

## SYLLABUS

### 1. Data about the program of study

1.1	Institution	Technical University of Cluj-Napoca
1.2	Faculty	Faculty of Civil Engineering
1.3	Department	
1.4	Field of study	Civil Engineering
1.5	Cycle of study	Master of Science
1.6	Program of study/Qualification	Artificial Intelligence in Construction Engineering and Management
1.7	Form of education	Full time
1.8	Subject code	17.04

### 2. Data about the subject

2.1	Subject name				Digitalization in railway infrastructure				
2.2	Course responsible/lecturer				S.L.dr.ing. Zsolt Laszlo ORBAN – zsolt.orban@cfdp.utcluj.ro				
2.3	Teachers in charge of seminars				S.L.dr.ing. Zsolt Laszlo ORBAN – zsolt.orban@cfdp.utcluj.ro				
2.4	Year of study	2	2.5	Semester	1	2.6	Assessment	C	
2.7 Subject category		Formative category							DS
		Optionality							DO

### 3. Estimated total time

3.1 Number of hours per week	3	of which	3.2 Course	2	3.3 Seminar		3.3 Laboratory	1	3.3 Project	
3.4 Total hours in the curriculum	42	of which	3.5 Course	28	3.6 Seminar		3.6 Laboratory	14	3.6 Project	
3.7 Individual study:										
(a) Manual, lecture material and notes, bibliography										14
(b) Supplementary study in the library, online and in the field										6
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays										14
(d) Tutoring										14
(e) Exams and tests										6
(f) Other activities										4
3.8 Total hours of individual study (sum (3.7(a)...3.7(f)))					58					
3.9 Total hours per semester (3.4+3.8)					100					
3.10 Number of credit points					4					

### 4. Pre-requisites (where appropriate)

4.1	Curriculum	Not applicable
4.2	Competence	Not applicable

### 5. Requirements (where appropriate)

5.1	For the course	Classroom equipped with projector and screen
5.2	For the applications	Classroom equipped with projector, screen, and computers

## 6. Specific competences

Professional competences	<ul style="list-style-type: none"> <li>• Deep knowledge on railway track digitalization processes in design, construction, and maintenance of the track.</li> <li>• Assessment of track quality based on information extracted by analysing data supplied by track geometry measuring devices / vehicles.</li> <li>• To use data driven solutions for efficient maintenance of a railway track.</li> <li>• Build a strategy for planning and implementing an Intelligent Asset Management in railway infrastructure.</li> <li>• Use specific software and digital twin platforms in railway track maintenance processes.</li> </ul>
Cross competences	<ul style="list-style-type: none"> <li>• Applying efficient and responsible work strategies, punctuality, seriousness, and personal responsibility, based on the principles, norms, and professional values.</li> <li>• Carrying out a rigorously documented synthesis work, considering the efficient adaptation to the new technical specifications.</li> <li>• Objective assessment of the colleagues' solutions in a working group, dissemination of results.</li> </ul>

## 7. Discipline objectives (as results from the *key competences gained*)

7.1	General objective	<ul style="list-style-type: none"> <li>• Knowledge of digital solutions for railway infrastructure design, construction, and maintenance works</li> <li>• Developing skills related to: <ul style="list-style-type: none"> <li>○ railway track monitoring using the latest technologies in the field,</li> <li>○ assessment of track geometry quality,</li> <li>○ compliance with safety requirements and sustainable behavior of railways,</li> <li>○ planning and implementing an Intelligent Asset Management in the railway sector,</li> <li>○ using data driven solutions in maintaining a railway track - Digital Twin</li> </ul> </li> </ul>
7.2	Specific objectives	<ul style="list-style-type: none"> <li>• Understanding and learning the theoretical and practical knowledge related to data driven management activities, operation and maintenance of a railway infrastructure.</li> </ul>

## 8. Contents

8.1. Lecture (syllabus)	Number of hours	Teaching methods	Notes
<b>Lecture 1 – Introduction in Artificial Intelligence (AI)</b> <ul style="list-style-type: none"> <li>• Artificial Intelligence (AI): what is AI? What does AI do? Why does AI matter? How is applied in construction industry and how is combined with other technologies?</li> <li>• History of AI and how it changed the construction industry (some relevant examples)</li> <li>• Role of data in AI</li> <li>• Artificial General Intelligence (AGI)</li> <li>• Narrow AI</li> <li>• Machine Learning as subset of AI: introduction – short description, machine learning algorithms.</li> <li>• Solutions for Railway Infrastructure</li> </ul>	2	Lecture, discussions	-
<b>Lecture 2 – Basic knowledge of the railway track system</b>	2		

<ul style="list-style-type: none"> <li>• Short description of railway infrastructure and superstructure component elements</li> <li>• Geometric parameters which are defining the quality of the railway track</li> </ul>			
<b>Lecture 3 – Railway track quality</b> <ul style="list-style-type: none"> <li>• Overview – what is quality?</li> <li>• Factors affecting the track quality.</li> <li>• Relation between quality and safety in railways</li> <li>• Assessment of track geometry quality</li> </ul>	2		
<b>Lecture 4 – Behavior of railway track in time under traffic</b> <ul style="list-style-type: none"> <li>• Railway track degradation</li> <li>• Behavior of railway track quality in time</li> <li>• Thresholds of railway track geometric parameters</li> </ul>	2		
<b>Lecture 5 – Railway Track Monitoring</b> <ul style="list-style-type: none"> <li>• Short history of Railway Infrastructure monitoring</li> <li>• Railway track monitoring devices</li> <li>• Railway track monitoring vehicles</li> </ul>	2		
<b>Lecture 6 – New technologies in railway track monitoring</b> <ul style="list-style-type: none"> <li>• Wayside track monitoring systems</li> <li>• Fiber optic movement sensing as a trackside method for monitoring railway track condition</li> <li>• Use of accelerometers and extraction of acceleration-based condition indicators for diagnosis and prognosis</li> <li>• Track monitoring devices from passenger trains</li> <li>• Ground penetrating radar solutions to detect failures in the subgrade levels.</li> </ul>	2		
<b>Lecture 7 – Data in railway infrastructure monitoring</b> <ul style="list-style-type: none"> <li>• Introduction: what is data? Why we need data? What type of data should be collected?</li> <li>• The first phase of the data, Data and databases</li> <li>• How data can be transformed in relevant information regarding track monitoring</li> <li>• Data strategies and digital platforms in railway construction and monitoring technology, computing, and AI machine learning, converting it in crucial information which railway engineers could use to make strategic decisions in optimizing the railway infrastructure</li> </ul>	2		
<b>Lecture 8 – Intelligent automation in Railway Track Construction and Maintenance</b> <ul style="list-style-type: none"> <li>• Overview: introducing automation</li> <li>• Challenges and background in railway construction and maintenance sector</li> <li>• Automation tools</li> <li>• Automation strategy</li> </ul>	2		
<b>Lecture 9 – Design, Construction and Maintenance of the Railway Track</b> <ul style="list-style-type: none"> <li>• Track Design: overview,</li> <li>• Track Construction</li> </ul>	2		

<ul style="list-style-type: none"> <li>Track Maintenance: historical background, maintenance strategies, maintenance planning process</li> <li>Types of maintenance strategies: reactive, preventative, corrective and predictive</li> <li>The future in railway track maintenance strategy</li> <li>The service life of a track</li> <li>Cost savings by adopting an effective maintenance policy</li> </ul>			
<b>Lecture 10 – Track Maintenance and Asset Management as foundation for Digital Twins in Railway</b> <ul style="list-style-type: none"> <li>Definition of an asset in railway industry</li> <li>What is Asset Management?</li> <li>Scope of Asset Management System in Railway Infrastructure</li> </ul>	2		
<b>Lecture 11 - Asset Management Framework for Railway Infrastructure Organizations</b> <ul style="list-style-type: none"> <li>Asset Management objectives</li> <li>Strategic Asset Management Plan: Asset + Operation</li> <li>Implementation of Asset Management Plan in railway infrastructure</li> <li>Role of artificial intelligence, algorithms, and machine learning in data-driven solutions for asset management</li> </ul>	2		
<b>Lecture 12 – Data driven solutions in maintaining a railway track - Digital Twin</b> <ul style="list-style-type: none"> <li>Overview</li> <li>Role of the collected data in creating a digital twin</li> <li>Types of digital twins in railway</li> </ul>	2		
<b>Lecture 13 - Applications and digital twin platforms for railway</b> <ul style="list-style-type: none"> <li>Infrastructure engineering software solutions</li> <li>AssetWise inspections in railway infrastructure.</li> </ul>	2		
<b>Lecture 14 – AssetWise analytics</b> <ul style="list-style-type: none"> <li>AssetWise rail condition analytics</li> <li>AssetWise linear analytics</li> </ul>	2		
<b>Bibliography</b> <ol style="list-style-type: none"> <li>[1]. EN 13848-1 – Railway applications. Track. Track geometry quality. Part 1: Characterization of track geometry.</li> <li>[2]. EN 13848-2 – Railway applications. Track. Track geometry quality. Part 2: Measuring systems – Track recording vehicles.</li> <li>[3]. EN 13848-3 – Railway applications. Track. Track geometry quality. Part 3: Measuring systems – Track construction and maintenance machines.</li> <li>[4]. EN 13848-4 – Railway applications. Track. Track geometry quality. Part 4: Measuring systems – Manual and lightweight devices.</li> <li>[5]. EN 13848-5 – Railway applications. Track. Track geometry quality. Part 5: Geometric quality levels – Plain line, switches, and crossings.</li> <li>[6]. EN 13803 - Railway applications. Track. Track alignment design parameters – Track gauges 1435 mm and wider</li> <li>[7]. ISO 55000 – Asset Management – Overview, principles and terminology</li> <li>[8]. ISO 55001 – Asset Management – Management systems – Requirements</li> </ol>			

- [9]. ISO 55002 – Asset Management – Management systems – Guidelines for the application of ISO 55001
- [10]. Al. Herman, L. Kazinnczy, G. Kollo , Railways – Geometrical elements, Ed. MIRTON Timișoara, 2011.
- [11]. Esveld, C.: Modern Railway Track – Second Edition, Delft University of Technology, ISBN 90-800324-3-3, Dior Zwarthoed-van Nieuwenhuizen, 2001.
- [12]. Tzanakakis K. – The Railway Track and Its Long Term Behaviour – A handbook for a Railway Track of High Quality, ISSN 2194-8119, ISBN 978-3-642-36050-3 – Springer Heidelberg, 2013.
- [13]. UIC Railway Application Guide – Practical implementation of Asset Management through ISO 55001, International Union of Railways, The Institute of Asset Management, ISBN 978-2-7461-2521-6, Paris 2016.

8.2. Seminars /Laboratory/Project	Number of hours	Teaching methods	Notes
Assessment of railway track quality based on the geometric parameters data collection and analysis.	4	Lecture, interactive teaching methods, workshop	-
Implementation of intelligent asset management in railway infrastructure maintenance (digital twin) – AssetWise track condition analytics	6		
Applications and digital twin platforms for railways	4		

#### Bibliography

- [1]. EN 13848-1 – Railway applications. Track. Track geometry quality. Part 1: Characterization of track geometry.
- [2]. EN 13848-2 – Railway applications. Track. Track geometry quality. Part 2: Measuring systems – Track recording vehicles.
- [3]. EN 13848-3 – Railway applications. Track. Track geometry quality. Part 3: Measuring systems – Track construction and maintenance machines.
- [4]. EN 13848-4 – Railway applications. Track. Track geometry quality. Part 4: Measuring systems – Manual and lightweight devices.
- [5]. EN 13848-5 – Railway applications. Track. Track geometry quality. Part 5: Geometric quality levels – Plain line, switches, and crossings.
- [6]. EN 13803 - Railway applications. Track. Track alignment design parameters – Track gauges 1435 mm and wider
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- [11]. Esveld, C.: Modern Railway Track – Second Edition, Delft University of Technology, ISBN 90-800324-3-3, Dior Zwarthoed-van Nieuwenhuizen, 2001.
- [12]. Tzanakakis K. – The Railway Track and Its Long Term Behaviour – A handbook for a Railway Track of High Quality, ISSN 2194-8119, ISBN 978-3-642-36050-3 – Springer Heidelberg, 2013.
- [13]. UIC Railway Application Guide – Practical implementation of Asset Management through ISO 55001, International Union of Railways, The Institute of Asset Management, ISBN 978-2-7461-2521-6, Paris 2016.

**9. Bridging course contents with the expectations of the representatives of the community, professional associations, and employers in the field**

The skills acquired will be necessary for subject matter experts working in the field of research, design, execution, and maintenance of railways. The content and complexity of the discipline is correlated with the actual tendencies of railway developments and the notions taught are permanently correlated with those of the related disciplines in the curriculum.

**10. Evaluation**

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Course	Theoretical test	Written test (T) – duration: 2 hours	60%
10.5 Seminars /Laboratory/Project	Assessment of submitted works	Student presentation The average of the submitted works grades is calculated as bellow: Mean Grade: $MG = \frac{\sum_1^i (W_i)}{i}$ Where: Wi – each submitted work grade	40%
10.6 Minimum standard of performance			
Final grade calculation formula: $FG = 0,6 * T + 0,4 * MG$ <ul style="list-style-type: none"> <li>Eligibility condition for the exam: attendance at min. 12 (twelve) work sessions and the timely delivery of the works (project).</li> <li><math>FG \geq 5</math> (five), if <math>T \geq 5</math> (five), <math>MG \geq 5</math> (five).</li> </ul>			

Date of filling in:		Title Surname Name	Signature
27.06.2024	Lecturer	S.L.dr.ing. Zsolt László ORBÁN	
	Teachers in charge of application	S.L.dr.ing. Zsolt László ORBÁN	

Date of approval in the department	Head of department
28.06.2024	Conf.dr.ing. Hortensiu Liviu CUCU
Date of approval in the faculty	Dean
12.07.2024	Prof.dr.ing. Daniela – Lucia MANEA