National Research Programme

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

Progress report for period
1.04.2016-31.12.2016

Scientific report for the 3. period

PART 1 – INFORMATION ON PROGRAM

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

1.7. The aim of the programme and objectives:

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

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

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

1.8. Executive summary of the programme

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

Project 1:

Tasks	Main results
1.Development of cyber-physical systems of smart sensor and their network innovative hardware and software platform: 1.1.Development of a software platform for easier programming of sensor networks and cyberphysical systems based on them; 1.2.Preparation for approbation and approbation of the Wireless sensor Testbed (including, the integrated modular platform prototype) system	Planned: Preparation of publications; Achieved: Submitted, presented at conference and accepted for publication (SCOPUS) one scientific article (J. Judvaitis, A. Salmins, K. Nesenbergs "Network Data Traffic Management Inside a TestBed", RTUWO); Planned: approbated system prototype; Achieved: System prepared for approbation and tested (Appendix 1, Section 1.2)
2.Research and develop conception for use of cyber-physical systems in medical and telemedicine uses: 2.1.Development of the smart clothing platform by introducing several data gathering channels; 2.2. Development and approbation of a prototype of the smart clothing platform for the use in telemedicine	Planned: Preparation of patent; Achieved: Identification of results apropriate for patenting; started preparation of patent application. Planned: Preparation of publications; Achieved: Prepared and published one journal publication (K. Nesenbergs "Architecture of smart clothing for standardized wearable sensor systems." IEEE Instrumentation & Measurement Magazine 19.5 (2016): 36-64) Planned: Developemnt of a prototype, aprobation of a system prototype; Achieved: Developed, tested and prepared for approbation a system prototype for computer control with head (Appendix 1, Section 1.3.3.2.3)
3.Usage of smart sensors in intelligent transport systems: 3.1.Development of technologies for extending the vision capabilities of the driver outside of the visible light range and for providing personal assistance to the drivier; 3.2.Development and approbation of a prototype for validating the intelligent transport system communication methods and developed external monitoring methods	Planned: Preparing of publications; Achieved: Prepared and submitted for publication one journal (SNIP>1) publication (I. Ribners, A. Mednis, K. Nesenbergs, R. Zviedris and L. Selavo "DIY Car Control System for Cooperative Driving", IEEE Intelligent Transportation Systems Magazine) Planned: Experimental prototype, software, approbated system prototype; Achieved: Developed an experimental prototype and a set of accompanying software, which is approbated in the international event GCDC (Appendix 1, Section 1.4.3)

Project 2:

Work tasks	Achieved
Further development of the ontology- and web technologies-based fast query language and its efficient implementation by introducing the view-based extension mechanism.	Planned: Prepared scientific publication or scientific report. Planned: Software prototype developed. Achieved: Prepared scientific publications (see. 2.3.2. [4, 8]) and scientific report, Annex 2, Section 2.1.1. Achieved: Software prototype developed (available upon request at UL, IMCS)
Development of data access control mechanism based on data ontologies and web technologies, to be used for the implementation of the Ad-hoc query language.	Planned: Prepeared scientific report. Achieved: Scientific report prepeared, Annex 2, Section 2.1.2.
Development of metamodel specialization methods and their application to building of domain specific language tools for web environment.	Planned: Prepared scientific publication or scientific report. Achieved: Prepared scientific publications (see. 2.3.2. [5, 7, 9, 10])
Participation in SemEval-2016 competition with an improved version of the C6.0 classification algorithm adapted for Abstract Meaning Representation (AMR) information retrieval	Planned: Prepared scientific publication or scientific report. Achieved: : The first place won in the SemEval-2016 Task 8 International Competition on AMR retrieval from natural language text. Prepared scientific publications (see 2.3.2. [1,2,3]) and scientific report, Annex 2, Section 2.1.4.
Further improvement of functionality of intelligent structural modeling tool I4S for multicriterial assessment of importance of elements for knowledge structures of different types and granularities	Planned: Method and algorithm for multicriterial assessment of importance of elements for knowledge structures as prepared scientific publication or scientific report. Achieved: Prepared scientific publications (see 2.3.2. [17, 18]) and scientific report, Annex 2, Section 2.2.1
Development, merging and application of knowledge structure models in ontology- and rule-based decision making	Planned: Developed repository of knowledge structure models and implemented the ontology- and rule-based decision making mechanism for multi-agent systems. Achieved: Developed repository of knowledge structure models and implemented the decision making mechanism. Prepared scientific publications (see 2.3.2. [28, 26]) and scientific report, Annex 2 Section 2.2.2
Detailed development of the approach for aligning requirements/systems engineering based knowledge flows (structures)/information artifacts	Planned: Prepared scientific publication or scientific report. Achieved: Prepared scientific publications (see 2.3.2. [23,24,25,29,30]) and scientific report, Annex 2 Section 2.2.3.
Development and integration of different services in Web portal using open Semantic Web resources and enhancement of software configuration management	Planned: Method and algorithm as prepared scientific publication or scientific report. Achieved: Prepared scientific publications (see 2.3.2. [19,20,21,22,27,31]) and scientific report,

methods	Annex 2 Section 2.2.4.
Development of technologies for large scale NoSQL data base exploration and visualization.	Planned: Prepared scientific publication, which describes the results of aprobation. Achieved: Prepared scientific publications (see 2.3.2. [13,14]) and scientific report, Annex 2, Section 2.3.1.
Business process runtime verification.	Planned: Prepared scientific publication, which describes the results of aprobation. Achieved: Prepared scientific publications (see 2.3.2. [11,12,15,16]) and scientific report, Annex 2, Section 2.3.2.

Project 3:

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

Project 4.

Tasks	Results
1. Develop image processing methods for safe urban environment: a) for object counting in video using the line detector and b) object recognition in video signals.	Planned: Scientific publication Achieved: - published paper: K. Sudars, I.Bilinskis, E.Buls, Discrete Fourier Transform of the signals recovered by using high-performance Event Timers, Baltic Electronics Conference 2016, Tallinn, Estonia (IEEEXplore), presented in conference BEC-2016; - paper accepted for publication: K. Sudars, Face Recognition Face2vec Based on Deep Learning: Small Database Case, Automatic Control and Computer Science (will be included in SCOPUS database).
2. Investigation of possibilities to use remote sensing (RS) data for solving city security tasks.	Planned: • Scientific publication

2.1. Development of city land use and vegetation maps for GIS systems with detection of changes over time. 2.2. Development of an algorithms for forecasting flooding on the basis of ground elevation models made from LiDAR data	• Algorithm for forecasting flooding of the territory Achieved: - published paper: Lorencs A, Mednieks I, Siņica-Siņavskis J. "Selection of Informative Bands for Classification of Hyperspectral Images Based on Entropy", Proc. of BEC2016, the 15th Biennial Conference on Electronics and Embedded Systems. Tallinn, Estonia, 2016. pp. 135-138 (IEEEXplore), presented in conference BEC-2016; - paper in preparation for submission to IEEE J-STARS journal: A.Lorencs, I.Mednieks, J.Sinica-Sinavskis. "Informative hyperspectral band subset selection based on entropy"; - algorithms and MATLAB programs developed for creation of vegetation spreading and changes maps (see Appendix 4, section 4.3); - algorithms and MATLAB program (interactive simulation tool) prepared for forecasting flooding of the territory, exploiting LiDAR data from Latvian Geospatial Information Agency (see Appendix 4, section 4.3).
3. Studies of ultra wideband (UWB) radar sensor application to city security monitoring: 3.1. Development and experimental testing of methods for processing UWB signals reflected from objects in order to detect their trajectories. 3.2. Improvement of UWB radar sensor modules to increase sensing distance.	Planned: • Scientific publication; • Interim scientific report; • Defend 3 bachelor thesis Achieved: • Publications: 1. Aristov V. Karhunen Loeve Transform as a Tool to Eliminate Signal's Redundancy, When Small Targets Detection. Sciences of Europe. Vol 2, № 2 , 2016. Praha, Czech Republic. 2. Aristov, V. Optimization of the transmitter pulse duration by the criterion of the radiation spectrum maximization at a given frequency. Automatic Control and Computer Sciences. 50(4), 220-225, 2016. [Scopus] Springer Link • Interim scientific report presented in Appendix no.4 (section 4.4.); • 3 bachelor theses defended in June 2016: Raitis Bērziņš, Eduards Lobanovs, Romans Maļiks. Participation in exhibition Minox 2016, Riga: Device for remote detection of life-sign (movement, breathing, heartbeat)- prototype presented.
4. Development of fiber optics transmission	

(FOTS) technologies	
4.1.Explore a variety of optical access network topology and its operations, to assess their configuration features (features of optical, electro-optical and opto-electrical combinations of elements, structure, design, etc.), parameters (transmission rate, modulation format, coding method, number of wavelengths, frequency band and others), safety elements (replacement mechanisms of optical, electro-optical and opto-electrical elements). 4.2. Create a new FOTS technology for fast data transfer using mathematical and experimental modelling of wavelength compression solution, new branching and connecting elements as well active optical elements.	Planned: • 4 defended Master thesis • 2 scientific publications (ERIH or SCOPUS) • 1 presentation at the conference Achieved: • 4 defended Master thesis: Valts Dilendorfs, Jūlija Putrina, Reinis Grūnvalds, Vladislavs Bičkovs • 2 scientific publications (ERIH or SCOPUS): 1.Sergejs Olonkins, Vjaceslavs Bobrovs, Girts Ivanovs "FOPA Pump Phase Modulation and Polarization Impact on Generation of Idler Components", Elektronika ir Electrotechnika, Vol.77, No.4, 2016, pp. 77-81, ISSN 1392-1215; 2. Lavrinoviča, I., Poriņš, J., Brūklītis, E., Supe, A. Evaluation of Effective Area and Nonlinearity Coefficient of Erbium-Ytterbium Doped Optical Fibers. In: Progress in Electromagnetics Research Symposium (PIERS 2016): Proceedings, China, Shanghai, 8-11 August, 2016. Shanghai: The Electromagnetics Academy, 2016, pp.1-5. ISBN 78-1-934142-30-1. ISSN 1559-9450. e-ISSN 1559-8985. •1 presentation at the conference: Shakya, S., Supe, A., Lavrinoviča, I., Spolītis, S., Poriņš, J. Different Optical Fiber Nonlinear Coefficient Experimental Measurements. No: Proceedings of 6th International Workshop on Fiber Optics in Access Networks (FOAN 2016), 2016, 1.-4.lpp. (will be included in SCOPUS).
5. Development of the bacteriological quality control system for the city water supply system	
5.1. Measurements in the experimental loop, simulating a variety of pollution results and identifying the effectiveness of the monitoring system in identifying different types and sources of pollution. 5.2. Pollution detection and alerting algorithm development. 5.3. Long-term measurements within the experimental system	Planned: • To determine thresholds for the practical application of the developed system • Defended 1 Master thesis • Scientific Publication • Alert algorithm • To determine real quality changes of the drinking water in water consumption point Achieved: • Thresholds for the practical application of the developed system determined • Published scientific publication on chlorination impact on the quality of drinking water: Nescerecka, A., Juhna, T., Hammes, F., 2016

	Behavior and stability of adenosine triphosphate (ATP) during chlorine disinfection. Water Research 101, 490-497. • Developed alert algorithm • Real quality changes of the drinking water in water consumption point determined • Published scientific publication on drinking water microbiological monitoring methods for improvement: Nescerecka, A., Hammes, F., Juhna, T., 2016. A pipeline for Developing and testing Staining Protocols for flow cytometry, demonstrated with SYBR Green I and propidium iodide viability Staining. Journal of Microbiological Methods 131, 172-180. • Completed a long-term (1 year) monitoring experiment,, where the assessment of microbiological quality of the drinking water was successfully performed using flow cytometry method • Experiments conducted and data collected for Master thesis, but due to unforeseen circumstances, its defense will be accomplished during the next phase of the project.

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

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

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

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

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

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

• Hospital of Traumatology and Orthopaedics, where developed device for contactless monitoring of cardiac and circulatory parameters at near infrared spectral range is approved and compared with industrial device.
• Clinic of esthetical dermatology where experimental prototype of the device for imaging of tissue moisture distribution at near infrared range is tested.
• Laserplastic clinic where skin multimodal imaging by the prototype device "SkImager" is approved and tested.

An important achievement thanks to the implementation of the programme is also
• submitted and accepted project SUMMA (No 688139) within Horizon 2020 call ICT-16 -2015 „Big data – research" for a total amount of 9.85 mEUR, of which Latvia will receive 1.16 mEUR. This proposal has been prepared together with SIA „LETA" on the basis of the results obtained within the Project 2.
• participation in Grand Cooperative Driving Challenge GCDC'2016, where technologies for self and cooperative driving cars have been presented and approved.
• On the basis of the results obtained within the Project 4 the European space agency financed project DynLand has been won.

1.9. Results of the programme:

Performance indicator	Results					
	Planned	Achieved				
		Total	Period 1	Period 2	Period 3	Period 4
A.Scientific performance indicators						
1. Scientific publications:	80	89	17	27	45	-
1.1 number of original scientific articles (*SCOPUS*)(SNIP>1)	17	4	0	2	2+2*	-
1.2 number of original scientific articles in journals or in proceedings of conferences in databases SCOPUS or Web of Science	63	69	13	22	34	-
1.3 number of reviewed scientific monographs	1	0	0	0	0	-
1.4 other original scientific articles	0	17	4	5	8	-
2. In the framework of the programme:						-
2.1 number of defended doctoral thesis	22	8	1	4	3	-
2.2 number of defended master's thesis	52	40	8	8	24	-
3. Number of improved courses	13	6	1	2	3	-
4. Research deliverables					-	-
4.1 Software prototypes	12	10	1	1	8	-
4.2 Methodology, descriptions	15	9	5	0	4	-
4.3 Mock-ups, prototypes, technologies	21	15	5	6	4	-
4.4 Involvement in international projects	6	5	1	2	2	-
B.Performance indicators of the promotion of the programme						
1. The number of interactive events to promote the process and results of the programme (target groups should include students):					-	-
1.1 Presentations in international conferences	50	51	13	15	23	-
1.2 Presentations in international seminars	4	4	0	1	3	-
1.3 organized seminars	25	19	5	8	6	-
1.4 popular-science publications, events, information in mass media	15	49	1	23	25	-
1.5 exhibitions	4	6	2	0	4	-
1.6 Organized international conferences	2	2	0	1	1	-
2. Press releases	0	7	2	3	2	-
3. Technological forecast	4	0	0	0	0	-
C.Economic performance indicators						
1. Amount of private funding attracted to the scientific institution in the framework of the programme, including:					0	-
1.1. co-funding from the private sector to implement the projects of the programme (EUR)	10000	70 820	0	0	070 820	-
1.2. income from commercializing the intellectual property created in the framework of the programme (alienation of industrial property rights, licensing, conferring exclusive rights or rights to use on a fee) (EUR)					-	-
1.3. income from contractual jobs that are based on results and experience acquired in the framework of the programme (EUR)	435000	1513346	232803	1198743	81800	-
1.4 Co-funding from the scientific organizations to implement the projects of the programme (EUR)	368300	319768.	22402	96730	200633	-

2. Number of applied for, registered, and valid patents or plant varieties in the framework of the programme:	12	2	1	1	0-	-
2.1 in the territory of Latvia	10	2	1	1	0	-
2.2 abroad	2	0	0	0	0	-
3. Number of new technologies, methods, prototypes or services that have been elaborated in the framework of the programme and approbated in enterprises	15	9	0	5	4	-
4. Number of new technologies, methods, prototypes, products or services that have been submitted for implementation (signed contracts on transfer of intellectual property)	3	0	0	0	0	-
5. Founded a new (spin-off) company	1	0	0	0	0	-
6. Earnings by the scientific institutions from other research projects in synergy (EUR)	4200000	1397067	0	108703	1288364	-

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

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

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

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

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

List of publications of the Project No1

A.1.Scientific publications

A.1.1.SCOPUS. SNIP>1:

1. Submitted for publication: I. Ribners, A. Mednis, K. Nesenbergs, R. Zviedris and L. Selavo "DIY Car Control System for Cooperative Driving", IEEE Intelligent Transportation Systems Magazine

A.1.2.SCOPUS, Web of Science:

1. Nesenbergs, Krisjanis. "Architecture of smart clothing for standardized wearable sensor systems." IEEE Instrumentation & Measurement Magazine 19.5 (2016): 36-64. http://ieeexplore.ieee.org/abstract/document/7579068/
2. J. Judvaitis, A. Salmins, K. Nesenbergs "Network Data Traffic Management Inside a TestBed", RTUWO, Accepted for publication, presented in conference.

List of publications of the Project No2:

1. Guntis Barzdins, Didzis Gosko. RIGA at SemEval-2016 Task 8: Impact of Smatch Extensions and Character-Level Neural Translation on AMR Parsing Accuracy. Proceedings of the 10th International Workshop on Semantic Evaluation (SemEval-2016), Association for Computational Linguistics, pp. 1143-1147. URL https://aclweb.org/anthology/S/S16/S16-1176.pdf. (to be indexed **ACL**)
2. Peteris Paikens. Deep Neural Learning Approaches for Latvian Morphological Tagging. Frontiers in Artificial Intelligence and Applications, Volume 289: Human Language Technologies – The Baltic Perspective, I. Skadiņa and R. Rozis (Eds.). IOS Press, 2016, pp 160-166. DOI 10.3233/978-1-61499-701-6-160 URL http://ebooks.iospress.nl/volumearticle/45531 (**SCOPUS**)
3. N. Gruzitis and G. Barzdins. The role of CNL and AMR in scalable abstractive summarization for multilingual media monitoring. Controlled Natural Language, Controlled Natural Language 5th International Workshop, CNL 2016, Davis, Brian, Pace, Gordon J., Wyner, Adam (Eds.), LNAI, Volume 9767, pp. 127-130, Springer 2016. doi = "10.1007/978-3-319-41498-0" (**SCOPUS**)
4. J.Barzdins, M.Grasmanis, E.Rencis, A.Sostaks, A.Steinsbekk, Towards a More Effective Hospital: Helping Health Professionals to Learn from their Own Practice by Developing an Easy to use Clinical Processes Querying Language. // J.E.Q. Varajão et. al. (Eds.), Procedia Computer Science, Vol. 100, Elsevier, pp. 498-506, 2016.
5. A.Kalnins, J.Barzdins, Metamodel Specialization for DSL Tool Building. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Databases and Information Systems, 12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, Proceedings, Communications in Computer and Information Science Vol. 615, Springer, pp.68-82, 2016. (**SCOPUS**)
6. A.Sprogis, DSML Tool Building Platform in WEB. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Databases and Information Systems, 12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, Proceedings, Communications in Computer and Information Science Vol. 615, Springer, pp.99-109, 2016. (**SCOPUS**)
7. A.Kalnins, J.Barzdins, Metamodel specialization for graphical modeling language support. // In: Proceedings of the ACM/IEEE 19th International Conference on Model Driven Engineering Languages and Systems. ACM, pp.103-112, 2016. (to be indexed **SCOPUS**)
8. J.Barzdins, M.Grasmanis, E.Rencis, A.Sostaks, J.Barzdins, Ad-Hoc Querying of Semistar Data Ontologies Using Controlled Natural Language. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 3-16, 2016. (to be indexed **SCOPUS**), http://ebooks.iospress.com/volumearticle/45695
9. A.Kalnins, J.Barzdins, Metamodel Specialization for Diagram Editor Building. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 87-100, 2016. (to be indexed **SCOPUS**), http://ebooks.iospress.com/volumearticle/45702
10. A.Sprogis, ajoo: WEB Based Framework for Domain Specific Modeling Tools. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 115-126, 2016. (to be indexed **SCOPUS**), http://ebooks.iospress.com/volumearticle/45704
11. Bicevska, Z., Bicevskis, J., Karnitis, G. Models of event driven systems. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Databases and Information Systems, 12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, Proceedings, Communications in Computer and Information Science Vol. 615, Springer, pp. 83-98, 2016. (**SCOPUS**)
12. Bicevskis, J., Bicevska, Z., Oditis, I. Self-management of information systems. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Databases and Information Systems,

12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, Proceedings, Communications in Computer and Information Science Vol. 615, Springer, pp. 167-180, 2016. (**SCOPUS**).
13. R.Bundulis and G.Arnicans. Conclusions from the evaluation of virtual machine based high resolution display wall system. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Databases and Information Systems, 12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, Proceedings, Communications in Computer and Information Science Vol. 615, Springer, pp. 211–225, 2016. (**SCOPUS**).
14. Rudolfs Bundulis, Guntis Arnicans. Infiniviz – Virtual Machine Based High-Resolution Display Wall System. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 225-238, 2016. (to be indexed **SCOPUS**)
15. Janis Bicevskis, Zane Bicevska, Girts Karnitis. Executable Models of Event Driven Systems. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 101-114, 2016. (to be indexed **SCOPUS**).
16. Janis Bicevskis, Zane Bicevska, Ivo Oditis. Implementation of Self-Management. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 169-182, 2016. (to be indexed **SCOPUS**).
17. Grundspenkis J. (2016). Historical Retrospection on Success and Failures during the Development of Concept Map Based System IKAS. Proceedings of the 7th International Conference on Concept Mapping, Tallinn, Estonia, September 5-9, 2016, Vol. 2, pp. 113-119.
18. Grundspenkis J. (2016). Towards the Formal Method for Evaluation of Concept Map Complexity from the Systems Viewpoint. Databases and Information Systems IX, G. Arnicans et al. (Eds.), Frontiers in Artificial Intelligence and Applications, Vol. 291. IOS Press, pp. 341-354. (to be indexed **SCOPUS**).
19. Jurenoks A., Novickis L. Adaptive Method for Assessing the Life Expectancy of a Wireless Sensor Network in Smart Environments Applications. In: Proceedings of 14th IFAC INTERNATIONAL CONFERENCE on PROGRAMMABLE DEVICES and EMBEDDED SYSTEMS PDES 2016, Brno University of Technology: 2016, pp.93-98.(**IEEExplore**)
20. Jurenoks A., Novickis L. Simulation-Based Experimental Research of Wireless Sensor Network Life Expectancy Reconfiguration Method in Transport Logistics Area. In: 2nd International Conference on Systems Informatics, Modelling and Simulation, Riga: 2016, pp.135-140. ISBN 978-1-5090-2693-7. (**IEEExplore**)
21. Novickis L., Mitasiunas A., Ponomarenko V. Information Technology Transfer Model as a Bridge between Science and Business Sector.In:Procedia Computer Science 2016, ICTE 2016, December, 8 p. (iesniegts)
22. Bartusevics A., Novickis L., Lesovskis A. An approach for development of reusable function library for automation of continuous processes. In:Procedia Computer Science 2016, ICTE 2016, December, 8 p. (iesniegts)
23. Businska L., Kirikova M., The Goal-Based Selection of the Business Process Modeling Language. 9th IFIP WG 8.1. Working Conference, PoEM 2016, Skövde, Sweden, November 8-10, 2016. Vol. 267 of the series Lecture Notes in Business Information Processing, pp 307-316. In database: SpringerLink. DOI: https:/doi.org/10.1007/978-3-319-48393-1_22
24. Kirikova, M. Towards Framing the Continuous Information Systems Engineering. Joint Proceedings of the BIR 2016 Workshops and Doctoral Consortium, co-located with 15th International Conference on Perspectives in Business Informatics Research (BIR 2016), September 14–16, 2016. Prague, Czech Republic. B. Johansson and F. Vencovský (Eds.). Managed Complexity. CEUR-WS.org, Vol. 1684.
25. Kirikova, M., Matulevičius, R., Sandkuhl, K.Application of the Enterprise Model Frame for Security Requirements and Control Identification. Databases and Information Systems IX, G.

Arnicans et al. (Eds.). IOS Press. 12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, pp.129-142. (to be indexed **SCOPUS**)

26. Lavendelis E. A Cloud Based Knowledge Structure Update and Machine Learning Framework for Heterogeneous Multi-Agent Systems. In: International Journal of Artificial Intelligence Vol 14 (2), October, 2016 CESER Publishing, pp. 157-170. (**Indexed in SCOPUS, SNIP: 1,159**)
27. Bartusevics A. Automation of Continuous Services: What Companies of Latvia says about it? In:Procedia Computer Science 2016, ICTE 2016, December, 8 p (iesniegts)
28. Petrovica, S., Pudane, M. Emotion Modeling for Simulation of Affective Student-Tutor Interaction: Personality Matching. International Journal of Education and Information Technologies, 2016, Vol.10, pp. 159.-167. (to be indexed **Web of Science**)
29. Peņicina L. Controlling Business Object States in Business Process Models to Support Compliance. PoEM 2016, Doctoral Consortium, Skövde, Sweden, November 8-10, 2016. (tiks publicēts Ceur-ws.org)
30. Kozlovs, D., Kirikova, M. Auditing Security of Information Flows. Proceedings Perspectives in Business Informatics Research. 15th International Conference, BIR 2016, Prague, Czech Republic, September 15-16, 2016, Vol. 261 of the series Lecture Notes in Business Information Processing. Springer, pp. 204-219. (**SCOPUS**)
31. Grocevs A., Prokofjeva N. The Capabilities of Automated Functional Testing of Programming Assignments. In: Procedia – Social and Behavioral Sciences, Vol. 228, 2016, pp. 457-461. (**Web of Science**)

List of publications of the Project No3:

1. 1. J. Spigulis, I. Oshina, Z. Rupenheits, "Smartphone single-snapshot mapping of skin chromophores," in *Biomedical Optics 2016*, OSA Technical Digest (online), JTu3A.46, https://www.osapublishing.org/abstract.cfm?uri=Cancer-2016-JTu3A.46. **[3rd period] (SCOPUS)**
2. E.Kviesis-Kipge, U.Rubīns. „Portable remote photoplethysmography device for monitoring of blood volume changes with high temporal resolution" BEC-2016, Proc. 15th Biennial Conference on Electronics and Embedded Systems. pp. 55-58 (2016); *IEEE Explore*, DOI: 10.1109/BEC.2016.7743727. **[3rd period] (SCOPUS)**
3. U.Rubins, J.Spigulis, A.Miscuks, "Photoplethysmography imaging algorithm for continuous monitoring of regional anesthesia", ESTIMedia'16, Proc.14th ACM/IEEE Symp. on Embedded Systems for Real-Time Multimedia, pp. 67-71 (2016), http://dl.acm.org/citation.cfm?id=2994308&CFID=863483070&CFTOKEN=69466985 *(IEEE Explore).* **[3rd period] (SCOPUS)**
4. J.Spigulis, I.Oshina, A.Berzina, A.Bykov, "Smartphone snapshot mapping of skin chromophores under triple-wavelength laser illumination", *J.Biomed.Opt*., submitted 2016. **(SNIP=1.181). [3rd period] (SCOPUS)**

List of publications of the Project No4:

1.K. Sudars, I.Bilinskis, E.Buls, Discrete Fourier Transform of the signals recovered by using high-performance Event Timers, Baltic Electronics Conference 2016, Tallinn, Estonia (IEEE Xplore, SCOPUS).

2.Lorencs A, Mednieks I, Siņica-Siņavskis J. 2016 "Selection of Informative Bands for Classification of Hyperspectral Images Based on Entropy", Proc. of BEC2016, the 15th Biennial Conference on Electronics and Embedded Systems. Tallinn, Estonia on October 3-5, 2016. pp. 135-138 (IEEE Xplore, SCOPUS).

3.Aristov V. Karhunen Loeve Transform As a Tool to Eliminate Signal's Redundancy, When Small Targets Detection. Sciences of Europe. Vol 2, № 2 , 2016. Praha, Czech Republic.

4.Aristov, V. (2016) Optimization of the transmitter pulse duration by the criterion of the radiation spectrum maximization at a given frequency. Automatic Control and Computer Sciences. 50(4), 220-225. . (SCOPUS) Springer Link.
5.Sergejs Olonkins, Vjaceslavs Bobrovs, Girts Ivanovs "FOPA Pump Phase Modulation and Polarization Impact on Generation of Idler Components", Elektronika ir Electrotechnika, Vol.77, No.4, 2016, pp. 77-81, ISSN 1392-1215 (to be included in SCOPUS).
6.Lavrinoviča, I., Poriņš, J., Brūklītis, E., Supe, A. Evaluation of Effective Area and Nonlinearity Coefficient of Erbium-Ytterbium Doped Optical Fibers. In: Progress in Electromagnetics Research Symposium (PIERS 2016): Proceedings, China, Shanghai, 8-11 August, 2016. Shanghai: The Electromagnetics Academy, 2016, pp.1-5. ISBN 78-1-934142-30-1. ISSN 1559-9450. e-ISSN 1559-8985 (to be included in SCOPUS).
7.Nescerecka, A., Hammes, F., Juhna, T., 2016. A pipeline for developing and testing staining protocols for flow cytometry, demonstrated with SYBR Green I and propidium iodide viability staining. Journal of Microbiological Methods 131, 172–180. doi:10.1016/j.mimet.2016.10.022.
8.Nescerecka, A., Juhna, T., Hammes, F., 2016. Behavior and stability of adenosine triphosphate (ATP) during chlorine disinfection. Water Research 101, 490–497. doi:10.1016/j.watres.2016.05.087. (SCOPUS, SNIP>1).
9.K. Sudars, Face Recognition Face2vec Based on Deep Learning: Small Database Case, Automatic Control and Computer Science (to be included in SCOPUS, accepted).
10.Dejus, S., Rusenieks, R., Nescerecka, A., Nazarovs, S., Juhna, T., *Long Term Drinking Water Quality Monitoring in Drinking Water Supply Systems by On-Line Sensors*, Book of Abstracts, 8th Eastern European Young Water Profesionals Conference, Gdansk, Poland, 2016, p.73-74, ISBN 978-83-7493-936-2
11.A.Lorencs, I.Mednieks, J.Sinica-Sinavskis. "Informative hyperspectral band subset selection based on entropy" (in preparation to submit to IEEE JSTARS journal).

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

2.1.2 Project goal and objectives

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

The overall goal of the project is to develop solutions and tools for cyber-physical systems (CPS), and in doing so, to make them usable and accessible for a wide user base and society in general. To help solve problems in medicine, intelligent transport systems and other fields important to the society, thus promoting economics based on production of competitive innovative CPS based products.

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

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

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

1. To ease the production, programming and usage of CPS, thus promoting competitive production of innovative CPS based products in economy, as well as facilitating their everyday usage and bridging the digital divide;

2. To improve the quality and ease of providing service in medical services, providing more effective prophylaxis, more timely diagnostics and more successful treatment and rehabilitation, based on innovative solutions, both locally and remotely in telemedicine;
3. To improve road traffic safety and ease of use of transport, by using intelligent transport system technologies;

While working on these goals, a strong connection between physical world, data gathered by smart sensors, processing and interpreting of this data as well as feedback back to physical world will be provided. A special care will be taken to improve efficiency and functionality of economic applications, through safe and autonomous measures, as well as a more convenient usage of CPS, and easier production of CPS based innovative systems.
In the third stage of the project the technologoies developed in the previous stages of the project were developed into prototypes, tested, validated, approbated and prepared for approbation/patenting, and also research results were submitted for publication.

Specific objectives were defined for the third stage as:
1.Testing and improving the integraded Testbed system prototype and its software, in order to prepare it for approbation; publish the research results;
2.Developing of wearable sensor network applications in medicine – such as prototype for ECG data registration and analysis device, werable system for computer control with head etc. Test and prepare these prototypes for approbatgion; Publish ar research paper; prepare patent application;
3.Develop intelligent transport system demonstration prototype for collaboratiove driving and approbate it in the GCDC event; prepare article for publication.
.

2.1.3 Description of gained scientific results
(Describe scientific results achieved during reporting period, give their scientific importance)
In depth project scientific results are described in the attached scientific report document (Appendix 1).
According to the goals of this project and specific objectives described in section 2.1.2. of this document, the work on these objectives within this project has been divided in three main groups:
1. **TestBed** (Appendix 1, section 1.2) – this group works on the objective of easing the development, programming and usage of CPS systems, by developing innovative hardware and software platform cyber-physical systems of smart sensors and their networks;
2. **MedWear** (Appendix 1, section 1.3) – this group works on the objective of improving the ease of serving and quality of medical services, by developing CPS for medical and telemedicine applications, and also by developing wearable sensor network technologies in general;
3. **SmartCar** (Appendix 1, section 1.4) – this group works on the objective of improving the read traffic safety and the ease of use of the cars, by developing uses of smart sensors in intelligent transport systems, as well as developing and testing advanced driver assistance systems (ADAS);

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

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

TestBed:
In this period the wireless sensor Testbed system prototype was improved and prepared for approbation (including both test devices and software), and also an analysis of the work and precision of this system was done.*Scientific purpose of the work*: New types of thecnologies are

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

MedWear:
In this period one experimental prototype has been developed which allows to control computer with head and project results have been accepted for publication as one article (indexed by SCOPUS), also including the results of the work one doctoral thesis and two masters thesis.
Scientific purpose of the work: New medical data gathering methods and devices have been developed, on which new medical research can be based, also the key results have been published.

SmartCar:
In this period a prototype collaborative self driving car and the accompanying software was developed and approbated in the international collaborative driving challenge (GCDC). Stereovision system has been developed for convertinf the data into a point cloud, which together with Lidar data serve as a basis for object detection. The results have been submitted for publication in a journal (SNIP>1) article. The work in ths part of the project has served as a basis for one masters thesis and three bachelors thesis. In addition a work has been started for miniature collaborative driving test track.

Scientific purpose of the work: Developed and approbated collaborative driving system and related algorithms, for use in the field of ITS and the results have been submitted for publication.

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

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

TestBed:
Further research activities and solvable problems: In the last period of the project, the system prototype approbation will be done, and alsothe application interface must be improved and made easier to use for the end users, thus making it easy to program and test wireless sensor networks.
Practical purpose and applications of the results: The results promote faster road to market of research intensive, sensor network based technologies, by increasing the speed of the development cycle and making testing easier. Companies developing sensor network solutions are target exploitation audience, using the infrastructure for developing and testing their products.

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

SmartCar

Further research activities and solvable problems: To continue the work on the miniature collaborative driving test track, and also to test developed algorithms with the smart car test platform. Continue the work on technologoies for advanced driver assistance, especially in monitoring the drivers themselves and expanding their senses (infrared spectrum etc.) as well as providing feedback.

Practical purpose and applications of the results: The smart car will be more secure and easier to use, because it can gather more data in a shorter period of time than the driver, thus allowing more efficient and more secure driving decisions. The developed technologies can prevent accidents on the road, both those caused by the external road conditions and other cars, and those caused by the tiredness or sleepiness of the driver. The developed smart car test platform and miniature test track will allow testing and validating of the developed technologies and to develop complex decision making algorithms for intelligent transport systems.

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

2.1.5. Dissemination and outreach activities

(Describe activities that were performed during reporting period to disseminate project results)

List of publications:

A. Scientific performance indicators of 3rd period:

A.1.Scientific publications

A.1.1.SCOPUS. SNIP>1:

1. Submitted for publication: I. Ribners, A. Mednis, K. Nesenbergs, R. Zviedris and L. Selavo “DIY Car Control System for Cooperative Driving”, IEEE Intelligent Transportation Systems Magazine

A.1.2.SCOPUS, Web of Science:

1. Nesenbergs, Krisjanis. "Architecture of smart clothing for standardized wearable sensor systems." IEEE Instrumentation & Measurement Magazine 19.5 (2016): 36-64. http://ieeexplore.ieee.org/abstract/document/7579068/
2. J. Judvaitis, A. Salmins, K. Nesenbergs “Network Data Traffic Management Inside a TestBed”, RTUWO, Accepted for publication, presented in conference.

A.2.Defended works:

A.2.1.Doctoral thesis:

- Atis Hermanis 25.11.2016. “SHAPE SENSING BASED ON EMBEDDED SENSORS FOR MOBILE CYBER-PHYSICAL SYSTEMS”/“FORMAS NOTEIKŠANA, IZMANTOJOT IESTRĀDĀTUS SENSORUS MOBILĀM KIBERFIZIKĀLAJĀM SISTĒMĀM” Academic supervisors Dr.sc.comp., senior researcher M. GREITĀNS, Dr.sc.ing., professor O. KRIEVS

A.2.2.Masters thesis:

- Armands Ancāns (2016) "An Acquisition and Processing of Inertial Sensor and Electromyogram Signal for Alternative Communication Device". Scientific supervisor Dr.sc.comp. M.Greitans.

- Maksis Celitāns (2016) "Multi branch sensor network for human biomechanical monitoring". Scientific supervisor Dr.sc.comp. M.Greitans.
- Rihards Novickis (2016) "Image Processing Using Heterogeneous Embedded Systems". Scientific supervisor Dr.sc.comp. M.Greitans..

A.2.3.Bachelors thesis:

- Voldemars Smelens (2016) "Acquisiton and processing of spatial point cloud ". Scientific supervisor Mg.sc.comp K.Nesenbergs.
- Martins Skudra (2016)"ADAS pedestrian detection, combining point cloud and thermal images". Scientific supervisor Mg.sc.comp K.Nesenbergs.
- Henrijs Smelens (2016) "RTK-GPS positioning system and its applications in self-driving cars ". Scientific supervisor Mg.sc.comp K.Nesenbergs.

A.3. Number of improved courses:

- Course „Special seminar: Cyber-physical systems" in the Bachelor programme, Faculty of Computer Sicence, University of Latvia.

A.4.Research deliverables:

A.4.1.Software prototypes:

- Software set for autonomous collaborative car approbation in the event GCDC.

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

- Prototype for a wearable device for computer control with head
- Prototype for autonomous collaborative driving platform, which together with the supporting software is the system prototype approbated in the GCDC event

A.4.4. International projects:

B.Performance indicators of the promotion of the programme of 3rd period:

B.1.Interactive events to promote the process and results of the programme (target groups include students):

B.1.1.Presentations in international conferences:

- 2016-11-04 A. Salms presents the achievements in the project at conference RTUWO 2016 Advances in Wireless and Optical Communications with presentation "Network Data Traffic Management Inside a TestBed";

B.1.2.Presentations in international seminars:

- 2016.05.28 – During the GCDC event the solution developed in the project was presented, including the user interface

B.1.5.Organized seminars:

- 23.11.2016 Progress and results seminar of period 3 of project No.1. "Development of technologies for cyber physical systems with applications in medicine and smart transport"
- 07.12.2016 SOPHIS period 3 progress and result seminar

B.1.5.Popular science publications, events, information in mass media:

- 2016-04-29 A. Ancāns – presents thesis "Inerciālo sensoru un elektromiogrammu signālu ieguve un apstrāde alternatīvās saziņas ierīcei" in the 57th RTU student scientific and technical conference;
- 2016.09.30 – Results of the project prresented during the event of Researchers'night 2016;
- 2016.10.17 – Publication in protal Delfi "Šonedēļ Ķīpsalā varēs apskatīt Latvijā radītu pašbraucošo auto", http://www.delfi.lv/auto/zinas/sonedel-kipsala-vares-apskatit-latvija-raditu-pasbraucoso-auto.d?id=48034021

- 2016-10.17 – Publication in portal epadomi.lv “Ķīpsalā ieripos Latvijā radīts pašbraucošs auto!”, http://epadomi.lv/auto/17102016-kipsala_ieripos_latvija_radits_pasbraucos
- 2016.10.26 – Publication in portal Kas Jauns “Latviešu zinātnieki cer atrisināt sastrēgumu problēmu – Ķīpsalā redzams pašbraucošs auto.”, http://www.kasjauns.lv/lv/zinas/234406/latviesu-zinatnieki-cer-atrisinat-sastregumu-problemu--kipsala-redzams-pasbraucoss-auto-foto
- 2016-12-04 – Publication in portal Kursors.lv “EDI Zinātnieku naktī aicina iepazīt viedos audumus, biometrijas iespējas, iegultās sistēmas un viedo transportu”, http://kursors.lv/2016/09/28/edi-zinatnieku-nakti-aicina-iepazit-viedos-audumus-biometri/
- Emil Syundukov . April 2016: Garage48 HealthTech hackathon: https://www.google.lv/search?num=30&espv=2&q=vesel%C4%ABbas+tehnolo%C4%A3iju+hakatons+garage48+healthtech&oq=vesel%C4%ABb&gs_l=serp.3.0.35i39k1l2j0l8.6160.8059.0.9105.11.9.1.0.0.0.313.1210.0j4j1j1.6.0....0...1c.1.64.serp..4.7.1212...0i10k1j0i30k1j0i10i30k1.RkhTKRfPaVU
- .April 2016: Participation in world biotechnological leader forum at Cambridge: http://www.df.lu.lv/zinas/t/39756/ Emil Syundukov;
- .May 2016: "Forbes 30 under 30": http://www.df.lu.lv/zinas/t/40692/ Emil Syundukov;
- Emil Syundukov May 2016: Participation in exhibition Upgraded Life Festival in Finland (http://www.upgradedlifefestival.com/);
- Emil Syundukov - http://www.df.lu.lv/zinas/t/40289/;
- Emil Syundukov - http://www.df.lu.lv/zinas/t/43098/;
- Emil Syundukov - http://www.df.lu.lv/zinas/t/39321/;
- Emil Syundukov - http://www.df.lu.lv/zinas/t/38614/;
- Emil Syundukov - http://www.db.lv/tehnologijas/programmatura/pulcesies-veselibas-tehnologiju-entuziasti-447088;
- Emil Syundukov - http://www.diena.lv/sodien-laikraksta/studenti-kuri-patiesam-aizravusies-14131465;
- Emil Syundukov -Guest lectures at BioTech Meetup, RSU (march 2016), LU, Latvian schools, SSE Riga (as part of Global Entrepreneurship Week event);
- Emil Syundukov Participation in the television show at LTV1 "Lielais Jautājums" : http://www.lsm.lv/lv/raksts/ekonomika/zinas/ka-apsteigt-igauniju-miljons-par-sasniegumiem-izglitibas-un-veselibas-aprupes-eksports.a212451/?utm_source=facebook&utm_campaign=news&utm_medium=admin;

- Exhibitions:

- Participation in exhibition «RIGA COMM 2016», Riga, Octoboer 20-21;
- Participation in exhibition “ROBOTEX” Estonia, Tallin, December 02-04

Leader of the project No.1. _____ L.Selavo _____ 01.2017

(signature and transcript) *(date)*

2.2.1. Project No. 2

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

2.2.2. Project goal and objectives

(Describe the project goals and objectives so that the 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 3rd stage of the SOPHIS program are:

1. Further development of the ontology- and web technologies-based fast query language and its efficient implementation by introducing the view-based extension mechanism.
2. Development of data access control mechanism based on data ontologies and web technologies, to be used for the implementation of the Ad-hoc query language.
3. Development of metamodel specialization methods and their application to building of domain specific language tools for web environment.
4. Participation in SemEval-2016 competition with an improved version of the C6.0 classification algorithm adapted for Abstract Meaning Representation (AMR) information retrieval
5. Further improvement of functionality of intelligent structural modeling tool I4S for multicriterial assessment of importance of elements for knowledge structures of different types and granularities
6. Development, merging and application of knowledge structure models in ontology- and rule-based decision making
7. Detailed development of the approach for aligning requirements/systems engineering based knowledge flows (structures)/information artifacts
8. Development and integration of different services in Web portal using open Semantic Web resources and enhancement of software configuration management methods
9. Development of technologies for large scale NoSQL data base exploration and visualization.
10. Business process runtime verification

2.2.3. Description of gained scientific results

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

1. Further development of the ontology- and web technologies-based fast query language and its efficient implementation by introducing the view-based extension mechanism.

We have further developed the semistar data ontologies-based fast query language that was developed within previous stages of this project. We have also implemented the language efficiently, and we have performed its performance test which have been based on real CCUH data and typical queries. We have reached the query execution performance of about 0.3 seconds on average per one query. This would match the performance of about 1 second per query if we took data from all the hospitals in Latvia (and take into account the potential to execute the query calculation process in parallel). These developments and results have been described in two publications [4, 8]. Additionally, we have introduced a new construct within the fast query language – the view definition mechanism –, and we have implemented it efficiently. This new feature allows end-users to create new subclasses of ontology classes by defining them using only constructs of the query language. Therefore end-users are not obliged to learn any new languages. An example of the subclass definition:

```
DEFINE SuccessfulPatient = Patient WHERE FORALL HospitalEpisodes HOLDS
                           dischargeReason=healthy
```

The newly defined subclasses are stored within the same structure as other classes, so they can at once be used in queries in the same way the basic class from the ontology are. It hugely improves the practical usability of the query language. The developed view definition mechanism does not decrease the performance of the system (i.e. the time needed for obtaining answer to queries that exploit views) significantly. The prototype of the system is available upon request in the IMCS, UL.

2. Development of data access control mechanism based on data ontologies and web technologies, to be used for the implementation of the Ad-hoc query language.

A very advanced access control definition mechanism for the fast Ad-hoc query language for semistar data ontologies has been developed. This mechanism uses an extended concept of a user role, where access rights are being defined using slightly extended facilities of the query language itself. For each role an access rule is specified which specifies what data from the semistar ontology can be accessed by the given role. The access rule can have two parameters to be set for the given user. All this creates the access control schema for the given data domain. An access rule is specified by an extension of the query language using the FULLSELECT statement with the following syntax - “FULLSELECT <class name> WHERE <select condition> WITHOUT <class name>[.<attribute name>], … ” . The FULLSELECT statement (which is similar in structure to the FULLSHOW statement in the basic query language) means that together with the instances of the specified class the children and parent instances are selected as well. The WITHOUT clause specifies which attributes or classes in the selection are hidden from the user. The semistar structure of the data model guaranties that such a definition is well-formed. The proposed access control mechanism permits to define in a simple way all typical access constraints in medical domain, that e.g. a Responsible Physician can see only data of the patients which have been treated by him, a ward manager can see data for patients being treated in the ward managed by him etc. A research has been done also to evaluate the impact of the access right application on query system performance, the expected slowdown is no more than 0.5 seconds on a query execution. Certainly, further experiments are required to check all this, such a research is planned for the next stage of the project.

3. Development of metamodel specialization methods and their application to building of domain specific language tools for web environment.

A new metamodeling method – the metamodel specialization method – has been developed. This method is based on standard UML facilities – class diagrams, class and association specialization and OCL constraints. An application of metamodel specialization method to building graphical DSL tools has been developed. This application results in a new kind of a platform for building DSL tools. In this platform at first a Universal metamodel for the chosen DSL tool domain (e.g., for graphical DSL modeling tools) is being created. A Universal engine for this metamodel is also built. Then any specific DSL tool from the chosen domain can be obtained by the metamodel specialization method. The proposed new approach differs from the existing traditional DSL tool building platforms by the feature, that instead of traditional metamodel instantiation we use the specialization of the universal

metamodel. This permits to build a complete definition of the chosen DSL tool by adding appropriate OCL constraints. To compare, for traditional metamodel instantiation applications when building a more complicated DSL tool, as a rule it is necessary to dive into the internal implementation model of the corresponding universal engine, thus making the platform usage much more complicated. The main research results have been published in [7] – in proceedings of the most prominent international conference in the area – Models 2016 (with paper acceptance rate 23.7%). Additional results have been published also in [5, 9]. A graphical tool building platform for web environment, to a great degree based on the above-mentioned ideas has been developed as well [10].

4. Participation in SemEval-2016 competition with an improved version of the C6.0 classification algorithm adapted for Abstract Meaning Representation (AMR) information retrieval

We continued research in information retrieval and semantic parsing with an application of our earlier Semeval-2015 approach to the formalism of Abstract Meaning Representation (AMR). AMR parsing extends the FrameNet micro-relations concept and attempts to build a semantic graph of all relations within a sentence.

We managed to achieve excellent AMR parsing accuracy, resulting in the first place in Task 8 of Semeval-2016 shared task competition [1]. In addition to integration of the C6.0 0 classifier with the AMR SMATCH scoring tool to improve accuracy of the CAMR parser, we implemented an ensemble with a character level sequence-to-sequence neural network model for semantic parsing with methods inspired by neural machine translation.

Exploration of these technologies also resulted in publications about applications of AMR in text summarization [3] and deep neural networks for Latvian tagging [2], and the development of three master's thesis on these technologies [1,2,3].

5. Further improvement of functionality of intelligent structural modeling tool I4S for multicriterial assessment of importance of elements for knowledge structures of different types and granularities

In this stage of research, the functionality of the tool I4S is extended. A novel method has been developed for assessment of importance of elements for knowledge structures of different types and granularities. The initial model to be used is aggregated model of morphological structure (MSM) for which the importance of each element in the whole structure is assessed using structural modeling approach. Three criteria are used – local, global, and causal connectedness. After transformation (homomorphism of models is ensured) of the initial model into a new model that has deeper level of granularity, the assessment of element importance is repeated. The obtained results are summarized for subsets of elements which correspond to each element of initial model. For implementation of the method, the corresponding algorithm has been developed.

The work started during the second stage of the project and focused towards the development of formal method for evaluation of concept map [17] complexity from the systems viewpoint is continued. Evaluation of complexity of concept maps as one kind of knowledge structure representation is based on criteria used in Systems Theory. The set of criteria is expanded by new formula for calculation of structural complexity, degree of centralization of structure, and relative weight of hierarchical levels. As a result, the framework for multicriterial evaluation of concept map complexity has been worked out [18].

Testing of methods is started for assessment of element importance in knowledge structures of different types and granularities using various criteria. In this research, the developed repository of knowledge structure models is used. The research concerning possibilities to combine different knowledge structures used in distributed artificial intelligence with focus on network schemas is also carried out.

6. Development, merging and application of knowledge structure models in ontology- and rule-based decision making

Development and analysis of different types of systems is essential to the creation of classification of knowledge structures. Within the current step of the task a repository of knowledge structures was built. This repository was made using developed software I4S and it serves as a central part where is stored knowledge about different types of systems. The input of knowledge structures of systems is made according to the previously developed methodology, and these descriptions are stored as different models in I4S. The functionality of software ensures a convenient way for transition between different type of models, which, in turn, is essential for carrying out appropriate research models and causal analysis

Besides the creation of a repository, a research related to the development of knowledge structure for the dynamic adaptation of emotion-based instructional process has been carried out to continue studies started in the previous stage. A multi-agent system is selected as a basic approach to enable a simulation of affective student-tutor interaction. Architecture of a pedagogical agent is designed supporting not only the usage of pedagogical knowledge (e.g., tutoring strategies including game-based learning) but also emotion ontology, which includes both descriptions of emotions and their possible causes. The communication of multi-agent system is enabled by using fragments of previously researched ontologies. The knowledge of personality is included in the model by transforming it into core mood thus ensuring communication of emotional state among agents. Furthermore, the reasoning mechanism of a pedagogical agent utilizes knowledge about student's personality that serves for various purposes, e.g., for the prediction of student's emotions and behavior, for the generation of appropriate tutor's personality and teaching actions, as well as for the selection of suitable teaching methods [28].

Development of autonomous multi-agent system knowledge structure update mechanism is continued. The previously developed conceptual framework has been implemented into ontologies and rules based multi-agent system management tool. The tool implements a simplified simulation of a multi robot system for cleaning tasks. The previously developed rule based priority mechanism is implemented into the tool and is applied to the task allocation in multi-robot systems (currently working in a simulated environment). Current functionality of the tool is the following: defining and updating knowledge structure (ontology), configuration of the environment, configuration of the multi-robot system as well as the knowledge base. Description of the developed tool has been published in a journal paper with SNIP over 1.0 [26].

7. Detailed development of the approach for aligning requirements/systems engineering based knowledge flows (structures)/information artifacts

The proposed approach for aligning requirements engineering based knowledge flows (structures)/information artifacts is based on the continuous requirements/systems engineering framework FREEDOM that was developed in the previous phase of the project. In this phase, the details of the framework, which influence the knowledge/information flow in the framework, were addressed (see [23, 25, 30] and Master Theses [13, 14, 15, 16]). In parallel the FREEDOM framework was compared to other frameworks developed for similar purposes; and the variants of the FREEDOM framework were identified and illustrated to demonstrate its flexibility [24].

Aligning requirements/systems engineering based knowledge flows (structures)/information artifacts requires addressing the existing gap between business process models and states of business objects. Therefore an approach was developed for explicit definition of states of business objects, automatic generation of conceivable state space at a process model design-time, automatic generation of lawful state space, and compliance checking at a process run-time (described in [29]). In this regard time aspects play an important role; therefore, in this phase of the project, also time aspects were analyzed with respect to the FREEDOM framework. Additionally an approach on the identification of system’s external knowledge structures/information artefacts and the changes of their state has been proposed. The approach is rooted in the analysis and the representation of the structure and content of the documents capturing valuable knowledge for the enterprises. Taking into consideration that large amount of requirements are elicited and analyzed during information systems development process and that those requirements can be processed, stored, and managed in various tools and communicated via various channels; the appropriate requirement distribution approach was

developed. To establish the background for unification of abovementioned aspects of artifact alignment in the next phase of the project, the possibility to use graph algorithms in information flow analysis was analyzed.

8. Development and integration of different services in Web portal using open Semantic Web resources and enhancement of software configuration management methods

The EAF methodology, which is based on MDA approach and is aimed at software configuration management and automation of IT operations for software practical application, has been further improved. A survey has been implemented to determine the main continuous processes that ICT companies are going to automate, the current automation level of these processes, and the main challenges in the automation field. The survey had 42 respondents from more than 35 ICT companies in Latvia. The results of survey will be used for further enhancing the EAF [21, 27].

The semantic services development and integration methodology utilizes model-driven approach to design, develop and maintain services with reusability in mind. One of the key elements of the approach – the Reusable Functions Library – was developed. This library makes it possible to reuse implemented automation functions in different projects and different workflows [22].

The methodology for systematic development of RESTful Semantic Web services using SADI (Semantic Automated Discovery and Integration) framework has been further developed. The methodology was used to develop a set of Semantic Web services that are used in eLOGMAR logistic portal (available at http://www.elogmar.eu). The validation was implemented in collaboration with industrial partner – company Logitrans Consult [19, 20, 31].

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

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

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

During stage 3 together with doctoral student R. Bundulis display wall architecture and data processing algorithms are improved. Prototype created is stable enough to start intensive research of usage of display wall. Created prototype is called Infiviz and is described in publications[13, 14].

Different display wall development possibilities are explored with students of University of Latvia. It is impossible to work in traditional way with keyboard and mouse because of the large screen size. Display wall control with Android device is researched (bachelor thesis of student Mārtiņš Andersons). Even more effective control can be achieved, if display wall would be built with touch screen monitors. We found that it is possible to use high resolution monitors in display wall (bachelor thesis of student Laura Ķirsone). For Microsoft Windows applications to work fast, DirectX technologies must be implemented into Virtualbox virtual graphics card (course work of student Matīss Ķeiris).

During the development of monitor wall itself, there was research for the possibility to implement applications for monitor wall. However, using web-based tools on a real monitor wall resulted in a decrease in performance. The understand the reasons for the performance decrease we study web technology guidelines, operating rules, and its internals.

Based on the results, a strategy has been created, and partially implemented, and its goal is to find the optimal combination of the right system configuration, tools, and web browser specific

optimization, that would help in creating effective web solutions for high definition display walls (the master thesis of student Aleksandrs Rilins).
Also display of connected web pages or resourses on display wall is researched during third stage (bachelor thesis of student Kristīne Karlsone). Monitor edges interfere large graph display on display wall. First algorithms is developed that ensures that graph nodes are not split between monitors (bachelor thesis of student Jānis Kašs).
During stage 3 tree prototypes for large data visualisation was created. First prototype collects different spatial data of city (Riga) and shows them on map, showing which parts of city are more fitted to user criteria (the master thesis of student Jānis Peisenieks). Second prototype gathers information about paraplane flights near Baltic seeshore and visualizes model of adequacy of weather conditions for flying in different places based on weather forecast (the master thesis of student Vladislavs Maksimčuks). Third prototype ganerates different test pictures and tests adequacy of popular web browsers for displaying large complex pictures on display wall (the master thesis of student Normunds Pureklis).

10. Business process runtime verification

Computerized system analysis and operation correctness evaluation during runtime in operational environment is understood as runtime verification in this research. Correctness evaluation can be done by tools built into system or by system events external monitoring. This research focuses on the last one. Verification is done according to each processes' verification description – model, where is defined events that confirm correctness of each process step, their execution sequence and execution time restrictions.
Prototype for runtime environment controlling system was developed in the first stage of the research. It fixes runtime environment events and via autonomous agents sent them to the controller. Controller monitors environment events and verifies them according to verification model. In second stage of the research prototype developed in first stage was used for real life business process verification to measure additional workload to information system added by runtime verification process. Obtained measurements show, that additional workload for information system is negligible. It shows practical usability of proposed business process runtime verification mechanism.
Research started in first two stages is continued during third stage. All research made by Ivo Oditis in his doctoral thesis defended on 4th of September 2016 was integrated. Additional research of usage of developed methods was continued in two directions:

(1)Define set of systems to whom usage of such system is adequate. As the result of the research class of so called event based system was defined, as well as conditions was defined when models of theese systems are authomatically executable. It opens wide possibilities to use runtime verification in lot of real-world systems.
(2)Run time verification is included in the set of attributes of smart technologies. Smart technologies follows the same goal as IBM's autonomous systems – reduce complexity of system usage by including tools of system runtime support into the system. The main difference between smart technologies and autonomous systems – IBM try to find universal solution, but smart technologies try to reduce complexity by developing realization of some system properties, in this case – run time verification.

Research results ar included in four papers. Two of them are already indexed by Scopus [11, 12], and two of them are included in a book published by IOS Press, but not yet indexed by Scopus [15, 16].

Publications:

1. Guntis Barzdins, Didzis Gosko. RIGA at SemEval-2016 Task 8: Impact of Smatch Extensions and Character-Level Neural Translation on AMR Parsing Accuracy. Proceedings of the 10th International Workshop on Semantic Evaluation (SemEval-2016), Association for Computational Linguistics, pp. 1143-1147. URL https://aclweb.org/anthology/S/S16/S16-1176.pdf. (to be indexed **ACL**)

2. Peteris Paikens. Deep Neural Learning Approaches for Latvian Morphological Tagging. Frontiers in Artificial Intelligence and Applications, Volume 289: Human Language Technologies – The Baltic Perspective, I. Skadiņa and R. Rozis (Eds.). IOS Press, 2016, pp 160-166. DOI 10.3233/978-1-61499-701-6-160 URL http://ebooks.iospress.nl/volumearticle/45531 (**SCOPUS**)
3. N. Gruzitis and G. Barzdins. The role of CNL and AMR in scalable abstractive summarization for multilingual media monitoring. Controlled Natural Language, Controlled Natural Language 5th International Workshop, CNL 2016, Davis, Brian, Pace, Gordon J., Wyner, Adam (Eds.), LNAI, Volume 9767, pp. 127-130, Springer 2016. doi = "10.1007/978-3-319-41498-0" (**SCOPUS**)
4. J.Barzdins, M.Grasmanis, E.Rencis, A.Sostaks, A.Steinsbekk, Towards a More Effective Hospital: Helping Health Professionals to Learn from their Own Practice by Developing an Easy to use Clinical Processes Querying Language. // J.E.Q. Varajão et. al. (Eds.), Procedia Computer Science, Vol. 100, Elsevier, pp. 498-506, 2016.
5. A.Kalnins, J.Barzdins, Metamodel Specialization for DSL Tool Building. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Databases and Information Systems, 12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, Proceedings, Communications in Computer and Information Science Vol. 615, Springer, pp.68-82, 2016. (**SCOPUS**)
6. A.Sprogis, DSML Tool Building Platform in WEB. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Databases and Information Systems, 12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, Proceedings, Communications in Computer and Information Science Vol. 615, Springer, pp.99-109, 2016. (**SCOPUS**)
7. A.Kalnins, J.Barzdins, Metamodel specialization for graphical modeling language support. // In: Proceedings of the ACM/IEEE 19th International Conference on Model Driven Engineering Languages and Systems. ACM, pp.103-112, 2016. (to be indexed **SCOPUS**)
8. J.Barzdins, M.Grasmanis, E.Rencis, A.Sostaks, J.Barzdins, Ad-Hoc Querying of Semistar Data Ontologies Using Controlled Natural Language. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 3-16, 2016. (to be indexed **SCOPUS**), http://ebooks.iospress.com/volumearticle/45695
9. A.Kalnins, J.Barzdins, Metamodel Specialization for Diagram Editor Building. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 87-100, 2016. (to be indexed **SCOPUS**), http://ebooks.iospress.com/volumearticle/45702
10. A.Sprogis, ajoo: WEB Based Framework for Domain Specific Modeling Tools. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 115-126, 2016. (to be indexed **SCOPUS**), http://ebooks.iospress.com/volumearticle/45704
11. Bicevska, Z., Bicevskis, J., Karnitis, G. Models of event driven systems. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Databases and Information Systems, 12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, Proceedings, Communications in Computer and Information Science Vol. 615, Springer, pp. 83-98, 2016. (**SCOPUS**)
12. Bicevskis, J., Bicevska, Z., Oditis, I. Self-management of information systems. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Databases and Information Systems, 12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, Proceedings, Communications in Computer and Information Science Vol. 615, Springer, pp. 167-180, 2016. (**SCOPUS**).
13. R.Bundulis and G.Arnicans. Conclusions from the evaluation of virtual machine based high resolution display wall system. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Databases and Information Systems, 12th International Baltic Conference, DB&IS 2016,

Riga, Latvia, July 4-6, 2016, Proceedings, Communications in Computer and Information Science Vol. 615, Springer, pp. 211–225, 2016. (**SCOPUS**).

14. Rudolfs Bundulis, Guntis Arnicans. Infiniviz – Virtual Machine Based High-Resolution Display Wall System. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 225-238, 2016. (to be indexed **SCOPUS**)
15. Janis Bicevskis, Zane Bicevska, Girts Karnitis. Executable Models of Event Driven Systems. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 101-114, 2016. (to be indexed **SCOPUS**).
16. Janis Bicevskis, Zane Bicevska, Ivo Oditis. Implementation of Self-Management. // In: G.Arnicans, V.Arnicane, J.Borzovs, L.Niedrite (Eds.), Frontiers of AI and Applications, Vol. 291, Databases and Information Systems IX, IOS Press, pp. 169-182, 2016. (to be indexed **SCOPUS**).
17. Grundspenkis J. (2016). Historical Retrospection on Success and Failures during the Development of Concept Map Based System IKAS. Proceedings of the 7th International Conference on Concept Mapping, Tallinn, Estonia, September 5-9, 2016, Vol. 2, pp. 113-119.
18. Grundspenkis J. (2016). Towards the Formal Method for Evaluation of Concept Map Complexity from the Systems Viewpoint. Databases and Information Systems IX, G. Arnicans et al. (Eds.), Frontiers in Artificial Intelligence and Applications, Vol. 291. IOS Press, pp. 341-354. (to be indexed **SCOPUS**).
19. Jurenoks A., Novickis L. Adaptive Method for Assessing the Life Expectancy of a Wireless Sensor Network in Smart Environments Applications. In: Proceedings of 14th IFAC INTERNATIONAL CONFERENCE on PROGRAMMABLE DEVICES and EMBEDDED SYSTEMS PDES 2016, Brno University of Technology: 2016, pp.93-98.(**IEEExplore**)
20. Jurenoks A., Novickis L. Simulation-Based Experimental Research of Wireless Sensor Network Life Expectancy Reconfiguration Method in Transport Logistics Area. In: 2nd International Conference on Systems Informatics, Modelling and Simulation, Riga: 2016, pp.135-140. ISBN 978-1-5090-2693-7. (**IEEExplore**)
21. Novickis L., Mitasiunas A., Ponomarenko V. Information Technology Transfer Model as a Bridge between Science and Business Sector.In:Procedia Computer Science 2016, ICTE 2016, December, 8 p. (iesniegts)
22. Bartusevics A., Novickis L., Lesovskis A. An approach for development of reusable function library for automation of continuous processes. In:Procedia Computer Science 2016, ICTE 2016, December, 8 p. (iesniegts)
23. Businska L., Kirikova M., The Goal-Based Selection of the Business Process Modeling Language. 9th IFIP WG 8.1. Working Conference, PoEM 2016, Skövde, Sweden, November 8-10, 2016. Vol. 267 of the series Lecture Notes in Business Information Processing, pp 307-316. In database: SpringerLink. DOI: https:/doi.org/10.1007/978-3-319-48393-1_22
24. Kirikova, M. Towards Framing the Continuous Information Systems Engineering. Joint Proceedings of the BIR 2016 Workshops and Doctoral Consortium, co-located with 15th International Conference on Perspectives in Business Informatics Research (BIR 2016), September 14–16, 2016. Prague, Czech Republic. B. Johansson and F. Vencovský (Eds.). Managed Complexity. CEUR-WS.org, Vol. 1684.
25. Kirikova, M., Matulevičius, R., Sandkuhl, K.Application of the Enterprise Model Frame for Security Requirements and Control Identification. Databases and Information Systems IX, G. Arnicans et al. (Eds.). IOS Press. 12th International Baltic Conference, DB&IS 2016, Riga, Latvia, July 4-6, 2016, pp.129-142. (to be indexed **SCOPUS**)
26. Lavendelis E. A Cloud Based Knowledge Structure Update and Machine Learning Framework for Heterogeneous Multi-Agent Systems. In: International Journal of Artificial Intelligence Vol 14 (2), October, 2016 CESER Publishing, pp. 157-170. (**Indexed in SCOPUS, SNIP: 1,159**)

27. Bartusevics A. Automation of Continuous Services: What Companies of Latvia says about it? In:Procedia Computer Science 2016, ICTE 2016, December, 8 p (iesniegts)
28. Petrovica, S., Pudane, M. Emotion Modeling for Simulation of Affective Student-Tutor Interaction: Personality Matching. International Journal of Education and Information Technologies, 2016, Vol.10, pp. 159.-167. (to be indexed **Web of Science**)
29. Peņicina L. Controlling Business Object States in Business Process Models to Support Compliance. PoEM 2016, Doctoral Consortium, Skövde, Sweden, November 8-10, 2016. (tiks publicēts Ceur-ws.org)
30. Kozlovs, D., Kirikova, M. Auditing Security of Information Flows. Proceedings Perspectives in Business Informatics Research. 15th International Conference, BIR 2016, Prague, Czech Republic, September 15-16, 2016, Vol. 261 of the series Lecture Notes in Business Information Processing. Springer, pp. 204-219. (**SCOPUS**)
31. Grocevs A., Prokofjeva N. The Capabilities of Automated Functional Testing of Programming Assignments. In: Procedia – Social and Behavioral Sciences, Vol. 228, 2016, pp. 457-461. (**Web of Science**)

2.2.4. Further research and practical exploitation of the results

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

We expect to participate in SemEval-2017, Task 9 on Abstract Meaning Representation (AMR) Parsing and Generation. Another potential research direction is Immitation Learning to unify Deep Reinforcement Learning with Episodic Memory one-shot learning for robotics applications. We also intend to participate in NIST TAC-KBP Cold Start task and workshop.

During the next stage, the developed method and algorithm for multicriterial assessment of importance of knowledge structure elements will be tested using a representative set of knowledge structures, the framework for evaluation of concept map complexity will be expanded by adding more criteria borrowed from graph theory, and formal algorithms for mutual transformations of different knowledge representation schemas will be worked out.

At present, the repository of models of systems is built taking into account their affiliation to technical or non-technical systems. Such a division of systems under investigation is not enough, namely, in the future another more detailed classification of systems must be developed, as well as a qualitative and quantitative analysis of models stored in a repository must be made and appropriate functionality for I4S software must be added. Further development of student and tutor emotion models is planned to include several functions, such as emotion generation and simulation of an emotional behavior. Future research in the area of ontology- and rule-based decision making in multi-agent systems during the next stage of the project is to implement the machine learning mechanism to enable the system to learn from the experience. Implementation of such a mechanism will make the tool fully functional and enable fully autonomous updates in multi-agent systems. The approach and tool after finalizing the implementation will give a significant contribution to the research of autonomous machines (for example, robots), by enabling autonomous changes in knowledge structures and knowledge itself after the system is deployed. Lack of such mechanisms is one of the obstacles that currently hinders the development of fully autonomous robotic systems.

Based on the results of the survey performed during the stage 3, it is planned to improve the developed Reusable Function Library to make it independent from particular infrastructure. The results of the performed validation will be used to enhance the ontologies used in eLOGMAR.eu Semantic Web services.

2.2.5. Dissemination and outreach activities

(Describe activities that were performed during reporting period to disseminate project results)

- G.Barzdins participated in the discussion forum "LAMPA" on July 1-2, 2016, Cēsis (http://www.festivalslampa.lv/) with public discussion on "Artificial Intelligence: Human vs. Machine" (Mākslīgais intelekts: cilvēks vs. mašīnas). The discussion was well attended and

concentrated on practical issues in AI and its adoption in various fields. See video at: https://youtu.be/870G4ABk11I

- Project participants fromUniversity of Latvia and Riga Technical University participated in organization of the 12th International Baltic Conference on Databases and Information Systems (Baltic DB&IS 2016), Riga, Latvia, July 4-6, 2016
- Project participants from the Faculty of Computer Science and Information Technology of Riga Technical University (FCSIT RTU) organized the following two scientific workshops co-located with the 15th International Conference on Perspectives in Business Informatics Research (BIR 2016) held in Prague, Czech Republic on September 14-16, 2016, which included also presentations on the results of this project:
  - 1st Workshop on Managed Complexity (ManComp 2016)
  - 4th International Workshop on Intelligent Educational Systems, Technology-enhanced Learning and Technology Transfer Models (INTEL-EDU 2016)
- Researchers from the FC UL, IMCS and FCSIT RTU presented the results achieved during the 3rd stage of the project at the following scientific conferences and workshops:
  - 12th International Baltic Conference on Databases and Information Systems (Baltic DB&IS 2016), Riga, Latvia, July 4-6, 2016
  - 7th International Conference on Concept Mapping (CMC 2016), Tallinn, Estonia, September 5-9, 2016
  - 15th International Conference on Perspectives in Business Informatics Research (BIR 2016), Prague, Czech Republic, September 15-16, 2016
  - 9th IFIP WG 8.1 Working Conference on The Practice of Enterprise Modeling (PoEM 2016) and Doctoral Consortium, Skövde, Sweden, November 8-10, 2016
  - 2nd International Conference on Higher Education Advances (HEAd´16), València, Spain, June 21-23, 2016
  - 14th IFAC International Conference on Programmable Devices and Embedded Systems (PDES 2016), Lednice, Czech Republic, October 5-7, 2016
  - 2nd International Conference on Systems Informatics, Modelling and Simulation, Riga, Latvia, June 1-3, 2016
  - 57th International Scientific Conference of Riga Technical University, Section: Computer Science, Applied Computer Systems, Riga, Latvia, October 14-18, 2016
  - 2016 International Conference on Communications and Computers (ICCC'16), Rome, Italy, November 5-7, 2016
  - 10th International Workshop on Semantic Evaluation (SemEval-2016), San Diego, California, June 16-17, 2016
  - Controlled Natural Language 5th International Workshop, (CNL 2016), 25–26 July 2016, Aberdeen, Scotland
  - 19th International Conference on Model Driven Engineering Languages and Systems (MODELS 2016), Saint Malo, Brittany, France, October 2-7, 2016
  - International Conference on Health and Social Care Information Systems and Technologies, (HCist 2016), Porto, Portugal, from 5 to 7 October 2016

Education:

Doctoral Thesis:

1. Ivo Odītis. Business process run-time verification. Defended at UL Promotion Council, September 2016, Scientific supervisor: J. Bičevskis
2. Aleksejs Jurenoks. Development and Estimation of Wireless Sensor Network Life Expectancy Assessing Model And Methods. Defended at RTU Promotion Council P-07, June 2016, Scientific supervisor: L. Novickis

Master Thesis:

1. Artūrs Znotiņš, Jēdzientelpas uun to pielietojumi. // Word embeddings and their applications. (2^{nd} place in Thesis competition "ZIBIT 2016") (Advisor: prof. Guntis Bārzdiņš. Defended at UL FC 06.2016)

2. Roberts Darģis, Liela apjoma datu kopu klasterēšanas algoritmi. // Clustering algorithms for large scale data sets. (Advisor: prof. Guntis Bārzdiņš. Defended at UL FC 06.2016)
3. Reinholds Pīrāgs, Automātiska teksta konspektēšana izmantojot jēdzientelpu. // Automatization of Text Summarization. (Advisor: prof. Guntis Bārzdiņš. Defended at UL FC 06.2016)
4. Aleksandrs Riļins, Efektīva tīmekļa lietotņu izstrāde augstas izšķirtspējas monitoru sienām. // Web application effective development for high-resolution monitor walls. (Advisor: prof. Guntis Arnicāns. Defended at UL FC 06.2016)
5. Normunds Pureklis, Liela apjoma datu vizualizācija uz augstas izšķirtspējas displeju sienas. // Big data visualization on the high-resolution display wall. (Advisor: prof. Ģirts Karnītis. Defended at UL FC 06.2016)
6. Elīna Kauķe, Testēšanas modeļa izveide testējamās sistēmas uzlabošanai. // Testing model development to improve the system under the test. (Advisor: prof. Jānis Bičevskis. Defended at UL FC 06.2016)
7. Jānis Peisenieks, Rīgas pilsētas dzīvojamības novērtēšana, izmantojot atvērtus datu avotus. // Livability evaluation of Riga city using open data. (Advisor: prof. Ģirts Karnītis. Defended at UL FC 06.2016)
8. Vladislavs Maksimčuks, Labvēlīgas laikapstākļu prognozes noteikšana lidošanai ar paraplānu. // Analysis and display of weather forecasts in iOS application. (Advisor: prof. Ģirts Karnītis. Defended at UL FC 06.2016)
9. Parshu Ram Dhungyel. Dzongkha valodas vārdu segmentēšanas metožu analīze. // Analysing the Methods of Segmentation of Dzongkha Words. (Advisor: prof. J. Grundspeņķis. Defended at FCSIT RTU 06.2016)
10. Royal Imanli. Spieta intelekta analīze robotizētām sistēmām un to vadība lietojot nestriktu loģiku.// Analysis of swarm intelligence for robotic systems and their control using fuzzy logic (Advisor: prof. J. Grundspeņķis. Defended at FCSIT RTU 06.2016)
11. Yan Kuchin. Urbumu ģeofizikālo datu interpretācija ar neironu tīkliem. // Interpretation of Drill Hole Geophysical Data with Neural Networks (Advisor: prof. J. Grundspeņķis. Defended at FCSIT RTU 06.2016)
12. Nail Karimov. Uz daudzaģentu pieeju balstītas siltumnīcas vadības un monitoringa sistēmas projektēšana un izstrāde.// Design and Development of Control and Monitoring System for Greenhouses Based-On Multi Agent Approach (Advisor: prof. J. Grundspeņķis. Defended at FCSIT RTU 06.2016)
13. Arjan Chakma. Datu informācijas un zināšanu plūsmas organizāciju informācijas sistēmās. // Data Information and Knowledge Flows in Organizations Information Systems (Advisor: prof. M. Kirikova. Defended at FCSIT RTU 06.2016)
14. Sangay Dorji. Datu, informācijas un zināšanu modelēšana darbsistēmu tīklos. // Data, Information and Knowledge modeling in work system networks (Advisor: prof. M. Kirikova. Defended at FCSIT RTU 06.2016)
15. Rakesh Parthasarathy. Informācijas loģistikas atsauces modeļa izstrāde. // Development of Information Logistics Reference Model (Advisor: prof. M. Kirikova. Defended at FCSIT RTU 06.2016)
16. Elmārs Sirovatskis. Vispārīga ostas informācijas sistēmas modeļa izstrāde. // Development of Generic Ports Information Systems Model (Advisor: prof. M. Kirikova. Defended at FCSIT RTU 06.2016)

Leader of the project No.2. J.Bārzdiņš 01.2017

(signature and transcript) *(date)*

2.3.1. Project No. 3

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

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

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

The main research objectives for the 3rd period:

1. Laboratory and clinical validation of the novel imaging technologies:
1.1. acquiring several monochromatic spectral images from the data of a single digital colour image;
1.2. contactless monitoring of cardiovascular parameters at the near infrared spectral range;
1.3. tissue moisture evaluation at the near infrared spectral range (1-2 microns).
2. Clinical validation of the improved skin multimodal imaging prototype device „SkImager".

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

A brief description of the main results is presented below; more detailed results are provided in the scientific report (Annex 3).

1.1. The elaborated methodology and prototype device for snapshot three chromophore mapping (see the 2nd period scientific report) were tested on dermatology patients. The main advantage of the novel technology is rapidness, since only one snapshot is needed under spectrally specific illumination. About 50 clinical RGB images were taken and analysed. Statistically reliable correlation between the distributions of the main skin chromophores (melanin, oxy-haemoglobin, deoxy-haemoglobin) and the diagnosis of a pathology given by dermatologist was obtained. Development of clinically representative maps of chromophore distribution, with indication of the critical levels of pathologies, is planned for the next period. Another direction will be mapping of larger number (n>3) of chromophores by newly developed and tested illumination devices.
1.2. Contactless cardiovascular studies were performed by means of the newly developed prototype device (see the 2nd period scientific report) and of a high performance professional camera (*ANDOR*, cooled sCMOS matrix 0^0C, 16-bit 2048x2048 pix. resolution). Generally good correlation between the data obtained by both devices has been obtained, with advantage in sensitivity of the commercial camera ~2.5 times. The original non-contact PPGI device passed clinical tests in the

Riga Hospital of Traumatology and Orthopaedics with wrist surgery patients that had regional anaesthesia (RA) procedure before the surgery. The non-contact device was fixed above the wrist and the PPGI signals were collected in parallel with thermography data obtained by a compact thermo-camera (FLIR-C2). Both devices detected the jump of microcirculation intensity as resonse to RA. Good correlation of results was obtained, which indicated to a successful design of the prototype. The image processing will be improved during the next period, along with development of more "doctor-friendly" output of the results in a clinical environment.

1.3. The previously designed NIR reflectance device for assessment of skin moisture (see the 2nd period scientific report) was clinically approbated in a dermatology clinic on 39 volunteers. The trial participants applied a moistening cream and a moistening serum on their left hand for a month; the right hand served for reference. Two devices were used for assessment of the moistening effects – the developed device and a commercial device *DermaLab* (*Cortex Technology*); the latter is based on skin conductivity measurements. Comparison of the cream and serum groups as measured by the developed device did not show statistically essential changes in the case of moisturing cream, but a convincing effect was recorded in the case of serum. The commercial device recorded significant changes in skin moisture at both cases, with double efficiency with the cream if compared to serum. The results confirmed clinical potential of the new device and highlighted the ways for design and software improvements which are planned during the next period.

2. Spectral imaging data from 50 *rossacea* patients with different grades of severity were collected by the improved SkImager prototype device. The doctors visually distinguish 5 grades of CEA - Clinician's Erythema Assessment index, starting from 0 (no erythema) to 4 (very pronounced erythema). RGB images at different colour illuminations were captured from 5 spots on the face – earlobe, both cheeks and both wings of the nose. 13 patient images with different CEA were selected: CEA=1 (3 patients), CEA=2 (5 patients), CEA=3 (5 patients). The images before treatment were analysed by a software that provided segmentation of the maps of erythema index (EI) and PCA - principal component analysis. It was concluded that the EI-segmentation more precisely marks the areas of expanded blood vessels, while the PCA 1st component maps better represent visible blood vessels. Clinically significant data confirming the functional abilities of the prototype for diagnostics of *rossacea* have been obtained.

To summarize, the main tasks at this stage of the project are completed. The original imaging methodologies have been validated in laboratory and clinical environments, and their applicability for contactless mapping of pathologic lesions and parameters of microcirculation was confirmed. Results are significant for clinical diagnostics and monitoring as demonstrating ways for patient-friendly collection of objective quantitative information on his/her health condition. The scientific significance lies in the novelty of the developed technologies, confirmed by 6 international publications and 6 conference reports at various countries (USA, Japan, Norway, Ireland, Estonia).

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

In the next project period the main attention will be paid to wider publicity of the developed technologies and to the commercialization measures. One more patent application is planned, as well as organisation of the licence tender. If the initially planned funding will be received, a conference or seminar on biophotonics achievements and future prospects will be organised. Design and software improvements of the prototypes will continue; we plan to create at least one new prototype device (for mapping five skin chromophores). Also clinical validation measurements will be continued, including those exploiting fluorescence methods in the groups of oncology patients.

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

Prepared publications

1. J.Spigulis, I.Oshina, A.Berzina, A.Bykov, "Smartphone snapshot mapping of skin chromophores under triple-wavelength laser illumination", *J.Biomed.Opt*., submitted 2016.
2. J. Spigulis, I. Oshina, Z. Rupenheits, "Smartphone single-snapshot mapping of skin chromophores," in *Biomedical Optics 2016*, OSA Technical Digest (online), JTu3A.46, https://www.osapublishing.org/abstract.cfm?uri=Cancer-2016-JTu3A.46.
3. E.Kviesis-Kipge, U.Rubīns. „Portable remote photoplethysmography device for monitoring of blood volume changes with high temporal resolution" BEC-2016, Proc. 15th Biennial Conference on Electronics and Embedded Systems. pp. 55-58 (2016); *IEEE Explore,* DOI: 10.1109/BEC.2016.7743727 **.**
4. U.Rubins, J.Spigulis, A.Miscuks, "Photoplethysmography imaging algorithm for continuous monitoring of regional anesthesia", ESTIMedia'16, Proc.14th ACM/IEEE Symp. on Embedded Systems for Real-Time Multimedia, pp. 67-71 (2016), http://dl.acm.org/citation.cfm?id=2994308&CFID=863483070&CFTOKEN=69466985; *IEEE Explore*.

Conference presentations

1. I.Saknite, A.Zavorins, I.Zablocka, J.Spigulis, J.Kisis, "Comparison of Optical and Conductance Methods for Estimation of Skin Hydration", Norwegian Electro-Optics Meeting 2016, Voss, Norway, 13-15April, 2016.
2. J.Spigulis, I.Oshina, Z.Rupenheits, "Smartphone single-snapshot mapping of skin chromophores", OSA Biomedical Optics Congress, Fort Lauderdale, USA, 25 - 28 April 2016.
3. I.Saknite, A.Zavorins, I.Zablocka, J.Spigulis, J.Kisis,"Near-Infrared Reflectance Spectroscopy System for Noninvasive Estimation of Skin Hydration", The 2nd Biomedical Imaging and Sensing Conference, 17-20 May, 2016, Yokohama, Japan.
4. J.Spigulis "Multi-laser illumination designs for skin chromophore mapping", Int. Conf. "Advanced Laser Technologies" (ALT16), 12-16 September 2016, Galway, Ireland.
5. E. Kviesis-Kipge, U.Rubīns. „Portable remote photoplethysmography device for monitoring of blood volume changes with high temporal resolution", BEC2016, 15th Bien. Conf. on Electronics and Embedded Systems, 3-5 October, 2016 Tallinn, Estonia.
6. U.Rubins, J.Spigulis, A.Miscuks, "Photoplethysmography imaging algorithm for continuous monitoring of regional anesthesia", ESTIMedia'16, 14th ACM/IEEE Symp. on Embedded Systems for Real-Time Multimedia, 6-7 October 2016, Pittsburgh, USA.

Public outreach

1. The elaborated methods and devices were presented to general public (>800 attendees) during the European Researcher's Night on 30.09.2016. at the Institute of Atomic Physics and Spectroscopy (Riga, Skunu Str. No.4).
2. The novel technology "Non-invasive skin assessment with a smartphone" was presented at the international exhibition RIGA COMM 2016 (October, 2016).
3. Related Internet publication (in Portugese): http://www.ifsc.usp.br/index.php?option=com_content&view=article&id=3956:docente-da-university-of-latvia-visita-grupo-de-optica&catid=3:ifsc-hoje&Itemid=281
4. Weekly journal article (in Latvian): žurnāls IR,#51/51, pp. 24-25. "Kas nodarbina pētnieku prātus? Jānis Spīgulis: Tehnoloģija operatīvam ādas stāvokļa novērtējumam ar viedtālruni".

Defended Master Theses:

Reinis Janovskis, “Infrared spectroscopy and imaging for evaluation of skin moisture”, supervisors: Prof. Jānis Spīgulis, Dr. Phys. Inga Saknīte.

Leader of the project No.3. Jānis Spīgulis .01.2017.
(signature and transcript) *(date)*

2.4.1. Project No. 4

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

2.4.2. Project goal and objectives
(Describe the project goals and objectives so that the 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.

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

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

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

EDI BIGDATA group
The following results obtained within the review period number 3 can be emphasized:
1.Technique of image descriptor for unique object description with one vector is explored. For this purpose, the human facial images are considered and processed based on artificial neural networks. The trained ANN model converts any image with face into feature vector which can be compared to another vector by calculating a correlation coefficient. Experiments shows that trained ANN achieves 94% accuracy on COLOR- FERET frontal image subset. More detailed it is described in the paper K. Sudars, Face Recognition Face2vec Based on Deep Learning: Small Database Case accepted at the SCOPUS journal Automatic Control and Computer Science;
2.Interdisciplinary Baltic Electronics Conference 2016 was attended and the paper presented. It was prepared in collaboration with another colleague from other projects: K. Sudars, I.Bilinskis, E.Buls, Discrete Fourier Transform of the signals recovered by using high-performance Event Timers.
3.To acquire labeled data for the moving object detector, two approaches were investigated. One of the approaches resulted in a method and an application for semi-automatic labeling. In this approach an algorithm performs fast but erroneous labeling. Then a human is presented with a GUI that allows convenient error correction. The second approach was based on the generation of synthetic data using game engine. Using this engine, a simplified environment with moving spheres was developed. This simulation will allow to generate a large amount of labeled data which in turn will allow to estimate if this approach of data generation is promising for more complex environments.

EDI REMSENS group
Studies in the following main directions were performed during the reporting period:
1.Urban land use and vegetation mapping. Development of algorithms and MATLAB programs for Sentinel-2 satellite data processing was performed, implementing vegetation and its change detection; vegetation classification into 5 categories (deciduous trees, coniferous trees, meadows, shrubs, no vegetation). Classification accuracy was assessed classification results of images obtained in years 2015 and 2016 were compared. Methodology was developed that allows to integration of MATLAB programs in ArcGIS Pro environment using Python modules;
2.During the reporting period, studies were continued related to creation of a practical tool for simulation of flooding on the basis of LiDAR elevation data. The following main activities should be mentioned:
- filling the holes in elevation image related to missing LiDAR data. The elevation model developed from LiDAR data during the previous reporting period misses data for water basins as LiDAR fails to detect reflections from water. To facilitate simulations of water level and its rise, algorithms for filling in these holes with real elevation data from the sea level were developed;
- developing algorithm for simulation of flooding due to the rise of the water level. It is based on the assumption that all river pixels are rising with the same increment as the pixel for what the rise is simulated (that is a serious simplification, of course, but to implement a more realistic flooding model, more sophisticated hydrologic model is needed which we are lacking at present);
- creation of a software tool implementing LiDAR data processing and flooding simulation.
Software tool for visualisation of possible flooding on the basis of such model was developed in MATLAB and compiled to standalone executable for Windows systems
3.Theoretical studies on selection of informative bands for classification of hyperspectral images were continued. Results of previous research were presented in BEC-2016 conference and described in corresponding paper. Further studies of this topic led to new results and deeper elaboration on this topic, a paper describing them are in preparation. It will be submitted to IEEE JSTARS jounal (http://www.grss-ieee.org/Publications/JSTARS/, SNIP>1).

EDI RADAR group
The following tasks where planned for the 3rd period:
1.Experimental tests of signal processing methods for detection of changes in a room, object displacement
2.Improvement of UWB radar sensor functional parts to increase range.

The following deliverables were planned for the 3rd period:
•Defended bachelor thesis: 3 planned / 2 defended
•Midterm progress report: delivered
•scientific publication: 1 planned / 2 published

Scientific results archived, their scientific importance
•UWB sensor signal processing methods researched and experimentally tested for moving object (2D) tracking. In the experiments an experimental multi-channel radar sensor prototype was used.
•Research on detection of small moving target (object) in ultra-wide band pulse radar sensors systems was carried out. The research aim was to investigate methods of small object movement detection that are masked by large signal reflections from other objects in the area covered by the radar sensor. Karhunen Loeve transform was used to filter out small object movements from the reflected radar sensor signals.
•Experimental tests were performed to confirm the existence of optimal duration, rise/fall time trapezoidal antenna excitation pulse for a chosen antenna with known central frequency. These research results were published in a scientific journal
•A remote life-sign (cardiac and respiratory movement) detection system device prototype device was presented at Invention and Innovation Exhibition MINOX 2016.
•On Radar group's supervision, two electrical engineering bachelor students carried out an alternative radar sensor application research as part of their bachelor thesis work. Experimental concrete water content tests were carried out. Advantages and disadvantages of radar sensors technology compared to conventional security sensor solutions (10GHz Doppler radar sensor, passive infrared sensor, ultrasonic sensor) were tested. The experimental radar sensor prototype designed by the group was used in the experiments.

RTU TI group
The scientific novelty:
1.An improved fixed DWDM grating has been worked out for central frequency separation of the transmission channels, which allows increasing the spectral efficiency of the frequency band used for transmission in PON.
2.By means of the proposed scheme for allocation of 10 Gbps, 40 Gbps and 100 Gbps transmission channels the relationship has been determined between the spectral efficiency (bps/Hz) in the frequency band, the average power consumption per bps transmitted (i. e., energy efficiency, J/bit) and the overall transmission distance in the 10-40-100 Gbps WDM-based FOTS.

The scientific results:
1.The spectral efficiency of the frequency band can be increased up to two times if for channel separation in mixed line rate (MLR) WDM-PON instead of the fixed DWDM grating described in the ITU-T recommendation the improved grating with unequal frequency intervals is used. The increase in spectral efficiency depends on the initial system configuration that determines the data transmission rate and modulation formats in different channels (at different wavelengths).
2.Apart from the used configuration of the mixed 10–40–100 Gbps WDM-PON, there is also "the point of equal energy efficiency" determined by the number of 10 Gbps NRZ-OOK channels, by the energy efficiency of 40 Gbps and 100 Gbps transponders and 3R regenerators, and by the

length of fiber-optical link according to which a definite quality of the received signal must be guaranteed (e. g., $BER \leq 1 \cdot 10^{-9}$).

Summary:
The following results obtained within the third period can be emphasized:
The study on multiwavelength light source that doubles the initial wavelength range and is applicable for use in WDM-PON applications. It has been formed on the base of fiber optical parametric amplifier consisting of highly nonlinear fiber and 2 high power pumping lasers. Proposed setup allows to double the initial 16 low power laser spectral component count to 32 by using the nonlinear optical effect - four wave mixing generated idler components. In such a way it is possible to double each laser efficieny. It is described in more details in the paper S.Olonkins "FOPA Pump Phase Modulation and Polarization Impact on Generation of Idler Components," accepted by the journal Elektronika ir Electrotechnika, Vol.77, No.4, 2016, pp. 77-81, ISSN 1392-1215 included in SCOPUS database
Developed and experimentally approved nonlinearity coefficient measurement method based on the use of four-wave mixing. The said measurement method can be used to carry full optical fiber characterization, because it requires fiber attenuation and dispersion parameters to determine nonlinearity coefficient through optical power measurements and calculations. Such an optical fiber characterization is necessary to select the most appropriate fiber for the optical WDM-PON transmission system. It is described in more details in the paper I.Lavrinoviča "Evaluation of Effective Area and Nonlinearity Coefficient of Erbium-Ytterbium Doped Optical Fibers," published In: Progress in Electromagnetics Research Symposium (PIERS 2016): Proceedings, China, Shanghai, 8-11 August, 2016. Shanghai: The Electromagnetics Academy, 2016, pp.1-5. ISBN 78-1-934142-30-1 and presentation in the conference S.Spolītis "Different Optical Fiber Nonlinear Coefficient Experimental Measurements." No: Proceedings of 6th International Workshop on Fiber Optics in Access Networks (FOAN 2016), 2016, pp. 1-4.

RTU WRL group:
The tasks of the 3rd period were performed based on the results, obtained during first two project periods.
One of the tasks aimed to conduct long-term measurements with online sensors. This was accomplished by drinking water quality changes' monitoring in the experimental pilot system, which was built in the previous period. Temperature, chloride concentration, pH, electrical conductivity, total organic carbon (TOC) and oxidation-reduction potential were measured continuously at two sampling points in the pilot scale system during 7 months of reporting period. As a result, a large detailed amount of data was collected, which well describes water quality changes. Systematic and non-systematic drinking water quality parameters variations were detected with this approach, where temperature and electrical conductivity sensors demonstrated the most sensitive and reliable data. This approach could be defined as a high-resolution (1 minute resolution) on-site drinking water quality monitoring at the point of consumption, which have never been applied before nor in Latvia, neither in neighbor countries. While normally drinking water quality sampling in distribution network is performed at specified time, our data provides real dynamic situation of drinking water quality. Up to now more than 3 500 000 readings were recorded at the single point. This data was successfully proceeded and showed that observed changes of measured parameters met legislative requirements. Part of the results were presented at two international scientific conferences (RTU 57th Internation Scientific conference subsection "Heat, gas and water technologies" (Riga, Latvia)" and "IWA 8th Eastern European Young Water Profesionals Conference (Gdansk, Poland)" and summarized in a scientific publication "Long Term Drinking Water Quality Monitoring in Drinking Water Supply Systems by On-Line Sensors". Our results highlight a need of continuous online monitoring and reveal limitations of existing monitoring system.
According to the planned project activities, novel microorganisms determination methods were also used for long-term monitoring, namely flow cytometric methods, which were used for total and

viable bacteria enumeration. For that, the method was applied for monitoring of microbiological drinking water quality at two locations in the Riga distribution system during one year. Seasonal changes were detected as a result of the study, and influence of water age on bacterial growth was observed. Additional experiments were done to understand the reasons of bacterial regrowth in the particular network. Generally, this long-term experiment could be defined as a minor deviation from the task of the 3rd project period, because the measurements were not performed in the pilot system. This is related to the fact, that it started in 2015, when the pilot system has not been set up yet. However, we would like to note, that one of the sampling locations was exactly in the same building, where the pilot system is built, thus we argue that results could be compared with on-line sensors data. The results of this study are particularly important as they demonstrate high potential of the method to be used for routine drinking water monitoring, and emphasize disadvantages of conventional methods used for biological analysis at water utilities worldwide. A scientific publication, based on long-term monitoring results, is getting prepared for submission, which is planned in the next period. "A pipeline for developing and testing staining protocols for flow cytometry, demonstrated with SYBR Green I and propidium iodide viability staining", describing various factors, which could influence method's outcome, has been published in Journal of Microbiological Methods.

Another task for the current period was to monitor drinking water parameters' changes during various contamination events. Wastewater, raw water (river water), groundwater, stagnated water and E.coli intrusion was simulated in the pilot-scale system in order to achieve this goal. Changes of physically-chemical parameters were monitored with the above mentioned sensors, while biological quality was evaluated with flow cytometry and ATP measurements. This combination of the methods proved to be an effective tool for rapid detection of contamination. Moreover, specific "fingerprints" were obtained for each type of contamination, which allowed not only detect changes of drinking water quality, but also to identify contamination type. Sensors' data were compared with the results, which were obtained with biological methods, and good correlations were found. Both methods were able to determine changes in biomass in very short time (5 – 20 min). In comparison with flow cytometry, ATP method appeared to be less sensitive to detect low levels of contamination, which could be explained by the instrument technical capacity. Nevertheless, it showed good results, when the pilot system was spiked with wastewater and pure cultures (E.coli). The results lead to development of contamination detection algorithm based on multidimensional vectors and Mahalanobis distances. ATP specific behavior, when applied for chlorinated water, was published as a research paper in the top-ranked scientific journal in water field "Water Research" ("Behavior and stability of adenosine triphosphate (ATP) during chlorine disinfection"), which raised resonance amongst researchers, as it shows that chlorination under certain circumstances could promote bacterial regrowth.

One master thesis was planned during the reporting period. Unfortunately, this goal was not achieved. While experiments have been performed and the data interpreted and summarized in the thesis, the defense did not occur due to unforeseen circumstances. We are planning to do this within the next project period.

2.4.4. Further research and practical exploitation of the results

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

In the last project period, EDI BIGDATA group will focus on practical implementation of the object counting system and face recognition algorithm.

During the next period, EDI REMSENS group will elaborate on software for vegetation mapping and flooding simulation and offer it to municipalities or other clients.

Further research activities, possibilities to practically exploit the results of the EDI RADAR group include:

•The work on improvement of Radar sensor hardware parts will be continued.
•Specific UWB radar sensor technology demonstration devices prototypes will be developed comprising:
-A miniaturized human presence and vital sign monitoring radar sensor device prototype.
-Moving object tracking radar sensor system prototype.
•The research results and experimental hardware prototypes designed by the radar group could be potentially used to make new and innovative products. For example, remote human presence and vital sign sensor solution, that could be used in smart hoses or medical facilities. A radar sensor network could be used to track human location and movement inside an apartment or house.

Future activities of the RTU TI group will involve creation of an experimental WDM-PON transmission system model that is compatible with existing typical WDM-PON transmitters and receivers as well as different sensor and sensor networks applications. All the previously obtained research results will be taken into account during the experimental implementation (network configuration, selection of elements based on the required and measured parameters, optical signal splitting and combining, data transmission rate, modulation formats, coding methods, wavelength, etc.). At this stage it is also intended to analyse transmission system reliability features (optical, electro-optical and opto-electrical element replacement mechanisms, system redundancy and others)..

Based on the successful long-term monitoring results, obtained with both sensors and biological methods, RTU WRL group plans to combine these data, and focus on simultaneous sensor and biological measurements. This will help to explain various processes in the distribution system, especially some of systematic water quality changes, which origin is unknown, and to improve algorithms for accurate early-alarm detection system. Also the algorithm precision on true positive and true negative alarms should be analyzed and verified.

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

Publications:

1.K. Sudars, I.Bilinskis, E.Buls, Discrete Fourier Transform of the signals recovered by using high-performance Event Timers, Baltic Electronics Conference 2016, Tallinn, Estonia (IEEE Xplore, SCOPUS).
2.Lorencs A, Mednieks I, Siņica-Siņavskis J. 2016 "Selection of Informative Bands for Classification of Hyperspectral Images Based on Entropy", Proc. of BEC2016, the 15th Biennial Conference on Electronics and Embedded Systems. Tallinn, Estonia on October 3-5, 2016. pp. 135-138 (IEEE Xplore, SCOPUS).
3.Aristov V. Karhunen Loeve Transform As a Tool to Eliminate Signal's Redundancy, When Small Targets Detection. Sciences of Europe. Vol 2, № 2 , 2016. Praha, Czech Republic.
4.Aristov, V. (2016) Optimization of the transmitter pulse duration by the criterion of the radiation spectrum maximization at a given frequency. Automatic Control and Computer Sciences. 50(4), 220-225. . (SCOPUS) Springer Link.
5.Sergejs Olonkins, Vjaceslavs Bobrovs, Girts Ivanovs “FOPA Pump Phase Modulation and Polarization Impact on Generation of Idler Components”, Elektronika ir Electrotechnika, Vol.77, No.4, 2016, pp. 77-81, ISSN 1392-1215 (to be included in SCOPUS).
6.Lavrinoviča, I., Poriņš, J., Brūklītis, E., Supe, A. Evaluation of Effective Area and Nonlinearity Coefficient of Erbium-Ytterbium Doped Optical Fibers. In: Progress in Electromagnetics Research Symposium (PIERS 2016): Proceedings, China, Shanghai, 8-11 August, 2016. Shanghai: The Electromagnetics Academy, 2016, pp.1-5. ISBN 78-1-934142-30-1. ISSN 1559-9450. e-ISSN 1559-8985 (to be included in SCOPUS).

7.Nescerecka, A., Hammes, F., Juhna, T., 2016. A pipeline for developing and testing staining protocols for flow cytometry, demonstrated with SYBR Green I and propidium iodide viability staining. Journal of Microbiological Methods 131, 172–180. doi:10.1016/j.mimet.2016.10.022.
8.Nescerecka, A., Juhna, T., Hammes, F., 2016. Behavior and stability of adenosine triphosphate (ATP) during chlorine disinfection. Water Research 101, 490–497. doi:10.1016/j.watres.2016.05.087. (SCOPUS, SNIP>1).
9.K. Sudars, Face Recognition Face2vec Based on Deep Learning: Small Database Case, Automatic Control and Computer Science (accepted).
10.Dejus, S., Rusenieks, R., Nescerecka, A., Nazarovs, S., Juhna, T., *Long Term Drinking Water Quality Monitoring in Drinking Water Supply Systems by On-Line Sensors*, Book of Abstracts, 8th Eastern European Young Water Profesionals Conference, Gdansk, Poland, 2016, p.73-74, ISBN 978-83-7493-936-2
11.A.Lorencs, I.Mednieks, J.Sinica-Sinavskis. "Informative hyperspectral band subset selection based on entropy" (in preparation to submit to IEEE JSTARS journal).

Presentation in conferences:

1.K. Sudars, I.Bilinskis, E.Buls, Discrete Fourier Transform of the signals recovered by using high-performance Event Timers, Baltic Electronics Conference 2016, Tallinn, Estonia.
2.Lorencs A, Mednieks I, Siņica-Siņavskis J. 2016 "Selection of Informative Bands for Classification of Hyperspectral Images Based on Entropy", Proc. of BEC2016, the 15th Biennial Conference on Electronics and Embedded Systems. Tallinn, Estonia on October 3-5, 2016.
3.Shakya, S., Supe, A., Lavrinoviča, I., Spolītis, S., Poriņš, J. Different Optical Fiber Nonlinear Coefficient Experimental Measurements. No: Proceedings of 6th International Workshop on Fiber Optics in Access Networks (FOAN 2016), 2016, 1.-4.lpp (to be included in SCOPUS).

The results of the RTU WRL group were presented at several international conferences:
1.RTU 57th international scientific conference in the “Heat, Gas and Water Technology” subsection (12th October, Riga, Latvia)
2.RTU 57th international scientific conference in the “Smart Biotechnologies” subsection (17th October, Riga, Latvia)
3.IWA Microbial Ecology in Water Engineering & Biofilms 2016 (4-7th September, Copenhagen, Denmark)
4.IWA 8th Eastern European Young Water Professionals Conference, Gdansk, Poland, 12-14 May 2016

Public seminar was organized on 30th November, 2016 about the results of the project no.4 obtained during the third period.

Master thesis:

1. Valts Dilendorfs “Effectiveness Evaluation of Dispersion Compensation Methods in FOTS ” (Supervisor Dr.sc.ing. Vjačeslavs Bobrovs), defended 2016;

2.Jūlija Putrina ” EDFA Characteristics and Working Principle Evaluation in FOTS” (Supervisor Prof. Dr.sc.ing. Vjačeslavs Bobrovs), defended 2016**]**;

3.Reinis Grūnvalds “Dispersion analysis in OPGW transmission lines” (Supervisor Prof. Dr.sc.ing. Jurģis Poriņš) defended 2016**;**

4.Vladislavs Bičkovs “Research of RAMAN Amplification in Fiber-optic Communication Systems” (Supervisor Prof. Dr.sc.ing. Vjačeslavs Bobrovs), defended 2016.

Bachelor thesis:

1.Raitis Bērziņš (2016)"Konstrukciju izpēte, izmantojot zemes zondēšanas un sienas zondēšanas radaru". Zinātniskais vadītājs Mg.sc.ing. G. Šūpols.
2.Eduards Lobanovs (2016) "Telpu izmaiņu un objektu kustības noteikšanas sensoru risinājumi". Zinātniskais vadītājs Mg.sc.ing. G. Šūpols.
3.Romans Maļiks (2016) "Kvadrotoru lidojuma stabilizācijas realizācija, izmantojot proporcionāli-integrāli-diferencējošo (PID) kontrolieri". Zinātniskais vadītājs Mg.sc.ing. G. Šūpols.
4.Atvars Trams (2016) “Hiperspektrālu attēlu dimensiju skaita redukcijas metodes”. Zinātniskais vadītājs J.Siņica-Siņavskis.

Leader of the project No.4. I. Mednieks 01.2017
(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 3period 465473**EUR

Use of the funding:

		1. period	2. period	3. period**	4. period
	TOTAL	433677.00	516609.7	465473	
	Personal costs	278264.3	440230.31	391291	
	Travel	31718.84	59466.39	62958	
	Consumables and services	53326.92	15016.89	15273	
	Equipment	19972.91	51086.5	46121	

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

Leader of the programme M.Greitāns 01.2017.
(signature and transcript) *(date)*