disseminate project results)
In addition to publiccations listed in the end of section 2.3.2, we participated with presentation at the International Workshop on Semantic Evaluation (SemEval-2015) and specifically in Task 18 on Broad-Coverage Semantic Dependency Parsing (SDP 2015), which was collocated with NAACL-HLT-2015 conference in Denver, Colorado.
The results were also presented in the University of Latvia scientific conference by Pēteris Paikens and Didzis Gosko – two doctoral students participating in this project.

Education:
PhD thesis:
[1p] Armands Šlihte. Integrētā priekšmetiskās vides modelēšana: pieeja un rīku kopa topoloģiskā funkcionēšanas modeļa iegūšanai. (Defended RTU Promotion Council P-07 8.06.2015)
Master thesis:
[1m] Svetlana Otto. Daudzaģentu sistēmu un ontoloģiju projektēšanas metožu integrēšanas metodoloģiju analīze (Consultant prof. J.Grundspeņķis. Defended RTU DITF 15.06.2015)

[2m] Emil Bikjanov. Zināšanu bāzu un deduktīvo datu bāzu salīdzināšanas analīze (Consultant prof. J.Grundspeņķis. Defended RTU DITF 15.06.2015)
[3m] Andrejs Gaidukovs. Laika dimensija biznesa procesu un uzņēmumu arhitektūras modelēšanā (Consultant prof. M.Kirikova. Defended RTU DITF 16.06.2015)
[4m] Edgars Kirkiļevičs. Sadarbojošos procesu testēšana (Consultant prof. J.Bičevskis. Defended LU DF 02.06.2015)
[5m] Dace Damberga. Uzraudzītas mašīnmācīšanās klasifikatoru izpēte un empīriska salīdzināšana (Consultant prof. Guntis Bārzdiņš. Defended LU DF 05.06.2015)
[6m] Zane Siliņa. Latviešu valodas sintaktiskā analizatora 'Čankeris' modernizācija (Consultant prof. Guntis Bārzdiņš. Defended LU DF 01.06.2015)

Leader of the project No.2. _____J.Bārzdiņš _____.11.2015__
(signature and transcript) *(date)*

2.1.3. Project No. 3

Title	Biophotonics: imaging, diagnostics and monitoring	
Project leader's name, surname	Janis Spigulis	
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

2.2.3. 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 1st period:
To develop experimental measurement methodologies for laboratory approbation of two new imaging technologies:
- for obtaining of several monochromatic spectral images from the data of single digital colour image;
- for contactless monitoring of cardiovascular parameters at the near infrared spectral range.

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

1. Metodology for obtaining several monochromatic spectral images from a single digital color image.

As the first step, extraction of three monochromatic images of the target under illumination simultaneously by 3 spectral lines was analysed and practically implemented in laboratory environment. The experimental setup schematically is shown at Fig.1. Three cw laser modules emitting at wavelengths 473nm (model 1011750, 30mW with attenuator), 532nm (model DD532-10-5, 10mW) and 609nm (model DB650-12-3, 12mW) were exploited for target illumination. Output beam of each laser was coupled into a 7-fibre bundle via the standard SMA connector; the optical fibre output ends were distributed randomly over a polished metallic ring surface which served as a shadowless 21-channel 3-wavelength illuminator. The emitting ring was further covered by a diffusing film that ensured uniform

illumination of the target area, as well as by a polarizing film. Another polarizing film oriented orthogonally to this one was placed in front of the CMOS camera lens, located inside the emitting ring; this helped to avoid detection of the surface-reflected radiation, since the diffuse reflectance of the target was our primary concern. A conical light-shielding element also provided a fixed distance between the target and camera at all measurements. The CMOS camera output signals were sent to a computer with installed Matlab software for further analysis.

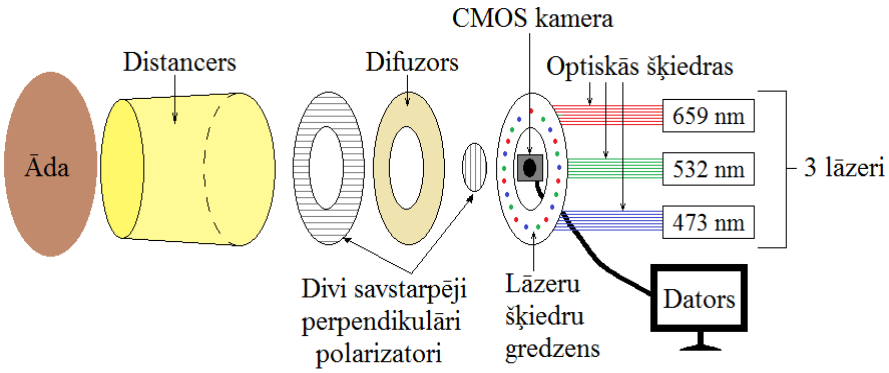


Fig.1. Schematic of the measurement setup.

A CMOS image sensor UI-1221LE-C-HQ (752 x 480 pixels) was used; spectral sensitivity curves of its R, G and B colour channels, provided by manufacturer, are shown at Fig.2.

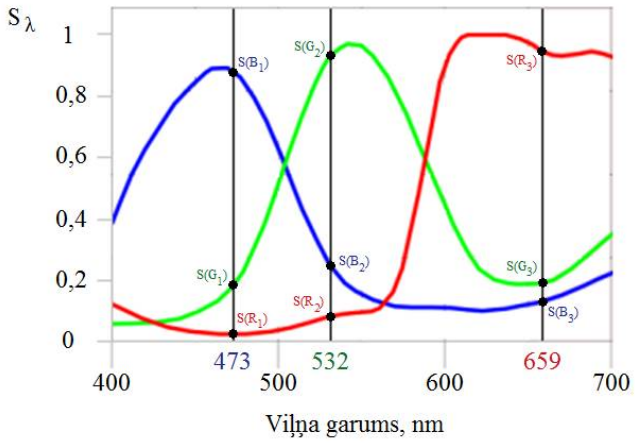


Fig.2. RGB spectral sensitivities of the image sensor.

Monochromatic spectral images of the colour targets and skin tissue were extracted from the RGB image data cube with respect of the RGB crosstalk correction, as described previously [1,2]. Measurements of different colour targets at single- and three-wavelength illumination confirmed versatility of this approach.

Human in-vivo skin was chosen as a bio-tissue target. Distribution maps of the main skin chromophores - melanin, oxy-haemoglobin and deoxy-haemoglobin were constructed from the single-snapshot RGB image data by using the Lambert-Beer law at each exploited wavelength:

$$\begin{cases} I_1 = I_{01} \cdot \exp[-(k_{a1} + k_{b1} + k_{c1}) \cdot l_1] \\ I_2 = I_{02} \cdot \exp[-(k_{a2} + k_{b2} + k_{c2}) \cdot l_2], \\ I_3 = I_{03} \cdot \exp[-(k_{a3} + k_{b3} + k_{c3}) \cdot l_3] \end{cases} \quad (1)$$

Where I_i – skin reflected intensity at the wavelength λ_i, I_{0i} – reference-reflected intensity at the wavelength λ_i, l_i – mean photon pass-length in the tissue at the wavelength λ_i , k_{ai}, k_{bi} and k_{ci} – absorption coefficients of the three skin chromophores (*a* – oxy-haemoglobin, *b* – deoxy-haemoglobin, *c* – melanin) at the wavelength λ_i (λ_1=473 nm, λ_2=532 nm, λ_3=659).

The absorption coefficients (k_{a1}, k_{b1} un k_{c1}) at wavelength λ_1 can be expressed as:

$$\begin{cases} k_{a1} = c_a \cdot \varepsilon_a(\lambda_1) \\ k_{b1} = c_b \cdot \varepsilon_b(\lambda_1), \\ k_{b1} = c_b \cdot \varepsilon_b(\lambda_1) \end{cases} \quad (2),$$

where c_a, c_b and c_c are the chromophore concentrations and ε_a, ε_b un ε_c – extinction coefficients that are tabulated at each of the exploited wavelengths.

Equations (1) and (2) were used to express analytically the values of three chromophore relative concentrations at each image pixel as functions of the measured signals, with subsequent building of three chromophore distribution maps. As example, Fig.3 illustrates the obtained results for two skin malformations – vascular (upper row) and pigmented (lower row). Both distributions qualitatively agree with the expectations from the physiological point of view.

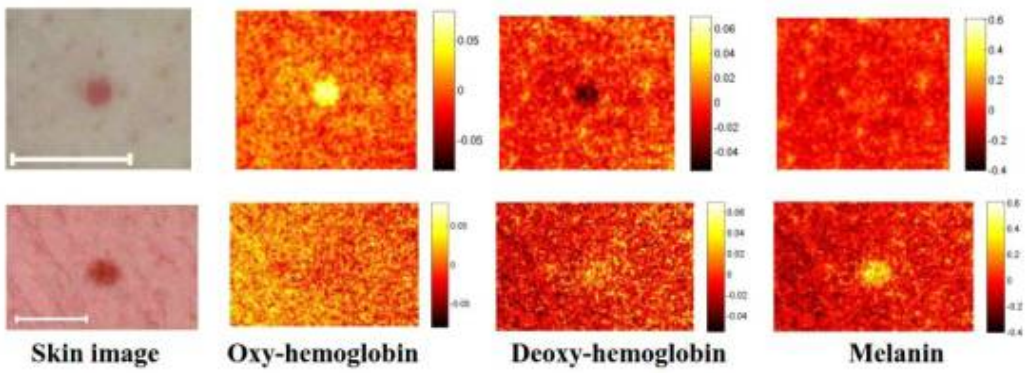


Fig.3. Maps of skin chromophore distributions for a vascular (upper row) and pigmented (lower row) skin malformations (the scale bar – 1 cm).

Results were published (with reference to the SOPHIS project) in a SCOPUS-cited paper:

- J.Spigulis, I.Oshina. „3x3 technology for snapshot mapping of skin chromophores", OSA Technical Digest, doi:10.1364/BODA.2015.JT3A.39 (2015).

Besides, a bachelor project on this topic was defended and evaluated as "outstanding" (10):

- I.Ošiņa, „Mapping of skin chromophores at tri-chromatic laser illumination" (supervisor J.Spigulis).

Scientific importance of the results:
Possibility to extract three monochromatic spectral images from a single digital RGB image with further conversion into distribution maps of three main skin chromophores was demonstrated for the first time. This technique considerably speeds-up, simplifies and improves accuracy of the procedure of chromophore mapping in dermatology, oncology, microscopy, artwork expertise and other related areas.

2. Methodology for contactless monitoring of cardiovascular parameters at the near infrared spectral range

The photoplethysmography imaging (PPGI) technology [3] at the NIR wavelength band around 760nm was developed and tested in laboratory and clinic. 24 volunteers (12 women and 12 men, 20-35 years old) were involved in the measurement series with permission of the local ethics committee. Wrist was selected as the most suitable body location for such measurements (Fig.4). The traditional PPGI at the green spectral band around 540nm was used for reference.

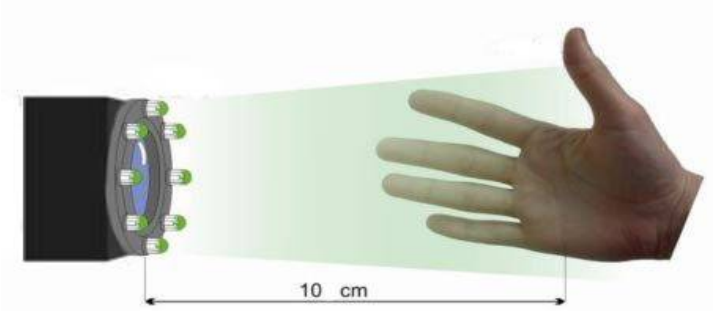
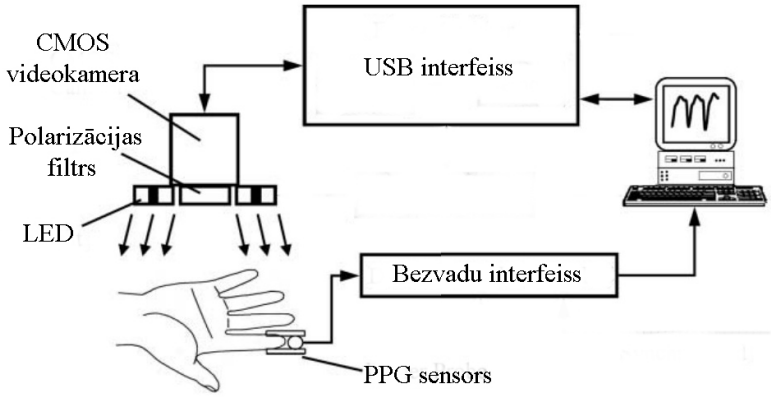


Fig.4. Remote PPGI measurements from human wrist.

3 measurements every 10 minutes were taken from both wrists – one was fan-heated, the other at room temperature. All data were collected at a database for further analysis. The schematic of experimental setup is given on Fig.5. Our previously designed wireless PPG finger clip (Fig.6) was used for parallel contact measurements.



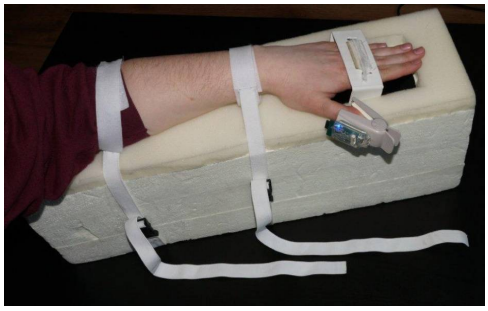


Fig.5. Schematic of the measurement setup (above) and fixed wrist during the NIR-PPGI measurements (below).

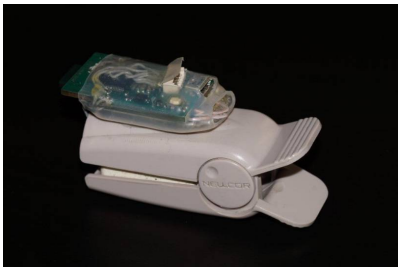


Fig.6. The wireless PPG contact probe.

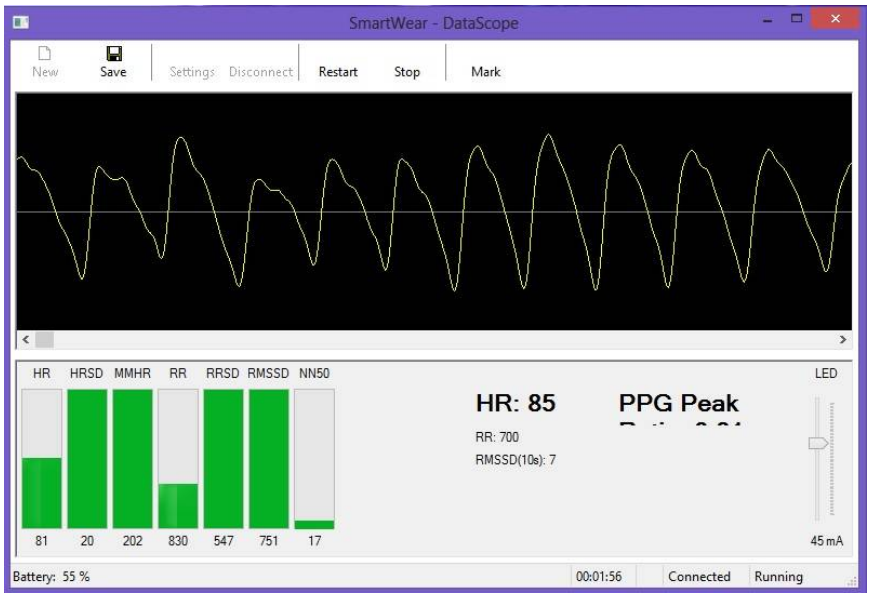


Fig.7. Screenshot of the programme «*DataScope*» interface.

Programme “DataScope” (Fig.7) was adapted for parallel collection and processing of the PPG signals detected at the three specified PPG channels. Spectral sensitivity and other main characteristics of the used video-sensor are presented at Fig.8.

Sensor	
Sensor Technology	CMOS Mono
Manufacturer	e2v
Resolution (MPix)	1.31
Resolution (h x v)	1280 x 1024
ADC	10 bit
Color depth (camera)	8 bit
Pixel Class	SXGA
Sensor Size	1/1.8
Shutter	Rolling shutter/Global shutter/Global start shutter
max. fps in Freerun Mode	25.8
Binning Modes	M/C automatic
Subsampling Modes	-
Sensor Model	EV76C560ABT
Pixel size	5.3 µm
Optical Size	6.784 mm x 5.427 mm
Optical sensor diagonal	8.69 mm (1/1.84")

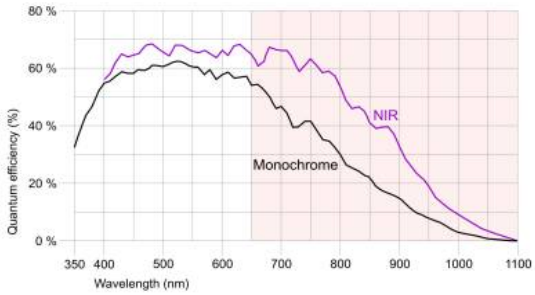


Fig.8. Specifications of the video-camera UI-1242LE.

The following physiological parameters could be evaluated in real time by means of the updated
DataScope software:

HR - heartrate (beats/min);
HRSD - deviation of heartrate (beats/min);
MMHR - difference between maximal and minimal heartbeat frequency (beats/min);
RR - pulse interval (ms);
RRSD - standard deviation of the pulse interval (ms);
NN50 - difference of pulse intervals exceeding 50 ms (%).

Examples of the collected data are illustrated at Fig. 9 and Fig.10. The row data are currently analysed and the results will be prepared for publishing.

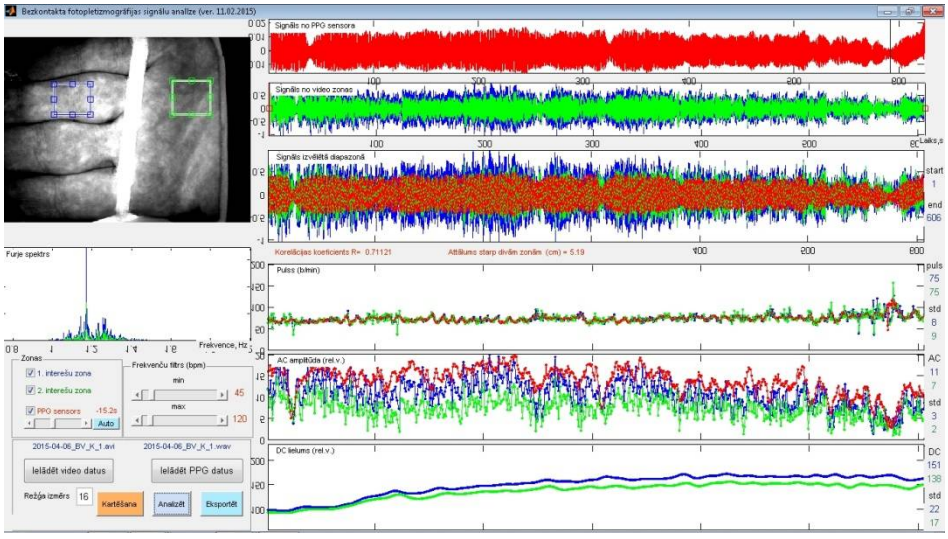


Fig.9. Representation of the raw measurement data.

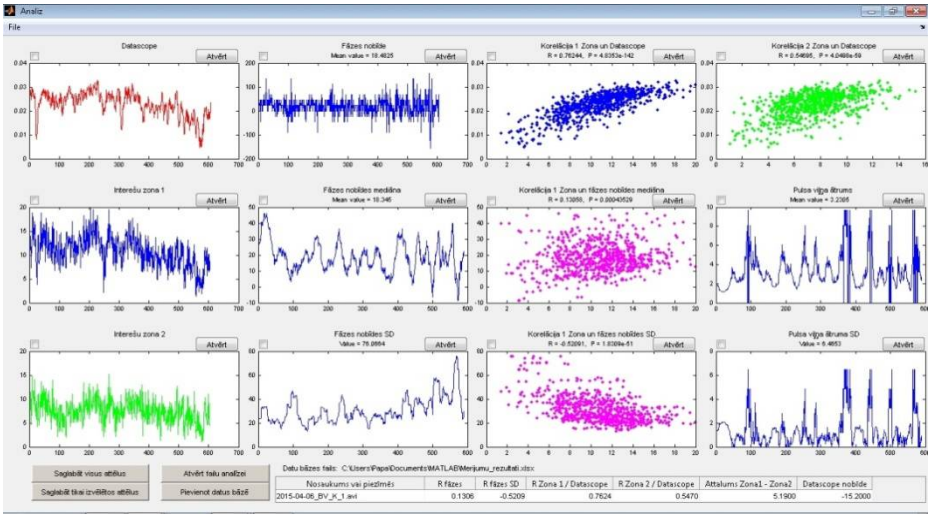


Fig.10. The collected data represented by the software analysis module.

A master project was elaborated on this topic and successfully defended:

- O.Lashuk, „Determination of pulse wave velocity by non-contact photoplethysmography method".

Scientific importance of the results:

The PPGI technology currently uses mainly visible (e.g. white, green) illumination of the subject; this causes some essential problems (e.g. influence of changes in ambient light, sensitivity dependence on skin colour, useless for secure monitoring of cardiovascular parameters). Extending this technology to NIR spectral range considerably diminishes or even avoids these issues so opening new application areas in clinical medicine, physiology and security sensing.

2.4.3. 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 development and tests of the prototype devices implementing both experimentally proven technologies are planned, in particular:

- Design, mounting and laboratory/clinical tests of a RGB camera supplied 3-wavelength skin illumination prototype device;
- Experimental approbation of options for mapping 4 chromophores at 4-wavelength illumination;
- Fabrication and routine clinical tests of the NIR-PPGI prototype device for distant anaesthesia and pain monitoring during wrist surgeries and an experimental system for secure remote video-sensing of cardiovascular parameters

Besides, development of a prototype device and software for analysis of tissue moisture and other parameters by NIR imaging in the spectral range 0.7-1.7 microns is planned. Improved image processing software will be elaborated for the previously designed skin diagnostic device *SkImager*.

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

1. The obtained results were presented at three international conferences:

- J.Spigulis, I.Oshina, „3x3 technology for snapshot mapping of skin chromophores", *OSA Optics in the Life Sciences* (Vancouver, CA, 12-15/04/2015);
- I.Oshina, J.Spigulis, „Snapshot mapping of skin chromophores at triple-wavelength illumination", *Developments in Optics and Communications* (Riga, 10-12/04/2015);
- I.Oshina, J.Spigulis, „Image processing for snapshot mapping of skin chromophores", *IONS Karlsruhe 2015* (Karlsruhe, DE, 26-29/06/2015).

2. The elaborated methods and devices were presented to general public (~500 attendees) during the European Researcher's Night on 25.09.2015. at Institute of Atomic Physics and Spectroscopy (Riga, Skunu Str. No.4)
3. Researcher Inga Saknite presented the project ideas and our main results to the most outstanding secondary school students at the summer campus "Alfa" in Zasa (July, 2015).
4. Researcher Andris Grabovskis presented the first results of this project at the annual conference of Latvia's physics teachers in Aizkraukle (October, 2015).

References

1. WO2013135311 (A1), Method and device for imaging of spectral reflectance at several wavelength bands, authors J.Spigulis and L.Elste (2012).
2. J.Spigulis, L.Elste. Single-snapshot RGB multispectral imaging at fixed wavelengths: proof of concept. *Proc.SPIE*, 8937, 89370L (2014).
3. U. Rubins, V. Upmalis, O. Rubenis, D. Jakovels, J. Spigulis. Real-time photoplethysmography imaging system. *Proc. IFMBE*, v. 34, 183-186 (2011).

Leader of the project No.3. _____J.Spīgulis _____.11.2015__
(signature and transcript) *(date)*

2.1.4. 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

2.2.4. 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 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.

2.3.4. 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 are described in this summary form. The full scientific report is attached in Appendix No.4.

EDI BIGDATA group was focused on the following tasks:

- to develop a concept for large scale video and other signal analysis and processing;
- to prepare the environment for signal content analysis and experimentation using High Performance Computing (HPC) resources.

A concept for analysis and processing of large-scale video and other signals within the smart city is developed. Environment for studies and experiments for signal content analysis is prepared on the basis of high performance computers (HPC) resources. The concept 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.

Artificial neural networks based on the so-called "Deep learning" are recognised as the most appropriate video analysis tool. Future research will focus on the development of appropriate network topologies, learning approaches and signal processing techniques based on them.

An Octave artificial neural network model was created for simulation of a variety of training conditions and network configurations.

Environment for development of deep neural networks was prepared based on EDI HPC server configuration with 4 NVIDIA Tesla K20 graphical processor cards. In this environment, an example "cat or rabbit" detector was implemented and trained using the published IMAGENET tagged images (see ww.image-net.org/challenges/LSVRC/2014/). The detector determines whether the input image contains a cat or a rabbit. The detector is based on deep learning network configuration AlexNet described in the publication: A. Krizhevsky I. Sutskever, G.E. Hinton, "IMAGENET Classification with Deep Convolutional Neural Networks," Advances in Neural Information Processing Systems 25 (NIPS 2012).

During the reporting period, 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 has chosen the following tasks of the smart city which can be solved with the assistance of remote sensing data processing (the list could be expanded during the next periods):

- 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.

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 European Space Agency Sentinel-2 satellite data should be set when they are available (expected in October 2015). Commercial satellite data with high resolution (Worldview-2, Worldview-3 images to be used) should be used for solving more important tasks. Sample LiDAR data were obtained for development of city land height model development methods. It is planned to use the LiDAR data collected by the Latvian Geospatial Information Agency for creation of accurate ground elevation models of Latvian cities.

Fusion possibilities of multisensory data were studied, obtained by the sensors with different spatial resolution. Land-use classifiers where 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 prepared for presentation at the conference "Electronics 2015".

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: radars for inspection of ground and walls, 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. Reflections from the metal object were obtained also in this case, 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.

During the reporting period new ultra-wideband radar functional modules, namely antenna and electronic modules were developed, produced and tested.

Within this research direction, 2 papers were published in journals, results were presented in 2 conferences and 3 bachelor's works were defended.

RTU TI group was focused on analysis of different topologies of fiber optics transmission systems as well as creation of an experimental model by means of mathematical modelling.

In optical transmission systems transmitted optical pulse sequence can be affected by the following dispersion types: modal dispersion, chromatic dispersion, and polarization mode dispersion. The dominant dispersion types in single mode fiber optical transmission systems are chromatic dispersion and polarization mode dispersion. Modal dispersion can be observed in multimode optical fibers, where multiple modes of the same signal pulse propagate at different velocities along the optical fiber and cause pulse broadening. Chromatic dispersion can be divided into two components - material and waveguide dispersion. Waveguide dispersion is caused by dependence of propagation velocity for different modes related to the wavelength used for transmission in optical fiber. Waveguide dispersion is affected by physical structure of optical fiber core and cladding (reflective index profile). Waveguide dispersion is relatively smaller if compared with material dispersion. Material dispersion is dominant part of chromatic dispersion, and is caused by change of optical fiber refractive index n with wavelength λ used for signal transmission. Dispersion causes optical signal pulses to broaden and lose their shape as they travel along optical fiber. When pulses become wider, they have tendency to interfere with an adjacent pulses. Eventually this limits the maximum achievable data transmission rate and transmission distance. This broadening of signal pulses causes intersymbol interference (ISI). In WDM-AON fiber optical access systems dispersion compensation modules (DCM) are used for chromatic dispersion compensation. These modules can provide a fixed or tunable amount of compensating chromatic dispersion (CD) value. Nowadays, dispersion compensating fiber (DCF) or fiber Bragg grating (FBG) can be used in these chromatic dispersion compensation modules. Typically DCM is specified by what length (in km) of standard ITU-T G.652 single mode fiber will be compensated (usually it is 20 to 80 km) or by the total compensation value of dispersion over a specific wavelength range, specified in ps/nm. Typically, the length of FBG grating is from 10 to 100 cm in commercially available DCM modules. As it can be seen, impact of chirped fiber Bragg grating on

optical signal is exactly opposite of optical fiber chromatic dispersion. A significant advantage of using a fiber Bragg grating (FBG) dispersion compensation modules over DCF fiber is its relatively small insertion loss resulting from the insertion of a device in fiber optical transmission system. For comparison, commercial DCF specified to compensate accumulated chromatic dispersion of 100 km standard single mode fiber span have about 10 dB of insertion loss, whereas a FBG based dispersion compensation module (DCM), capable to compensate the same fiber span length, has insertion loss of 3 to 4 dB. In contrast to DCF, FBG based dispersion compensation module can be used at higher optical powers without inducing nonlinear optical effects (NOE) and their influence on transmitted optical signal.

Within this research direction, 5 master theses were defended, 1 scientific paper accepted for publication, 1 patent application prepared.

RTU BF group mainly focused on different organizational, planning and preparation tasks. The main tasks were: analysis of literature on the continuous monitoring of quality of drinking water, early detection systems of the problems; validation of various testing methods of water samples; creation of laboratory experimental system.

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 submitted to the IWA 7th Eastern European Young Water Professionals Conference. Methods available for microbial and general contamination events detection have been discussed in relation to possibility of applying them for water quality monitoring in a drinking water distribution system. The principle of event detection system operation has been reviewed in detail. It was concluded that, however, 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.

The batch tests were conducted to check availability, reproducibility and feasibility of some of the tools and methods, which could be used manually and/or developed as on-line tools. It was planned to test flow cytometry methods, ATP measurements, chlorine in-situ approach, total organic carbon (TOC) measurements and microorganism growth potential. 9 water samples were studied from the water networks, rivers, sea and drinking water from shops. As a conclusion, ATP and FCM will be the main biological methods used for the further activities, evaluation of biological stability should be considered for simulation experiments. As for other physically-chemical parameters for on-line monitoring Total organic carbon (TOC), electrical conductivity (EC), pH, temperature, Cl ions, oxidation – reduction potential (ORP) were chosen.

Based on the literature studies and batch experiments, the lab-scale experimental pilot system was designed. The aim of the system is 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 (Figure 3). The system is equipped with online sampling points where online sensors for Temperature, pH, Electrical conductivity, Cl ions, Oxidation-reductions potential, Total organic carbon measurements might be done. The sensors installed in the system are Hanna Instruments Inc. production. All of the

data collected from the online sampling points are sent to the computer where it might be analysed. Also electromagnetic flow meter and manometers are installed to monitor the hydraulic parameters of system. In future the hydraulic parameters are going to be automated. Pilot system parameters:
pipe length – 200 meters; pipe inner diameter– 25 mm, pipe outer diameter– 33 mm; pipe material– PVC; water source – Riga city DWDS; dosage points – 1; manual sampling points – 3; sampling points equipped with online sensors – 2; max designed pressure – 1 bar; average designed flow velocity – 0.1 m/s.

Numerous experiments were done to adjust the sensors and data collection system.

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 capabilities using deep neural networks will be considered. Other aspects of these networks will be studied as well.

During the next periods, EDI REMSENS group will develop elaborated algorithms for land use classification, land surface 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.

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 2nd and 3rd year of the research. Developed system for control of bacterial contamination in water supply system will be offered to municipalities.

2.5.4. 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 (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).

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. 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).
4. 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).
5. Aristov, V.; Shavelis, R.; Shupols, G.; Cirulis, R., "An investigation of non-traditional approach to narrowing the GPR pulses," in Radioelektronika (RADIOELEKTRONIKA), 2015 25th International Conference , vol., no., pp.373-375, 21-22 April 2015 (+ conference presentation).

Patents:

1. Patent application submitted: Sandis Spolitis, Lilita Gegere, Anita Alsevska, Ilja Trifonovs, Jurgis Porins, Vjaceslavs Bobrovs „Implementation of WDM-PON technology".

Public seminar organized about the results of the project no.4 obtained during the first period.

Leader of the project No.4. _____I. Mednieks_ _____.11.2015__
(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 1.period 433677 EUR

Use of the funding:

		1. period	2. period	3. period	4. period
	TOTAL	433677.00			
	Personal costs	278264.3			
	Travel	31718.84			
	Consumables and services	53326.92			
	Equipment	19972.91			

Leader of the programme _____M.Greitāns_ __.11.2015__
(signature and transcript) *(date)*