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Context

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	2014/06/15	Michael Seyfarth	First complete version
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1 Executive summary

This deliverable presents the report on the integration of AIISM in the curricula of Master Programs in the Northwest Interuniversity Regional Educational and Scientific Centre NW IRC "SPSPU-Festo" Synergy" that is responsible for MEDIS Project in the Peter the Great St. Petersburg Polytechnic University.

The Centre was found in 2014 and integrates laboratories:

- Laboratory of enterprise resource planning systems and SAP
- Laboratory of intelligent systems for data processing and control systems
- Laboratory of motion control systems for robotics
- Laboratory of complex automation and control
- Laboratory of electronics and electrical drives

puts its main task more efficient use of the intellectual potential and high-tech equipment, as well as a focus of educational programmes, improving the efficiency of scientific research in collaboration with leading companies.

The activities aimed at developing and implementing educational programmes for engineers. Educational programmes of the Centre are based on specific disciplines in the field of control, automation and drive systems. As part of the educational programmes is carried out modernisation of existing and development of new curricula and programmes; preparation of the necessary guidelines and manuals, updating and creation of experimental base and laboratory stands.

2 Possibilities for the Integration of AIISM Courses

The analysis of five proposed AIISM courses and the curricula of the programme “Intelligent Systems and Technologies” enables to conclude the following:

- The duration of the proposed courses is 15 weeks and the duration of each semester in the St. Petersburg State Polytechnic University is 18 weeks. Thus, 3 weeks can be used for additional training skills.
- The proposed AIISM courses can be integrated into curricula as courses of a variable part of a Master Programme. According to current regulations a variable part equals to 4 or 5 credits of ECTS and may include several alternatives (elective courses). Thus, the proposed courses can be considered as elective courses to be chosen by students.

According to the analysis of the proposed AIISM courses and the curricula of three programmes (27.04.04_06 Control Systems of Electrical Drive, 27.04.04_07 Distributed Intelligent Control Systems, 27.04.04_02 Automation of Technological Processes and Production) which are implemented at the department of Control Systems and Technologies, Institute of Computer Science and Technology the following possibilities for the integration of AIISM Courses have been discovered:

1. The duration of the proposed courses is 15 weeks and the duration of each

semester in the St. Petersburg State Polytechnic University is 18 weeks. Thus, 3 weeks can be used for additional training skills.

2. Three Master Programmes (27.04.04_06 Control Systems of Electrical Drive, 27.04.04_07 Distributed Intelligent Control Systems, 27.04.04_02 Automation of Technological Processes and Production) can be used as the basis for AIISM implementation.
3. The proposed AIISM courses can be integrated into curricula as courses of a variable part of a Master Programme. According to current regulations a variable part equals to 4 or 5 credits of ECTS and may include several alternatives (elective courses). Thus, the proposed courses can be considered as elective courses to be chosen by students.

3 Programme Proposal of EU Partners

3.1 Industrial Computers module

The Industrial Computers is an AIISM module structured with different activities. These activities are developed during 3 hours/day (during 15 weeks) through a PBL methodology, using as a case study the example of the control of the liquids tank. To develop the course, students have to apply the knowledge acquired from the lectures and the laboratory practices. The proposed learning activities are the following:

- Lecture and problems: lecturer presents main ideas of lecture contents and proposes some application problems which student solves individually (1 h).
- Laboratory session: To implement (1 h 15’’) a practical problem previously presented during lecture. Students work by teams of two students.
- Seminars: a panel discussion with student teams (4 students) lasting 45 minutes is proposed, consisting generally of solving a problem by means of PBL.
- Mini-project: dedicated to planning, design and development of the control system of the educational liquids tank. The mini-project is performed by teams of 4 students during 2 hours. Weekly, the mini-project is advanced progressively.

Based in the previous proposals, the set of chapters to group different topics is the following:

1. Introduction to industrial informatics
2. Computer architecture
3. Project management
4. Software development
5. Process interface
6. Graphical user interface
7. Task scheduling
8. Regulation strategies

9. Integration and validation

Chapters 1 and 2 introduce basics about computer architecture and the applicability of computers to industry.

Another basic of an engineer is the correct management of a project. This is the objective of the chapter 3 that is spread along the course. This is also a horizontal content of the module, so it is spread along the course and in a position where student understands its implications.

Chapter 4 develops skills on C programming to be applied on the application creation. This is a horizontal requirement of the module.

Chapter 5 deals with the connection of the computer to the real world, the so called “process interface”. This is set tends to motivate the student because he/she sees the interaction with physical reality.

Taking into consideration that the actual student’s generation is accustomed to stunning visual user interfaces. Chapter 6 is in place for introducing another motivating set of activities related to this aspect.

At this point, it is necessary to start coordinating actions inside the application. So chapter 7 introduces the very basics around task coordination/scheduling.

And, finally, the student needs to see that your development works. From the point of view of the teacher, it is adequate to introduce here the regulation problem according to chapter 8.

A serious project of industrial informatics needs an investing on testing of each piece and integration. This important task is in chapter 9.

The scheduling distribution in weeks for this module is shown in Figure 1.

Week	Chapter	Type	Topic
	1	INTRODUCTION	
1	1	Lecture	Introduction to industrial informatics
1	1	Lab	Development environment - Programming the "Hello World"
1	1	Seminar	C programming (1) - Basic resources
1	1	Miniproject	Presentation of the problem to solve
2	1	Lecture	Structure and design of industrial informatics systems
2	1	Lab	Event oriented programming
2	1	Seminar	C programming (2) - Programming tools
2	1	Miniproject	Analysis of the project requirements
	2	COMPUTER	
3	2	Lecture	Computer architecture
3	2	Lab	Using libraries in C
3	2	Seminar	C programming (3) - Libraries
3	2	Miniproject	Project formal specification
	3	PROJECT PLANNING	
4	3	Lecture	Project management (1)
4	3	Lab	Tools for project management
4	3	Seminar	Discussing cases of project management systems
4	3	Miniproject	Project planning
	4	PROGRAMMING + DATA	
5	4	Lecture	Modular programming
5	4	Lab	Modular programming in C
5	4	Seminar	Modular programming resources
5	4	Miniproject	Modular decomposition of the program
6	4	Lecture	Data representation and sharing
6	4	Lab	Data sharing between C modules
6	4	Seminar	Chosing the appropiate data representation
6	4	Miniproject	Implementation of the shared data module
	5	PROCESS INTERFACE	
7	5	Lecture	Process interface (1) - Introduction and digital input
7	5	Lab	Digital input
7	5	Seminar	DAQ card (1) - Introduction and digital input
7	5	Miniproject	Implementation of the process interface module (1) - DI
8	5	Lecture	Process interface (2) - Digital output
8	5	Lab	Digital output
8	5	Seminar	DAQ card (2) - Digital output
8	5	Miniproject	Implementation of the process interface module (2) - DO
9	5	Lecture	Process interface (3) - Analog input and output
9	5	Lab	Analog input and output
9	5	Seminar	DAQ card (3) - Analog input and output
9	5	Miniproject	Implementation of the process interface module (3) - AIO
	6	USER INTERFACE	
10	6	Lecture	Graphical user interface (1) - Introduction
10	6	Lab	Programming GUI controls
10	6	Seminar	Graphical user interface for the industry (1) - Basic
10	6	Miniproject	Implementation of the user interface module (1) - Basic
11	6	Lecture	Graphical user interface (2) - Advanced resources
11	6	Lab	Programming a GUI for an industrial application
11	6	Seminar	Graphical user interface for the industry (2) - Advanced
11	6	Miniproject	Implementation of the user interface module (2) - Advanced
	7	TASKS	
12	7	Lecture	Task scheduling
12	7	Lab	Basic scheduler
12	7	Seminar	Scheduling strategies
12	7	Miniproject	Implementation of the task scheduler module
	8	REGULATION	
13	8	Lecture	Foundations and continuous control
13	8	Lab	Programming regulation strategies (1) cc
13	8	Seminar	Control strategies (1) cc
13	8	Miniproject	Implementation of the regulator module (1) cc
14	8	Lecture	Event-driven control
14	8	Lab	Programming regulation strategies (2) edc
14	8	Seminar	Control strategies (2) edc
14	8	Miniproject	Implementation of the regulator module (2) edc
	10	PROJECT (2) ENDING	
15	10	Lecture	Project documentation and presentation
15	10	Lab	Tools for project documentation
15	10	Seminar	Project documentation strategies
15	10	Miniproject	Documentation and presentation of the project

Figure 1 Scheduling of the Industrial Computers AIISM module

About the module assessment [WP1.4 UPV], we will collect all grades earned along the continuous assessment developed along the course and proceed to obtain the final grade for the module.
To do this we establish the following proportion between the different sections to ensure a fair rating for differentiating their individual acquisition of knowledge and skills against the student group work:

- The evaluation of the student attitude (A) a 10% of the final score.
- The evaluation of the miniproject represents (MP) a 40% of the final score.
- The evaluation of the Laboratory (L): 20% of the final score.
- The evaluation of the Problems (P): 15% of the final score.
- The evaluation of the Seminars (S): 15% of the final score.

With all the information of ratings and percentages described will get a single grade for each student.

Considering conclusions of the analysis presented in [WP3.1 SPBSPU] the **“**Intelligent Systems and Technologies” master programs of the Institute of Information Technology and Control Systems (IITCS) fits perfect for integration of the AIISM.

In this manner, after the analysis of the curricula of the St. Petersburg State Polytechnic University and the partner regulations as a Russian National Research Polytechnic University, in order to integrate the Industrial Computers AISSM module, the following conclusions have been obtained:

- The Industrial Computer module can be integrated into curricula as courses of a variable part of the selected master program.
- The students that course the AISSM will obtain the **“**Intelligent Systems and Technologies” master degree.
- The duration of the Industrial Computer module is 15 weeks and the duration of each semester in the St. Petersburg State Polytechnic University is 18 weeks. Thus, 3 weeks can be used for additional training skills.
- According to current regulations a variable part equals to 4 or 5 credits of ECTS and may include several alternatives (elective courses). Thus, the Industrial Computer module can be considered as elective courses conforming the AISSM intensification.
- The Industrial Computer module should be included in the second and third semesters.
- The students of the selected Master program have the sufficient background to course the Industrial Computer module.
- The proposed evaluation method for Industrial Computer AISSM module fits with the SPBSPU regulations.

In this manner, the Industrial Computer module can be integrated into the "Intelligent Systems and Technologies" master in the 1st year covering an elective course slot (see Table 1):

	Code	Title of the discipline	ECTS
	GS	**General Sciences**	18
	GSB	*Basic part*	6
1	GSB1	Intelligent Systems	3
2	GSB2	Methods of optimisation	3
	GSV	*Variable part*	12
3	GSV1	Knowledge Engineering	2,5
4	GSV 2	Mathematical Modelling and Simulation	4,5
5	GSV3S	Elective discipline	5
5.1	GSV3S1	Digital Image processing	
5.2	GSV3S2	Distributed Intelligent Systems	
	PS	**Professional Subjects**	43,5
	PSB	*Basic Part*	13
6	PSB1	Computing Systems	5
7	PSB2	Software Development Technologies	3,5
8	PSB3	Modern problems of Information Science and Computer Engineering	4,5
	PSV	*Variable Part*	30,5
9	PSV1	Neuroinformatics and Neurotechnologies	5
10	PSV2	Intelligent Computing	5
11	PSV3	Intelligent Systems for Data Processing	3,5
12	PSV4	CAD Engineering	4
13	PSV5	Signals and Information Theory	5
14	PSV6S	Elective discipline	8
14.1	PSV6S1	Intelligent Control Systems	
14.2	PSV6S2	Cognitive Multiagent Systems	
15	PR	Practices and research work	46,5
16	SC1	Final State Certification	12

Table 1. SPBSPU Master "Intelligent Systems and Technologies"

3.2 Microcontroller module

The above mentioned module is an AIISM module containing different learning activities. These activities are taught during 5 hours/day, one day of the week (during 15 weeks) through a PBL methodology, using as a case study the example of the control of a liquids tank. The total supervised contact time is 75 hours during the semester. The total workload for the students is approximately 150 hours, resulting in 5 credit points (ECTS).

To successfully run through the course, students have to apply the knowledge acquired from the lectures and the laboratory practices. The proposed learning activities are the following:

- Lecture: lecturer presents main ideas of lecture contents and proposes some application problems which student solves individually (1 h contact time).

- Laboratory session: To implement (1 h 45’’) a practical problem previously presented during lecture. Students work by teams of two students. Contact time is given by a technician and the lecturer.

- Seminars: a panel discussion with student teams (4 students) lasting 45 minutes is proposed, consisting generally of presenting the solution for a problem, which previously was analysed by the student team. The lecturer leads the discussion and summarizes the main results.

- Mini-project: dedicated to planning, design and development of the control system of an industrial production and transportation process. Teams of 4 students work on the mini-project during 2 hours/week (supervised by a technician and partly by a lectruer). Independent work of about another 2-3 hours/week advance the mini-project progressively.

Based on the previous proposals, the set of chapters to group different topics is the following:

1. Introduction to microcontrollers and process control
2. Project management and project planning
3. Input-/Output system of microcontrollers
4. Timer and interrupt functions on microcontroller systems
5. Graphic systems for microcontrollers

6. Communication systems on microcontrollers
7. Implementation of Control methods on microcontrollers
8. Integration and validation

Chapter 1 focuses on an introduction to microcontrollers, sample Applications, definition of Basic concepts and important terms.

Chapter 2 deals with project-management. There is no lecture for this topic, as it is not the main focus of this course. The contents of this chapter are worked out by seminars about project management methods and project documentation strategies.

Chapter 3 focuses on the I/O-system of microcontrollers. The interfaces of the microcontroller interact with the process directly. The chapter introduces the different kinds of input- and output-signals and their programming in the microcontroller.

Chapter 4 introduces timer and interrupts. In addition this chapter deals with the concepts of programming timer and interrupts using the microcontroller Arduino Due.

Chapter 5 deals with graphical user interfaces for microcontrollers. The main part of this chapter focuses on a graphical TFT-display wired to the microcontroller Arduino Due. In detail the necessary libraries and functions are explained.

Chapter 6 gives a short introduction to concepts of communication between microcontrollers. This lecture focuses on special communication mechanisms used with microcontrollers.

Chapter 7 introduces algorithms of closed loop control. Key feature of closed loop control is the recirculation of a current value and comparison with a desired value. There are different types of controllers – their mathematical models will be explained.

Chapter 8 deals with the integration and validation of the mini-project. There is no lecture for this topic. The contents of this chapter are worked out by a seminar about test and validation strategies. In addition the students learn directly by developing the mini-project and integrating and documenting their own mini-project.

Figure 2 shows the scheduling of this module spread to 15 weeks:

Type	Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
INTRODUCTION																
Lecture	Introduction to microcontrollers; architecture of microcontrollers	x														
Lab	Development environment; connection of microcontroller to PC	x														
Lecture	Introduction to Process Control and mini project		x													
Seminar	C programming basics		x													
PROJECTMANAGEMENT																
Project	Formal specification of the mini-project		x													
Project	Analysis of project specification			x												
Seminar	Project managment			x												
Project	Project planning, management and timetable of mini-project				x											
Project	Design of mini-project					x										
Seminar	Discussing mini-project status										x					
Lab	Tools for project documentation														x	
Seminar	Project documentation strategies														x	
I/O-SYSTEM of microcontrollers																
Lecture	Digital I/Os of microcontrollers			x												
Lab	Digital I/O			x												
Lecture	Analog I/Os of microcontrollers				x											
Lab	Analog I/O				x											
Lecture	Amplifier circuits for actuators and sensors					x										
Lab	Build up a basic amplifier circuit					x										
Seminar	Libraries					x										
Lecture	State machines, scheduling						x									
Seminar	Software tools for modeling of state machines						x									
Project	Using libraries in the mini-project						x									
TIMER AND INTERRUPT HANDLING																
Lecture	Timer Handling							x								
Lab	Basic timer functions							x								
Project	Implementing digital I/O							x								
Lecture	Interrupt handling								x							
Lab	Basis interrupt functions								x							
Project	Implementing analog I/O								x							
GRAPHIC SYSTEM																
Lecture	Displays and graphic routines									x	x					
Lab	Basic Display functions									x						
Project	Implementing state machine and controller									x						
Lab	Advanced display functions										x					
Project	Implementing display										x					
Project	Implementing user interface											x				
COMMUNICATION between microcontrollers																
Lecture	Communication between different microcontrollers												x	x		
Lab	Basic communication methods (Serial)												x			
Project	Communication to other liquid tanks												x	x		
Lab	Advanced Communication Methods													x		
Lecture	Communication between different microcontrollers														x	
CONTROL METHODS																
Lecture	Closed Loop Controller: modeling and algorithms											x				
Lab	Programming closed loop controllers											x				
INTEGRATION AND VALIDATION																
Project	Module integration and documentation of the mini-project.														x	
Lecture	Testing microcontroller projects															x
Seminar	Test and validation strategies															x
Project	Test and validation of the project; documentation of the mini-project															x

Figure 2 Scheduling of the Microcontroller module

Deliverable [WP1.4 USTUTT] describes the details of grading the students in the module. The overall grade is calculated by different grades, earned along the continuous assessment of the students during the whole module.

For the microcontroller module the following proportion of grading between the different learning activities ensures a fair rating for differentiating the individual acquisition of knowledge and skills of the students:

- The evaluation of the student attitude (A): 10% of the final score.
- The evaluation of the miniproject (MP) represents 40% of the final

score.

- The evaluation of the Lecture (L): 15% of the final score.
- The evaluation of the Laboratory (P): 20% of the final score.
- The evaluation of the Seminars (S): 15% of the final score.

Considering the conclusions of the analysis presented in [WP3.1 SPBSPU] the **“**Intelligent Systems and Technologies” the master programs of the Institute of Information Technology and Control Systems (IITCS) fit perfectly for an integration of the AIISM.

In this manner, after the analysis of the curricula of the St. Petersburg State Polytechnic University and the partner regulations as a Russian National Research Polytechnic University, in order to integrate the Microcontroller AISSM module, the following conclusions have been obtained:

- The Microcontroller module can be integrated into curricula as courses of a variable part of the selected master program.
- The students that choose the AISSM profile will obtain the **“**Intelligent Systems and Technologies” master degree.
- The duration of the Industrial Computer module is 15 weeks and the duration of each semester in the St. Petersburg State Polytechnic University is 18 weeks. Thus, 3 weeks can be used for additional training skills. For example the results of the miniprojects of different student teams can be combined to an integrated shop floor.
- According to current regulations a variable part equals to 4 or 5 credits of ECTS and might include several alternatives (elective courses). Thus, the Microcontroller module can be considered as an elective course intensifying the AISSM profile.
- The Microcontroller module should be included in the second and third semester.
- The students of the selected Master program have the sufficient background to visit the Microcontroller module.
- The proposed evaluation method for the Microcontroller AISSM module fits with the SPBSPU regulations.

In this manner, the Microcontroller module can be integrated into the “Intelligent Systems and Technologies” master in the 1st year covering an elective course slot (see Table 2):

	Code	Title of the discipline	ECTS

	GS	**General Sciences**	18
	GSB	*Basic part*	6
1	GSB1	Intelligent Systems	3
2	GSB2	Methods of optimisation	3
	GSV	*Variable part*	12
3	GSV1	Knowledge Engineering	2,5
4	GSV 2	Mathematical Modelling and Simulation	4,5
5	GSV3S	Elective discipline	5
5.1	GSV3S1	Digital Image processing	
5.2	GSV3S2	Distributed Intelligent Systems	
	PS	**Professional Subjects**	43,5
	PSB	*Basic Part*	13
6	PSB1	Computing Systems	5
7	PSB2	Software Development Technologies	3,5
8	PSB3	Modern problems of Information Science and Computer Engineering	4,5
	PSV	*Variable Part*	30,5
9	PSV1	Neuroinformatics and Neurotechnologies	5
10	PSV2	Intelligent Computing	5
11	PSV3	Intelligent Systems for Data Processing	3,5
12	PSV4	CAD Engineering	4
13	PSV5	Signals and Information Theory	5
14	PSV6S	Elective discipline	8
14.1	PSV6S1	Intelligent Control Systems	
14.2	PSV6S2	Cognitive Multiagent Systems	
15	PR	Practices and research work	46,5
16	SC1	Final State Certification	12
		AISSM: Microcontroller based systems for controlling industrial processes	4

Table 2. SPBSPU Master “Intelligent Systems and Technologies”

In order to integrate the Industrial Computer module in the curricula from the previous integration analyses the following possibilities and obstacles for the integration of the

Microcontroller module have been discovered:

- The Microcontroller module can be integrated into the cited programs as a course of a variable part of a Master Programmes, conforming an intensification. According to current regulations a variable part equals to 9 credits of ECTS and may include several alternatives (elective courses).
- The duration of the Microcontroller module is 15 weeks and the duration of each semester in the SPbPU is 18 weeks. Thus, 3 weeks can be used for additional training skills. For example the results of the miniprojects of different student teams can be combined to an integrated shop floor. This would additionally strengthen the PBL approach.

About the module assessment [WP1.4 UPV], we will collect all grades earned along the continuous assessment developed along the course and proceed to obtain the final grade for the module.

To do this we establish the following proportion between the different sections to ensure a fair rating for differentiating their individual acquisition of knowledge and skills against the student group work:

- The evaluation of the student attitude (A) a 10% of the final score.
- The evaluation of the miniproject represents (MP) a 40% of the final score.
- The evaluation of the Laboratory (L): 20% of the final score.
- The evaluation of the Problems (P): 15% of the final score.
- The evaluation of the Seminars (S): 15% of the final score.

With all the information of ratings and percentages described will get a single grade for each student.

3.3 Mobile and Cloud Computing module

This module is an AIISM module structured with different activities. Similar to the other modules, the activities are developed during 3 hours/day (during 15 weeks) through a PBL methodology, using as a case study the example of the remote control of the liquids tank. To develop the course, students have to apply the knowledge acquired from the lectures and the laboratory practices. The proposed learning activities are the following:

- Lecture and problems: lecturer presents main ideas of lecture contents and proposes some application problems which student solves individually (1 h).
- Laboratory session: To implement (1 h 15’’) a practical problem previously presented during lecture. Students work by teams of two students.
- Seminars: a panel discussion with student teams (4 students) lasting 45 minutes is proposed, consisting generally of solving a problem by means of PBL.
- Mini-project: dedicated to planning, design and development of the control system of the educational liquids tank. The mini-project is performed by teams of 4 students during 2 hours. Weekly, the mini-project is advanced progressively.

Based in the previous proposals, the set of chapters to group different topics is the following:

Fundamentals of Remote Monitoring and Control

- Integrated Development Environment
- Basic App Development
- Graphical user interface (GUI)
- Security
- Reliability

The first 2 lectures will give an introduction to the fundamentals of remote monitoring and control of embedded systems as well as the liquid tank system which will be used throughout the course. Lectures 3 and 4 will give an overview of a number of integrated development environments (IDEs) for developing apps that will be deployed on the most common operating systems, i.e. IOS and Android. Lectures 5 and 6 lecture will cover practical aspects of developing a basic app in one of the platforms using an example. The main feature of the app will be inter-device communication using Bluetooth and WiFi. The basics for designing a functional and intuitive graphical user interface will be covered in lectures 7 and 8. It will provide knowledge on the programming of GUI controls as well as addressing the limited bandwidth issues that can occur while dealing with media streaming. Securyt and Reliability will be addressed in lectures 9-12 that will cover the security related issues that a system connected to the internet might experience, suggest solutions and discuss the role based access control approach as well as reliability of embedded systems and usage of fault tolerance and testing for dependable systems design. It will also cover the synchronization issues that can occur with multiple accesses during remote monitoring and control of these systems. The last lecture will be a seminar for discussions of the research finding in the selected topics.

Additionally, the labs are the practical exercises that follow the corresponding lectures that help the students to acquire basic set of skills related to the topic of the lecture. Each lecture will be followed by a seminar where the student teams present the outcomes of their course work, as well as submit a written report, as well as miniprojects dedicated to planning, design and development of the control system of the educational liquids tank. The mini-project is performed by teams of 4 students during 2 hours.

The schedule distribution in weeks for this module is shown in Table 3.

Table 3 Schedule of the Remote Monitoring and Control Module

Week	Type	Topic
1 – Introduction		
1	Lecture	Fundamentals of Remote Monitoring and Control
1	Seminar	Research of Remote Monitoring and Control

1	Laboratory	Lab introduction - Liquid tank system I
1	Miniproject	Presentation of project goals
2	Lecture	Lab introduction - Liquid tank system
2	Seminar	Research of mobile communication
2	Laboratory	Lab introduction - Liquid tank system II
2	Miniproject	Control systems and mobile devices
2 – IDE		
3	Lecture	Dedicated IDE's for IOS and Android (Anita)
3	Seminar	IDE for mobile devices
3	Laboratory	IDE introduction - installation and usability
3	Miniproject	Design and structuring of control application
4	Lecture	Cross-platform development tools (Titanium, PhoneGap, etc)
4	Seminar	State of the Art on development tools
4	Lab	Basic app development !
4	Miniproject	Testing of mobile apps and I/O address mapping
3 – Basic App Development		
5	Lecture	Inter-device communication 1 (Anita)
5	Seminar	Research inter-device communication
5	Lab	Basic app development II
5	Miniproject	Implement basic control logic
6	Lecture	Inter-device communication 2 (Anita)
6	Seminar	Research synchronisation in distributed systems.
6	Lab	GUI development and implementation
6	Miniproject	Implement complex control logic
4 – Graphical User Interface (GUI)		
7	Lecture	Graphical User Interface (GUI) 1 (Anita)
7	Seminar	Structure of code for GUIl
7	Lab	GUI development and implementation II
7	Miniproject	Add control logic to GUI
8	Lecture	Graphical User Interface (GUI) 2 (Anita)
8	Seminar	Propose structure of code implementing wireless communication on micro-controller
8	Lab	Implement wireless communication with the PC
8	Miniproject	Mapping of physical I/O to mobile devices
5 – Security		
9	Lecture	Security in mobile communication
9	Seminar	Research application areas of secure wireless communication
9	Lab	Access control and synchronization mechanisms I
9	Miniproject	Build a library of functions to secure access
10	Lecture	Security and control
10	Seminar	Research on secure control systems
10	Lab	Access control and synchronization mechanisms II
10	Miniproject	Secure sending and receiving of messages.
6 – Reliability		
11	Lecture	Reliability in mobile communication
11	Seminar	Research methods of reliability
11	Lab	Implement reliable communication
11	Miniproject	Simple distributed reliable control application
12	Lecture	Fault tolerance
12	Seminar	Research one fault tolerance for mobile devices
12	Lab	Implement fault tolerant communication
12	Miniproject	Add synchronous data transfer to distributed application.

13	Lecture	Testing of reliable mobile applications
13	Seminar	Research on testing of mobile communication
13	Laboratory	Testing approaches for mobile communication
13	Miniproject	Determine latency of traffic in miniproject.
7 – Research findings		
14	Lecture	Research on dependable mobile communication 1 (All)
14	Seminar	Research on app controlled ES
14	Laboratory	App control framework
14	Miniproject	Add hierarchical supervisory control of distributed control application.
15	Lecture	Research on dependable mobile communication 2 (All)
15	Seminar	Research on reliable communication for embedded control systems
15	Laboratory	Final project demonstration
15	Miniproject	Presentation of the project(s)

About the module assessment [WP1.4 MDH], we will collect all grades earned along the continuous assessment developed along the course and proceed to obtain the final grade for the module.

To do this we establish the following proportion between the different sections to ensure a fair rating for differentiating their individual acquisition of knowledge and skills against the student group work:

- The evaluation of the student attitude (A) a 10% of the final score.
- The evaluation of the miniproject represents (MP) a 40% of the final score.
- The evaluation of the Laboratory (L): 20% of the final score.
- The evaluation of the Problems (P): 15% of the final score.
- The evaluation of the Seminars (S): 15% of the final score.

With all the information of ratings and percentages described will get a single grade for each student.

3.4 Industrial Networks and Fieldbuses module

The Industrial Networks and Fieldbuses module has been prepared as a 15 week long 3 ECTS course, corresponding to a total workload of 81 hours. This workload is distributed between classes (67,5 to 75 hours) and individual study (6 to 13,5 hours). Class hours include lectures, seminars, assisted laboratory and independent laboratory (mini-project) work. The division of effort between these 4 activity types will differ from week to week depending on the subject matter and the expected output for the mini-project work for that week, but the total classroom time always totals from 4,5 to 5 hours per week. When the course is taught using 4,5 classroom hours per week, it is expected that the students will spend an average of extra 0,5 hours per week working on the mini-project by themselves.

An analyses of the requirements of the universities that will implement this course leads one to the conclusion that some universities require a course with less classroom contact hours, while others require a course with a either more classroom hours or total course contact hours. In this section we describe how the course may be adapted to cover these requirements.

Chapter 1 (Introduction to Industrial Filedbuses and Networks) is taught over the first 2 weeks (weeks 1 and 2). The universities that require longer contact hours may extend the week 1 laboratory session to cover the study of other protocols using the 'wireshark' tool, or to cover in more detail or more completely the already suggested list of protocols. Additionally the students may even try to manually simulate the client end of some of the text based protocols (example: SMTP and HTTP) using a telnet session. In particular the manual execution of the SMTP protocol allows sending emails from a fake email address, which is invaluable in letting the students become aware of security issues that may also arise in industrial networks. During week 2 the seminar session should be extended to cover in higher detail the existing fieldbus protocols, allowing the students to obtain a better higher level overview of the current status of fieldbus networks as used in reality.

Chapter 2 focuses on the Modbus protocol in general, and its implementation over the TCP/IP stack in particular. During these 2 weeks the students are expected to implement a very simple control algorithm for 3 conveyors that only use *binary* sensors and actuators. For longer classroom sessions standard mini-project sessions should be extended by asking the students to control a more complex layout of the factory floor that now includes a warehouse from which work-pieces may be retrieved and later returned. Control of the warehouse requires the use of a Modbus function to write to 16 bit registers. Implementing this extra Modbus function, as well as the more complex control algorithm, constitute the extra work proposed for the longer mini-project sessions.

d 3 conveyors (weeks 3 and 4)

5 and 6), and during this period the students for modeling complex discrete event control in software. The universities that have longer ory and/or the mini-project sessions of weeks 5 used to model the control algorithm of the plant eeks 3 and 4. Since the extended version of this plant floor now includes a warehouse, this modeling effort is also slightly more elaborate. The week 6 laboratory session is traditionally used to augment the previous control algorithm in such a way as to allow concurrent control of multiple work-pieces simultaneously. As the base control algorithm is already more complex, the work for this week is automatically also slightly more time-consuming, and therefore requires a class with longer hours. However, we predict that these changes are not sufficient as the extra effort is not really significant. For this reason we suggest that the plant floor to be controlled during the mini-project also be extended to have a warehouse. The control

requirements may also be extended so that the pieces doing the left (red) circuit are automatically taken out of the warehouse (see figure), and these should be done using work-pieces of type P1 and P3 alternately. Work-pieces P2 doing the right-hand (blue) circuit are unchanged. Work-pieces P1 and P3 may also be given different processing requirements on each machine. We expect each university to refine the difficulty of the proposed control problem to both the available class time, as well as to the proficiency of the students in solving the problems.

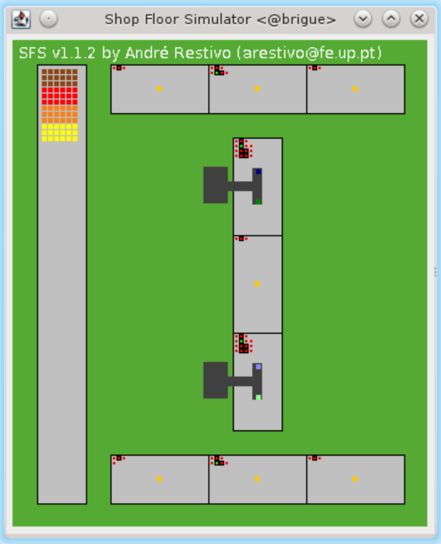

Figure 3 Extended plant floor layout with warehouse

In chapter 4 the serial version of the Modbus protocol is introduced over weeks 7 and 8. This serial Modbus protocol is used for the communication between an Arduino and the computer running both the simulated plant floor and the discrete event control program. This involves implementing the Modbus serial protocol on both the PC as well as the Arduino in the laboratory sessions. The buttons and the lights on the Arduino are then used during the mini-project sessions as a physical interface with an operator, and the control algorithm is extended to take into account a RUN and STOP state. The universities requiring longer classroom hours may extend the laboratory sessions of both weeks 7 and 8 by having the students also implement the Modbus functions related to reading and writing of 16 bit registers. If required, the mini-project sessions may also be extended by adding an extra PAUSE button and a corresponding suspended operation mode to the control algorithm. When the operator presses the PAUSE button the control algorithm enters a suspended state which should be indicated by a flashing GREEN light. When the operator presses the PAUSE button again, the suspended state is canceled and the control algorithm resumes operations from the exact same place where it was suspended.

In chapter 5, corresponding to weeks 9 and 10, the students come into contact with the CAN fieldbus and use it to establish a network of arduino devices. This network is used to simulate remote discrete Input/Outputs, and the students are expected to integrate these remote I/Os as an extra physical interface to the operator (RUN, STOP and PAUSE buttons, and GREEN and RED lights). For universities with longer classroom hours the mini-project sessions may be extended by asking the students to use an additional remote button - TYPE. The operator will press this button for a variable amount of time (x seconds), and this time value should be sent over the CAN network as a 16 bit variable. This variable is then sent over the Modbus connection to the PC as a 16 bit Modbus register, and the value is used by the control algorithm to decide which work-piece type to remove from the warehouse.

In chapter 6 the students are asked to implement the CAN-Open protocol over the CAN network, and to use it in the mini-project. This is done during weeks 11, 12 and 13. Unlike the previous chapters, we believe that the work proposed in deliverable 2 is sufficient for the universities with extended classroom time. In fact, and in order for the students to be able to complete the classes within the originally allotted time, we expect that the students will need to be given a partial solution to the work proposed for the laboratory session. Each university should decide how much of the partial solution should be provided to the students taking into account the problem solving capacities the students have shown up to this point of the module.

In chapter 7 the industrial networks module focuses on hierarchical control architectures, and the communication protocols used in this capacity. In the first of two weeks (week 14) the students are asked to build a small SCADA based (Supervisory Control And Data Acquisition) graphical user interface (GUI) for a plant floor supervisor and/or operator. We suggest that universities with longer classroom time use any spare time to extend the capacities of the developed SCADA GUI. For example, students may wish to take advantage of the Modbus functions for reading and writing 16 bit registers implemented in chapters 2 and 4 to insert statistics into the SCADA GUI such as total number of work-pieces processed in each machine, as well as the total operating time for each machine and conveyor. The mini-project session of week 15 (the last week of the module) is used for the presentations of the mini-project work. We believe that any extra classroom time may be gainfully employed in a deeper discussion of the different approaches taken by each group, and a presentation and sharing of the lessons learned through experience during the mini-project implementation.

3.5 Process Controllers and Simulators module

The Process Controllers and Simulators module in AISSM course is structured with different activities. These activities are developed during 4 hours/day (during 15 weeks) through a PBL methodology, using as a case study the example of the control of the liquids tank. The learning sessions are organized in these activities: lectures, seminars, laboratories, mini-project and tutorship.

The proposed learning activities are the following:

- **Lectures** - the first step in the learning process for each of the topics in a module. The lecturer presents the main topics, basic knowledge and the structure of the contents. This includes some application examples. Some lectures include elements of general theory not directly included in the exercises and mini-projects but very important for the applications.

- **Laboratory sessions (labs)** - the first practical exercise that students take to acquire a basic set of skills related to the topic presented in the lecture. The exercises in the lab solve specific and well-defined problems; they are guided, fully documented, and of progressively increasing complexity. The lab provides students with a set of tools and skills that can be used to solve more open problems during the seminars.
- **Seminars** - During the seminars the students must solve problems on the topic of the lecture. They have already collected experiences on related topics and procedures in the previous laboratories.
- **Mini-projects** - During the mini-project students use the knowledge and skills that they have acquired in the lectures, labs and seminars to develop the couple controller-simulator for a physical process in an integral way. The problem of the mini-project is the highest complexity problem in the course. The working teams in the mini-project are the same as in the seminars. The designs developed by the teams during the seminars are used as components of the mini-project's problem's solution. The teams can combine seminar designs of different other teams to solve their mini-project.

Based in the previous proposals, the set of chapters to group different topics is the following:

1. **Introduction**

Classification and characteristics of the Computer Control Systems (CCS): embedded (specialized) systems; control systems for industrial applications with standardized functions.

2. **Architecture of Computer Control Systems**

Functional organization of the modern hierarchical industrial control systems.

Types of computer control and data acquisition systems: data collection systems, supervisor control, direct numerical control, logical controllers, etc. Modern, decentralized and distributed control systems.

3. **Organization and structure of computers for control purposes**

- Organization and structure of computers for the industrial controller and for embedded system. Analog and discrete I / O subsystems; analog and discrete control peripherals.
- Organization of computational processes in CCS for continuous control. Concept of static and dynamic process scheduling.
- Organization of computational processes in CCS interacting with discrete objects: implementation of synchronous, asynchronous and synchronous-asynchronous state machines.

4. **Basic control algorithms**

Controllers for analog objects - standard functions and algorithms; concept of configuration vs coding - specialized languages for continuous control system. Controllers for discrete objects - logical and sequential controllers.

5. **Real-Time software environment**

Real-Time operating systems - functions and subsystems; management processes (tasks). Scheduling in hard real-time constraints.

6. **SCADA**

Basic structure. Functions. Standards. Connection to the controllers. Interfaces.

7. **Simulators – general theory**

Software-in-the-Loop simulators. Hardware-in-the-Loop simulators. Agent-based simulators.

8. **Simulators – practical aspects**

Computer simulators including process periphery. Connecting the controller to the simulator. Setting-up the simulator. Induction of errors and special situations. Keeping the history of the process. Analysis encountered in real operation problems. Training of the personnel.

9. **Simulation of distributed objects and control systems**

Virtual monomachine approach. Component approach. Communication network influences – simulation.

10. **Simulators validation**

Validation using the "Configure/Reconfigure" approach.

11. **Real-Time system improvement using simulation environment**

Model improvements. Software improvements. Performance optimization.

The course has been scheduled assuming duration of 15 weeks, with **4** hours of direct teacher student interaction per week.

Another basic of an engineer is the correct management and documentation of a project. This is the objective of the following activities that are spread along the course. This is also a horizontal content of the module, so it is spread along the course and in a position where student understands its implications.

Table 4 The scheduling distribution in weeks for this module is shown in the next tableau

Chapter	Type	Topic	Week														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	**Introduction**																
1	Lecture		x														
1	Seminar		x														
1	Lab		x														
1	Mini-project		x														
2	**Architecture of Computer Control Systems**																
2	Lecture			x													
2	Seminar			x													
2	Lab			x													

2	Mini-project			x													
3	**Organization and structure of computers for control purposes**																
3	Lecture				x												
3	Seminar				x												
3	Lab				x												
3	Mini-project				x												
4	**Basic control algorithms**																
4	Lecture					x											
4	Seminar					x											
4	Lab					x											
4	Mini-project					x											
5	**Real-Time software environment**																
5	Lecture						x										
5	Seminar						x										
5	Lab						x										
5	Mini-project						x										
5	**Real-Time software environment**																
5	Lecture							x									
5	Seminar							x									
5	Lab							x									
5	Mini-project							x									
6	**SCADA**																
6	Lecture								x								
6	Seminar								x								
6	Lab								x								
6	Mini-project								x								
6	**SCADA**																
6	Lecture									x							
6	Seminar									x							
6	Lab									x							
6	Mini-project									x							
7	**Simulators – general theory**																
7	Lecture										x						
7	Seminar										x						
7	Lab										x						
7	Mini-project										x						
7	**Simulators – general theory**																
7	Lecture											x					
7	Seminar											x					
7	Lab											x					
7	Mini-project											x					
8	**Simulators – practical aspects**																
8	Lecture												x				
8	Seminar												x				
8	Lab												x				
8	Mini-project												x				
8	**Simulators – practical aspects**																
8	Lecture													x			
8	Seminar													x			
8	Lab													x			
8	Mini-project													x			

9	**Simulation of distributed objects and control systems**																
9	Lecture													x			
9	Seminar													x			
9	Lab													x			
9	Mini-project													x			
10	**Simulators validation**																
10	Lecture														x		
10	Seminar														x		
10	Lab														x		
10	Mini-project														x		
11	**Real-Time system improvement using simulation environment**																
11	Lecture															x	
11	Seminar															x	
11	Lab															x	
11	Mini-project															x	

About the module assessment [WP1.4 TUS], at this level we will collect all grades earned along the continuous assessment developed along the course and proceed to obtain the final grade for the course.

To do this we establish a just proportion between the different sections to ensure a fair rating for differentiating their individual acquisition of knowledge and skills against the student group work.

The proposal will apply as follows:

- The evaluation of the student attitude (A) a 10% of the final score.
- The evaluation of the miniproject represents (MP) a 40% of the final score.
- The evaluation of the Laboratory (L): 20% of the final score.
- The evaluation of the Problems (P): 15% of the final score.
- The evaluation of the Seminars (S): 15% of the final score.

With all the information of ratings and percentages described will get a single grade for each student.

For the calculation of the final grade (FG) can be followed as the following equation:

$$FG = A*0.1+MP*0.4+L*0.2+P*0.15+S*0.15$$

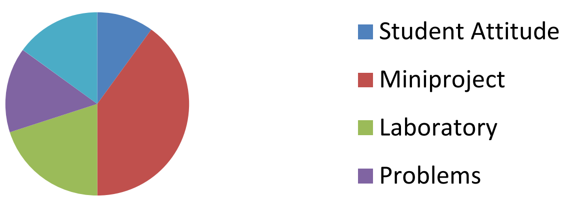

Figure 4 Distribution of percentages for final grade

4 Integration of AIISM Courses into Curricula at SPbPU

The scope of these programmes is 120 ECTS. Education is provided in Russian and English languages, also possible to use distance learning with the help of foreign scientists and professors.

As an example we can consider one of the programmes 27.04.04_07 Distributed Intelligent Control Systems. Curricula of this programme present in Table 5. Types of teaching hours for each discipline are present in Table 6.

Table 5 Curricula of the programme Distributed Intelligent Control Systems.

№	Code	Title of the discipline	ECTS
	GS	**General Sciences**	18
	GSB	*Basic part*	6
1	GSB1	Intelligent Systems	3
2	GSB2	Methods of optimisation	3
	GSV	*Variable part*	12
3	GSV1	Knowledge Engineering	2,5
4	GSV 2	Mathematical Modelling and Simulation	4,5
5	GSV3S	Elective discipline	5
5.1	GSV3S1	Digital Image processing	
5.2	GSV3S2	Distributed Intelligent Systems	
	PS	**Professional Subjects**	43,5
	PSB	*Basic Part*	13
6	PSB1	Computing Systems	5
7	PSB2	Software Development Technologies	3,5
8	PSB3	Modern problems of Information Science and Computer Engineering	4,5
	PSV	*Variable Part*	30,5
9	PSV1	Neuroinformatics and Neurotechnologies	5
10	PSV2	Intelligent Computing	5
11	PSV3	Intelligent Systems for Data Processing	3,5
12	PSV4	CAD Engineering	4
13	PSV5	Signals and Information Theory	5
14	PSV6S	Elective discipline	8
14.1	PSV6S1	Intelligent Control Systems	

14.2	PSV6S2	Cognitive Multiagent Systems	
15	PR	Practices and research work	46,5
16	SC1	Final State Certification	12

Table 6

Title of the discipline		Type and number of hours					
	Lectures	Lectures	Labs	Practical classes / Seminars	Contact hours	Self-study	Total
Control Systems and Technologies		18	0	18	36	72	108
Knowledge engineering		18	0	36	54	36	90
Methods of optimisation		18	0	18	36	72	108
Mathematical modelling and simulation		36	18	0	54	108	162
Digital image processing		18	0	36	54	126	180
Distributed intelligent systems		18	0	36	54	126	180
Computing systems		36	18	0	54	126	180
Software development technologies		36	18	0	54	72	126
Modern problems of information science and computer engineering		36	0	18	54	108	162
Neuroinformatics and neurotechnologies		36	18	0	54	126	180
Intelligent computing		18	18	18	54	126	180
Intelligent systems for data processing		36	0	18	54	72	126
CAD engineering		18	18	18	54	90	144
Signals and information theory		18	0	36	54	126	180
Intelligent control systems		18	36	36	90	198	288
Cognitive multiagent systems		18	36	36	90	198	288
Practice and research work		0	0	180	180	694	874

Presented AIISM courses (Microcontroller-based systems, Apply mobile devices, Industrial networks and fieldbuses to achieve the control, Design of controllers and simulators, and Industrial computer) can be integrated into Curricula as a variable part of the pogrammes (27.04.04_06 Control Systems of Electrical Drive, 27.04.04_07 Distributed Intelligent Control Systems, 27.04.04_02 Automation of Technological Processes and Production) instead of courses Neuroinformatics and neurotechnologies, CAD engineering, Signals and information theory, Intelligent control systems, and Cognitive multiagent systems, for example, see Table 3.

5 Adaptation of EU Proposal to SPbPU Curricula

Students enrolled in the master's programmes come from various universities and from different areas of study and, therefore, have different background of training disciplines. For them, it is important to choose courses that will help increase the level of training.

The proposed AIISM disciplines are grouped as the Module by student’s choice and included into existing Curricula with the distribution of academic hours shown in Table 7.

Table 7

Subject	ECTS Credits	Academic Hours per Semester				
		Total	Contact Hours	Lectures	Laboratory Lessons	Unsuper-vised Work
Programming of Industrial Computers	3	90	54	36	18	36
Programming of Controllers and Simulators	3	90	54	36	18	36
Programming of Microcomputers	3	90	54	36	18	36
Mobile and Cloud Computing	3	90	54	36	18	36
Industrial Networks and Fieldbuses	3	90	54	36	18	36

As it is presented in the Table 5, every subject has equal number of ECTS credits, namely 3 ECTS credits that is an equivalent of 90 academic hours. This total number of academic hours is divided to 54 contact hours and 36 academic hours of unsupervised student’s work. Contact hours include 36 academic hours of lectures and 18 academic hours of laboratory lessons.

6 Implementation of ECTS

ECTS - European Credit Transfer System - The European System of offsetting credits developed within the Council of Europe project.

ECTS is based on three elements:

- course information and results of the student's work,
- agreement between the universities - partners and the student,
- designation of the volume of student work.

SPbPU many years cooperates with leading universities in Germany, UK, Finland, etc. and joint educational program of double diplomas.

According to this programme the University graduates can get along with a diploma SPbPU document the successful completion of a foreign university.

The international programmes of two diplomas, for example, used the European Credit Transfer System (ECTS).

A unified grading system is used in all international cooperative education programmes. Training is carried out under general integrated curriculum, used a consistent description of the disciplines, which allows subjects studied in the same university to recognise the partner institution - without repetition of the passed material.

Accordingly, both ours and foreign students can transfer credits to the home university periods of study and exams handed abroad.

According to the educational programmes one academic year corresponds to 60 ECTS credits, i.e. 1 ECTS credit corresponds to 36 academic hours (1 academic hour is equal to 45 minutes).

Usually one course includes from 3 to 5 ECTS credits (90-150 academic hours). However either less or more number of ECTS credits is acceptable as well. An average subject of 3 ECTS credits (90 academic hours) includes typically 36 academic hours of lectures, 18 academic hours of practical lessons (laboratory lessons), and 36 academic hours of student’s unsupervised work.

The duration of a semester in SPbPU is 18 weeks. An examination session lasts three weeks and includes three o four exams. In addition, students pass tests on courses that don’t include exams. Thus, every subject finishes either with test or with exam.

7 Evaluation system

According to the internal regulations of SPbPU an evaluation system description is a part of a course curriculum. This evaluation system description includes detailed information about components of student’s rating, criteria of evaluation, rules of rating calculation, etc. Standard practice in SPbPU is to use 100-point scale for the evaluation system of every course. The main objective of the evaluation system is to encourage students to work actively and continuously during a whole semester as well as to ensure fair evaluation of student's learning results.

Since the proposed learning activities within MEDIS methodology are the following:

- Lecture
- Problems for individual work of a student
- Laboratory session
- Seminar
- Mini-project.

they are used as a basic set of student's activities for every subject of MEDIS section of the curriculum. To obtain a final set of activities, the proposed proportion between the different sections to ensure a fair rating for differentiating individual acquisition of knowledge and skills against the student group work should be taken into consideration:

- The evaluation of the student attitude (A) a 10% of the final score.
- The evaluation of the miniproject represents (MP) a 40% of the final score.
- The evaluation of the Laboratory (L): 20% of the final score.
- The evaluation of the Problems (P): 15% of the final score.
- The evaluation of the Seminars (S): 15% of the final score.

Thus, the student attitude (A) can be applicable to "Lecture" activity in the basic set, what gives us the final activity to be evaluated – "Active attitude of the student on lectures", what means student's questions and participation in discussions during a lecture. The maximum number of points for activity is 10, what is 10% of 100 points. The criteria of evaluation for this activity can be the following:

- The student gets from 8 to 10 points if he or she participates actively in every lecture – asks questions, participates in discussions (active attitude).
- The student gets from 5 to 7 points if he or she participates actively in discussions or asks questions in more than a half of lectures during the semester (quite active attitude).
- The student gets from 2 to 4 points if he or she participates actively in discussions or asks questions in less than a half of lectures during the semester (rather active than passive attitude).
- The student gets 1 point if he or she doesn't participate in discussions or ask questions (passive attitude).
- The student gets 0 point if he or she doesn't attend lectures.

The evaluation of the mini-project representation (MP) is applicable to "Mini-project" activity in the basic set, what gives us the final activity to be evaluated – "Fulfilment and presentation of mini-project", what allows to evaluate a student's work from the very beginning of the work on the mini-project to presentation of this project. The maximum number of points for activity is 40, what is 40% of 100 points. Since this activity is complex, it should be evaluated by several criteria to be defined separately. The final score for this activity is a sum of points according to every criterion. The list of criteria can be the following:

- Quality of the mini-project fulfilment – it gives the student from 1 to 10 points according to the project's quality level.
- Ability to work in a team – it gives the student from 1 to 10 points according to effectiveness of the student's work.
- Quality of the report documentation on the mini-project – it gives the student from 1 to 10 points according to the project documentation's quality level.
- Quality of the presentation of the mini-project – it gives the student from 1 to 10 points according to the project presentation's quality level.

These criteria should be applied to every student in the project team individually.

The evaluation of the Laboratory (L) can be applicable to "Laboratory session" activity in the basic set, what gives us the final activity to be evaluated – "Quality of student's work during laboratory sessions", what includes different aspects of the student's work during laboratory session. The maximum number of points for activity is 20, what is 20% of 100 points. Since this activity is also complex, it should be evaluated by two criteria to be defined separately. The final score for this activity is a sum of points according to every of two criterion. The criteria are as follows:

- Quality of the laboratory tasks fulfilment – it gives the student from 1 to 10 points according to the quality level.
- Quality of the answers during fulfilled task discussion – it gives the student from 1 to 10 points according to the student's answers quality level.

The evaluation of the Problems (P) can be applicable to "Problems for individual work of a student" activity in the basic set, what gives us the final activity to be evaluated – "Quality of student's individual work on given problems", what means quality student's solution of given individual tasks. The maximum number of points for activity is 15, what is 15% of 100 points.

The criteria of evaluation for this activity can be the following:

- The student gets from 14 to 15 points if problems solved correctly, the solution is explained and illustrated well, there are no mistakes of typos.
- The student gets from 11 to 13 points if problems solved correctly, but the solution is explained and illustrated too short, but there are no mistakes of typos.
- The student gets from 7 to 10 points if problems solved almost correctly, but there are some insignificant mistakes of typos.
- The student gets from 3 to 6 points if problems solved, but there are significant mistakes of typos.

- The student gets from 1 to 2 points if problems don't solved.
- The student gets 0 point if solutions are missing.

The evaluation of the Seminars (S) can be applicable to "Seminar" activity in the basic set, what gives us the final activity to be evaluated – "Active attitude of the student on seminars", what means student's participation in discussions during a seminar. The maximum number of points for activity is 15, what is 15% of 100 points. The criteria of evaluation for this activity can be the following:

- The student gets from 13 to 15 points if he or she participates actively in every seminar (active attitude).
- The student gets from 8 to 11 points if he or she participates actively in discussions in more than a half of seminars during the semester (quite active attitude).
- The student gets from 4 to 7 points if he or she participates actively in discussions in less than a half of lectures during the semester (rather active than passive attitude).
- The student gets from 2 to 3 points if he or she rarely participates in discussions (rather passive than active attitude).
- The student gets 1 point if he or she doesn't participate in discussions (passive attitude).
- The student gets 0 point if he or she doesn't attend seminars.

The final score of the student is calculated as a sum of his or her individual score for every of five evaluation elements. The final student's grade is defined according to Table 8. Example of the evaluation system is present in Fig 5.

Table 8 Evaluation system of AIISM courses

Activities	Points
Student attitude (A), max 10%	
Miniproject (MP), max 40%	
Laboratory (L), max 20%	
Problems (P), max 15%	
Seminars (S), max 15%	
Average	
From 85 to 100	Excellent
From 70 to 85	Good
From 60 to 70	Satisfactory
Less than 60	Unsatisfactory

1	id	email	username	Lab 06	Lab 07	Lab 08	Lab 09	Lab 10	Lab 11	Lab 12	Lab Avg	Midterm 01	Midterm 02	Midterm 03
2	57156	ihysm@mail.ru	NamelessM	1.0	1.0	1.0	0	0	0	0	0.984375	1.0	1.0	1.0
3	56469	aleksandra.subbotina2015@yandex.ru	subal23	0.875	1.0	1.0	0	0	0	0	0.921875	1.0	1.0	1.0
4	43161	ymnik-bad@mail.ru	id50138970	0.875	0.875	1.0	0	0	0	0	0.953125	1.0	0.888888888889	1.0
5	43575	prismakin@live.com	Prismakin	1.0	1.0	1.0	0	0	0	0	0.875	1.0	0.444444444444	1.0
6	50684	butramenko_andreu@mail.ru	andreibutramenko	0.0	1.0	1.0	0	0	0	0	0.84375	1.0	0.888888888889	1.0
7	43693	antipenko_dmitry.1996@mail.ru	Dmitry_Antipenko	0.875	0.875	0.875	0	0	0	0	0.90625	0.833333333333	0.777777777778	1.0
8	50035	senin66iv@gmail.com	senin66iv	0.75	1.0	0.0	0	0	0	0	0.800347222222	1.0	0.555555555556	1.0
9	1185	andrej.moiseev@gmail.com	Andrej	0.875	1.0	0.0	0	0	0	0	0.75	1.0	0.444444444444	1.0
10	4119	s.d.v.lip@gmail.com	id101182332	1.0	1.0	0.0	0	0	0	0	0.75	0.333333333333	0.777777777778	1.0
11	43721	Sidden1994@mail.ru	siden2010	1.0	1.0	0.0	0	0	0	0	0.484375	1.0	1.0	0.857142857143
12	60939	pavel_rozkar@mail.ru	pavlo2	0.125	0.375	0.25	0	0	0	0	0.515625	1.0	0.666666666667	1.0
13	1748	dan-sky@yandex.ru	danilmedvedev	1.0	1.0	0.0	0	0	0	0	0.734375	1.0	1.0	1.0
14	36996	GORGON67@yandex.ru	GORGON67	1.0	1.0	0.0	0	0	0	0	0.784722222222	1.0	0.222222222222	0.857142857143
15	14047	novikov.paul@gmail.com	npaul	0.0	0.0	0.0	0	0	0	0	0.282986111111	1.0	0.666666666667	1.0
16	43541	puss95@yandex.by	Puss95	0.25	0.0	0.25	0	0	0	0	0.421875	1.0	0.555555555556	1.0
17	28340	kestava@yandex.ru	Kestava	0.25	1.0	0.0	0	0	0	0	0.375	1.0	0.444444444444	1.0
18	44154	salinoid@mail.ru	diimas	0.0	1.0	0.0	0	0	0	0	0.515625	0.833333333333	0.555555555556	0.857142857143
19	21297	kayak10@mail.ru	kayak10	0.0	0.0	0.0	0	0	0	0	0.5	0.0	1.0	1.0
20	58658	vorontsov.gs@gmail.com	educationweb	0.0	0.25	0.0	0	0	0	0	0.15625	1.0	0.888888888889	0.857142857143
21	42503	andrewyuriev@mail.ru	AndreyYuryev	0.0	0.375	0.0	0	0	0	0	0.3125	1.0	0.333333333333	1.0
22	12504	mr.chazer@mail.ru	mr_chazer	0.0	0.0	0.0	0	0	0	0	0.125	1.0	0.0	1.0
23	43171	Grommerin@gmail.com	Grommerin	0.0	0.0	0.0	0	0	0	0	0.296875	0.666666666667	0.666666666667	1.0
24	19278	miha_ars@mail.ru	Odyvan4ik_irk	0.0	0.0	0.0	0	0	0	0	0.125	1.0	0.555555555556	1.0
25	23292	pokazanevmax@ya.ru	pokazanevmax	0.0	0.0	0.0	0	0	0	0	0.1875	1.0	0.222222222222	0.857142857143
26	45582	al_s07@mail.ru	almusis	0.125	1.0	0.0	0	0	0	0	0.625	1.0	0.333333333333	0.857142857143
27	50911	monkssau@mail.ru	monkssau	0.0	0.0	0.0	0	0	0	0	0.392361111111	0.833333333333	0.333333333333	0.714285714286
28	1320	levinpavel77@mail.ru	lion77	0.0	0.0	0.0	0	0	0	0	0.111111111111	0.833333333333	0.666666666667	1.0
29	2932	loktistov@yandex.ru	loktistov	0.0	0.0	0.0	0	0	0	0	0.234375	0.666666666667	0.222222222222	1.0

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Figure 5 Midterm result of evaluation system of students' activities

8 Conclusion

As a result, in the 2015-2016 academic year, the SPbPU included AIISM courses as a semester course and course elements for short training programmes (two weeks – 72 hours).

Within the framework of the project "Open education" (https://openedu.ru) designed online course on "Modern Industrial Electronics", whose main purpose is to develop ideas about the composition and appointment of modern industrial electronics PCS structure. The methodology of MEDIS project has been used in preparing this course.

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