SYLLABUS

1. Program data

1.1 Higher education institution	Technical University of Cluj-Napoca
1.2 Faculty	Road Vehicles, Mechatronics and Mechanics
1.3 Department	Road Vehicles and Transport
1.4 Field of study	Automotive Engineering
1.5 Study cycle	Master's Degree
1.6 Study program / Qualification	Advanced Techniques in Automotive Engineering (English) /Engineer
1.7 Form of education	IF – part-time education

2. Data about the discipline

2.1 Name of the discipline	Hardware and Software in the Loop					Code of Discipline	13.00
2.2 Course holder	*Associate Professor Ph.D. Iclodean Călin* *calin.iclodean@auto.utcluj.ro*						
2.3 Head of seminar/laboratory/project/practical activities	*Associate Professor Ph.D. Iclodean Călin* *calin.iclodean@auto.utcluj.ro*						
2.4 Year of study	2	2.5 Semester	1	2.6 Type of Assessment			E
2.7 Discipline regime	Formative category						DA
	Optionality						DOB

3. Total estimated time

3.1 Number of hours per week	4	of which:	3.2 Lecture	2	3.3 Seminary	0	3.3 Laboratory	2	3.3 Project	0	3.3 Practice	0
3.4 Number of hours per semester	56	of which:	3.5 Lecture	28	3.6 Seminary	0	3.6 Laboratory	28	3.6 Project	0	3.3 Practice	0

3.7 Distribution of time (hours per semester) for individual study and assessment:	
(a) Assessment	2
(b) Studying according to the textbook, course material, bibliography and notes	16
(c) Additional documentation in the library, on specialized electronic platforms and in the field	16
(d) Preparation of seminars / laboratories, assignments, papers, portfolios and essays	10
(e) Tutoring	-
(f) Other activities	-
3.8 Total hours of individual study and assessment (sum of (3.7(a)...3.7(f))	44
3.9 Total hours per semester (3.4+3.8)	100
3.10 Number of credits	4

4. Preconditions (where applicable)

4.1 Curriculum	Fundamental concepts of electronics, electrical engineering, and automotive electronic systems.
4.2 Skills	Basic knowledge of motor vehicles, electronics, computer science, and the use of software applications.

5. Conditions (where applicable)

5.1. Lecture delivery	Lecture room equipped with a computer and multimedia projector.
5.2. Seminar / laboratory / project delivery	Attendance and successful completion of all laboratory activities are mandatory prerequisites for admission to the final assessment.

6. Specific skills acquired

Professional skills	Analyze and explain the operating principles of electronic control systems used in modern motor vehicles. Model, simulate, and interconnect physical and virtual models of control systems using dedicated software applications. Apply development and validation methods based on the Model-in-the-Loop (MiL), Software-in-the-Loop (SiL), Processor-in-the-Loop (PiL), and Hardware-in-the-Loop (HiL) concepts for embedded systems. Apply AUTOSAR and Automotive SPICE standards in the design, integration, and validation of automotive electronic systems. Analyze the performance of electronic control systems and interpret the results obtained through simulation and testing.
Transversal skills	Use software applications and digital technologies efficiently for the development and validation of automotive systems. Organize and carry out design and simulation activities responsibly, while complying with quality standards and project deadlines. Collaborate effectively in multidisciplinary teams and communicate technical results clearly. Continuously develop professional competencies through the use of modern learning resources and technical documentation.

7. Expected learning outcomes

Knowledge	The student/graduate identifies and explains the operating principles of electronic control systems, as well as the physical and virtual models used in motor vehicle development. The student/graduate describes modern modeling, simulation, and validation methods (Model-in-the-Loop (MiL), Software-in-the-Loop (SiL), Processor-in-the-Loop (PiL), and Hardware-in-the-Loop (HiL)), as well as the AUTOSAR and Automotive SPICE standards used in the automotive industry.
Skills	The student/graduate uses software applications to model, simulate, and interconnect automotive control systems. The student/graduate develops, tests, and validates virtual models of electronic systems, analyzes simulation results, and optimizes system performance using appropriate methods and tools.
Responsibility and autonomy	The student/graduate uses specialized technical resources and demonstrates autonomy in the development and validation of automotive electronic systems. The student/graduate demonstrates professional responsibility and collaborates effectively in the design, simulation, and integration of automotive control systems.

8. The objectives of the discipline (based on the grid of specific competencies acquired)

8.1 General objective of the discipline	Develop knowledge and competencies in the modeling, simulation, interconnection, and validation of electronic control systems used in modern motor vehicles using methods and software applications specific to the automotive industry.
8.2 Specific objectives	Understand the architectures and operating principles of electronic control systems used in motor vehicles. Apply development and validation methods based on the Model-in-the-Loop (MiL), Software-in-the-Loop (SiL), Processor-in-the-Loop (PiL), and Hardware-in-the-Loop (HiL) concepts for embedded systems. Use software applications to model, simulate, and interconnect physical and virtual models of automotive systems. Become familiar with the AUTOSAR and Automotive SPICE standards and apply them in the development and validation of automotive electronic control systems.

9. Content

9.1 Lecture	Hrs.	Teaching methods	Observation
1. Introduction to Automotive Electronic Control Systems (ECUs).	2	Lectures, interactive discussions, practical examples, and case studies. Use of multimedia tools and specialized software applications.	
2. Virtual ECU for Powertrain Systems (Powertrain Domain).	2		
3. Virtual ECU for Chassis and Safety Systems (Chassis and Safety Domain).	2		
4. Virtual ECU for Body and Comfort Systems (Body and Comfort Domain).	2		
5. Virtual ECU for Infotainment Systems.	2		
6. Virtual ECU for Telematics and Connectivity Systems (Telematics Domain).	2		
7. Development of Embedded Systems Using the V-Model.	2		
8. Model-Based Development of Embedded Systems: Model-in-the-Loop (MiL).	2		
9. Model-Based Development of Embedded Systems: Software-in-the-Loop (SiL).	2		
10. Model-Based Development of Embedded Systems: Processor-in-the-Loop (PiL).	2		
11. Model-Based Development of Embedded Systems: Hardware-in-the-Loop (HiL).	2		
12. AUTOSAR Classic Platform and Application Architecture.	2		
13. AUTOSAR Adaptive Platform and Application Architecture.	2		
14. Automotive SPICE: Reference Model for the Development and Assessment of Automotive Software Processes.	2		
References (all teaching materials are available at the following address: (link): 1. Iclodean Introducere în sistemele automobilelor (link). 2. Iclodean Autonomous Vehicles for Public Transportation (link). 3. Iclodean Metode de Simulare a Sistemelor de Propulsie prin Aplicații Numerice (link). 4. Iclodean Simularea Avansată a Modelelor Virtuale de Autovehicule în CarMaker (link) 5. Iclodean Rețele de Comunicație pentru Autovehicule (link). 6. Iclodean Interconectarea sistemelor virtuale de ... control pentru autovehicule (link). 7. Varga Electric and Plug-In Hybrid Vehicles Advanced Simulation Methodologies (link). 8. Varga Electric and Hybrid Buses for Urban Transport Energy Efficiency Strategies (link). 9. AUTOSAR Standard Classic Platform (link). 10. AUTOSAR Standard Adaptive Platform (link).			

9.2 Seminar / laboratory / project / practice	Hrs.	Teaching methods	Observation
1. Introduction to XiL Development Methodologies (MiL, SiL, PiL, and HiL) and Configuration of the Simulation Environment.	2	Practical exercises, demonstrations, modeling, and computer-aided simulation.	
2. Definition and Development of a Virtual Model Based on a Physical System – Phase I.	2		
3. Definition and Development of a Virtual Model Based on a Physical System – Phase II.	2		
4. Definition and Validation of the Virtual Model of the Electronic Control System.	2		
5. Definition, Modeling, and Configuration of a Virtual ECU – Phase I.	2		
6. Definition, Modeling, and Configuration of a Virtual ECU – Phase II.	2		
7. Integration and Validation of the Virtual ECU within the XiL Simulation Platform.	2		
8. Testing and Optimization of the Virtual ECU Model Parameters – Phase I.	2		

9.2 Seminar / laboratory / project / practice	Hrs.	Teaching methods	Observation
9. Testing and Optimization of the Virtual ECU Model Parameters – Phase II.	2		
10. Functional Testing and Validation of the Virtual ECU Model under Different Simulation Scenarios.	2		
11. Analysis and Interpretation of the Results Obtained for the Virtual ECU Model – Phase I.	2		
12. Analysis and Interpretation of the Results Obtained for the Virtual ECU Model – Phase II.	2		
13. Comparative Analysis of the Results and Optimization of the Virtual ECU Model.	2		
14. Presentation and Evaluation of the Individual Simulation and Validation Project for an Automotive Electronic Control System.	2		

References (all teaching materials are available at the following address: (link):

1. Iclodean Introducere în sistemele automobilelor (link).
2. Iclodean Autonomous Vehicles for Public Transportation (link).
3. Iclodean Metode de Simulare a Sistemelor de Propulsie prin Aplicații Numerice (link).
4. Iclodean Simularea Avansată a Modelelor Virtuale de Autovehicule în CarMaker (link)
5. Iclodean Rețele de Comunicație pentru Autovehicule (link).
6. Iclodean Interconectarea sistemelor virtuale de ... control pentru autovehicule (link).
7. Varga Electric and Plug-In Hybrid Vehicles Advanced Simulation Methodologies (link).
8. Varga Electric and Hybrid Buses for Urban Transport Energy Efficiency Strategies (link).
9. AUTOSAR Standard Classic Platform (link).
10. AUTOSAR Standard Adaptive Platform (link).

10. Correlating the content of the discipline with the expectations of representatives of the epistemic community, professional associations and representative employers in the field related to the program

The course content is aligned with the current requirements of the automotive industry and the academic community, reflecting employers' expectations regarding the development of competencies in the modeling, simulation, and validation of automotive electronic control systems. The course develops knowledge and practical skills in the application of XiL methodologies (Model-in-the-Loop (MiL), Software-in-the-Loop (SiL), Processor-in-the-Loop (PiL), and Hardware-in-the-Loop (HiL)), the AUTOSAR and Automotive SPICE standards, and software tools for embedded systems development, in accordance with the curricula and professional practices adopted by leading universities and automotive companies in Romania and internationally.

11. Evaluation

Activity	11.1 Assessment criteria	11.2 Assessment methods	11.3 Weight of final grade
11.4 Lecture	Level of knowledge acquisition and understanding of automotive communication networks and protocols, as well as the ability to analyze and apply these concepts.	Written examination (summative assessment)	60%
11.5 Seminar/Laboratory /Project / Practice	Ability to model, simulate, and analyze automotive communication networks, as well as the accuracy of practical assignments and laboratory work.	Continuous assessment based on laboratory activities	40%

11.6 Minimum Performance Standard
Acquisition of the fundamental concepts related to the modeling, simulation, and validation of automotive electronic control systems, as well as the application of XiL methodologies and software tools used for embedded systems development.
Minimum passing grade for both the laboratory activities and the final examination: 5.00.

Date of completion	Responsible	Grade, Title, Second name First NAME	Signature
09.07.2026	Lecture	*Associate Professor Ph.D. Iclodean Călin*	
	Applications	*Associate Professor Ph.D. Iclodean Călin*	

Date of approval in the ART Department Council 24.07.2026 _____	ART Department Director Prof.dr.ing. Barabás István
Date of approval in the ARMM Faculty Council 16.09.2026 _____	Dean, Prof.dr.ing. Filip Nicolae